UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232

May 19, 2021

Via Electronic Mail

Refer to NMFS No: WCRO-2021-01008

Mr. Bryan Mercier, Regional Director
Northwest Regional Office
Bureau of Indian Affairs (BIA)
911 N.E. 11th Avenue
Portland, Oregon 97232-4169
Brian.mercier@bia.gov

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Impacts of the Role of the BIA Under its Authority to Assist with the Development of the 2021-2022 Puget Sound Chinook Harvest Plan, the Role of the U.S. Fish and Wildlife Service in Activities Carried out under the Hood Canal Salmon Management Plan and in Funding the Washington Department of Fish and Wildlife under the Sport Fish Restoration Act in 2021-22, and the Role of the National Marine Fisheries Service in authorizing fisheries consistent with management by the Fraser Panel and Funding Provided to the Washington Department of Fish and Wildlife for Activities Related to Puget Sound Salmon Fishing in 2021-2022

Dear Mr. Mercier:

Thank you for your letter of April 26, 2021, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for Impacts of the Role of the BIA Under its Authority to Assist with the Development of the 2021-2022 Puget Sound Chinook Harvest Plan. Enclosed is a biological opinion prepared by NMFS and issued under the authority of section 7 of the Endangered Species Act of 1973 (ESA), as amended (ESA; 16 U.S.C. 1536).

We also reviewed the likely effects of the proposed action on essential fish habitat (EFH), pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA; 16 U.S.C. 1855(b)). We concluded that the action would adversely affect EFH for stocks managed under the Pacific Coast Groundfish Fishery Management Plans. Therefore, we have included the conservation recommendations in this document.

The biological opinion evaluates the impacts of the proposed fisheries on the following ESA-listed species:

- Puget Sound Chinook Salmon Evolutionarily Significant Unit (ESU),
- Puget Sound Steelhead Distinct Population Segment (DPS),
- Southern Resident killer whale DPS, and

- two Puget Sound/Georgia Basin rockfish DPSs (yelloweye and bocaccio),
- two Humpback whale DPSs (Mexico and Central America)

Other ESA-listed species occurring in the Action Area are either covered under existing, long-term ESA biological opinions or 4(d) determinations, or we anticipate the proposed actions are not likely to adversely affect the species. This biological opinion and EFH consultation expire on May 14, 2022.

We have concluded in the biological opinion that the action, if conducted consistent with the terms of the Incidental Take Statement, is not likely to jeopardize the continued existence of the listed species that are subject of the opinion, or to destroy or adversely modify critical habitat. The Incidental Take Statement includes non-discretionary terms and conditions that must be applied to the proposed fisheries to provide an exemption from the prohibited acts outlined in section 9 of the ESA. The biological opinion also includes discretionary Conservation Recommendations that are intended to help your agency comply with the affirmative conservation responsibilities of section 7(a)(1) of the ESA.

NMFS also concluded that the programs would adversely affect EFH for groundfish managed under the MSA. Therefore, enclosed are several Conservation Recommendations, provided under section 305(b)(4)(a) of the MSA, that would avoid or minimize those adverse effects.

As prescribed by ESA section 7 regulations, consultation on the programs administered by the BIA involving these Puget Sound salmon and steelhead fisheries must be re-initiated if:

(1) the amount or extent of taking specified in the Incidental Take Statement is exceeded for any of the actions identified in the biological opinion;

(2) new information reveals effects of these actions that may affect listed species or critical habitat in a manner or to an extent not previously considered;

(3) any of the identified actions are subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion; or

(4) a new species is listed or critical habitat designated that may be affected by the identified actions.

Please contact James Dixon in our Sustainable Fisheries Division (360.522.3673, james.dixon@noaa.gov) if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Barry A. Thom
Regional Administrator

Enclosure

cc: Susan Bishop, Sustainable Fisheries Division, NMFS West Coast Region
Christina Iverson, Sustainable Fisheries Division, NMFS West Coast Region

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 2021-2022 Puget Sound Chinook Harvest Plan, the Role of the U.S. Fish and Wildlife Service in Activities Carried out under the Hood Canal Salmon Management Plan and in Funding the Washington Department of Fish and Wildlife under the Sport Fish Restoration Act in 2021-2022, and the Role of the National Marine Fisheries Service in authorizing fisheries consistent with management by the Fraser Panel and Funding Provided to the Washington Department of Fish and Wildlife for Activities Related to Puget Sound Salmon Fishing in 2021-2022

NMFS Consultation Number: WCRO-2021-01008

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

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	No
Humpback whale (*Megaptera novaeangliae)* Central America DPS	Endangered	Yes	No	No	No

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

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

Issued by: ______________________________
Barry A. Thom, Regional Administrator
West Coast Region
National Marine Fisheries Service

Date: **May 19, 2021** (***Date expires: May 14, 2022***)

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ACOE	ARMY CORPS OF ENGINEERS
B.C.	BRITISH COLUMBIA
BIA	BUREAU OF INDIAN AFFAIRS
BO	BIOLOGICAL OPINION
BRT	BIOLOGICAL REVIEW TEAM
C&S	CEREMONIAL AND SUBSISTENCE
CA	CALIFORNIA
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
CRS	COLUMBIA RIVER SYSTEM
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
LAT	LOW ABUNDANCE THRESHOLDS
LCR	LOWER COLUMBIA RIVER

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
mtDNA	Mitochondrial deoxyribonucleic acid
MSY	Maximum Sustainable Yield
MU	major unit
NAS	Naval Air Station
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
NRKWs	Northern Resident Killer Whales
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
PCSRF	PACIFIC COASTAL SALMON RECOVERY FUND
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
SPLASH	STRUCTURE OF POPULATIONS, LEVELS OF ABUNDANCE, AND STATUS OF HUMPBACKS
SR	SNAKE RIVER
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
UCR	UPPER COLUMBIA RIVER
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 2021-2022 Puget Sound Harvest Plan, and expenditure of funding to support implementation of federal court decisions including US v. Washington, as reflected in BIA's April 26, 2021 request for consultation to NMFS, inclusive of BIA's Biological Assessment and Environmental Assessment.

(2) USFWS actions that it funds or carries out as a signatory to the Hood Canal Salmon Management Plan (U.S. v. Washington, Civil No. 9213, Ph. 1 (Proc. 83-8)), from May 1, 2021-May 14, 2022 (dates of analysis). Past NMFS Biops have erroneously stated that USFWS authorizes fisheries as a party to the Hood Canal Salmon Management Plan. USFWS does not authorize any fisheries in Puget Sound.

(3) Two actions associated with the management of the 2021 U. S. Fraser Panel sockeye and pink fisheries under the Pacific Salmon Treaty (PST):

(a) NMFS' approval of the Pacific Salmon Commission's recommended fishing regime for the annual Fraser River sockeye and pink salmon fishing season, 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.

(4) NMFS' funding of WDFW activities associated with managing Puget Sound salmon fisheries, primarily through appropriations for purposes of implementing the PST. In 2021 these funds are anticipated to be used for activities including fishery monitoring and sampling, coded-wire tag application, processing of coded-wire tags and data, and technical and management support for Puget Sound fisheries.

(5) USFWS funding to WDFW under the Sport Fish Restoration Act to conduct the Comprehensive Puget Sound Recreational Fisheries Sampling Program. In 2021, these funds are anticipated to be used for activities including fishery monitoring, biological and coded-wire tag sampling and processing, and technical management and support.

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, and critical habitat, occurring in the action area are either covered under existing, long-term ESA opinions or 4(d) determinations as shown in Table 1, or NMFS has determined that the proposed actions are not likely to adversely affect the species (Section 2.12).

1.2 Consultation History

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

Since 2001, NMFS has received, evaluated, and approved a series of jointly developed resource management plans (RMP) from the Puget Sound Treaty Indian Tribes (PSIT) and the Washington Department of Fish and Wildlife (WDFW) (collectively the co-managers) under

Limit 6 of the 4(d) Rule. These RMPs provided the framework within which the tribal and state jurisdictions jointly managed all recreational, commercial, ceremonial, subsistence and take-home salmon fisheries, and steelhead gillnet fisheries impacting listed Chinook salmon within the greater Puget Sound area. The most recent RMP, approved in 2011, expired April 30, 2014 (NMFS 2011b). NMFS has consulted under ESA section 7 and issued biological opinions on its 4(d) determinations for each of these RMPs and related federal actions including BIA planning and implementation assistance for Puget Sound tribal fisheries, for USFWS Hood Canal Salmon Plan-related actions, and U.S. Fraser Panel fishery 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 in Section 1.1. These 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 specific, annual stock management issues. NMFS issued one-year biological opinions for the 2014, 2015, 2016[1], 2017, 2018, 2019, and 2020 Puget Sound fishery cycles that considered BIA's, USFWS's and NMFS' actions related to the planning and authorization of the Puget Sound fisheries based on the 2010-2014 RMP framework (NMFS 2014b; 2015c; 2016f; 2016d; 2016e; 2017b; 2018c; 2019b; 2020d). 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, Puget Sound/Georgia Basin yelloweye rockfish, or the Central America or Mexico DPS of Humpback whales. 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 2021, NMFS will complete a consultation under section 7 of the ESA analyzing the effects of 2021-2022 Puget Sound salmon fisheries on ESA-listed species.

On April 26, 2021, the BIA formally requested consultation on its authority to assist with the development and implementation of the co-managers 2021-2022 Puget Sound Harvest Plan, and expenditure of funding to support implementation of federal court decisions including US v. Washington, as described in (Mercier 2021). The request included a joint plan produced by the WDFW and the PSIT, as an amendment to the 2010-2014 Puget Sound RMP, for the proposed 2021-2022 Puget Sound salmon and hatchery 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 hatchery 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 2021), the Environmental Assessment on the 2021 Puget Sound Chinook Harvest Plan (BIA 2021), discussions with Puget Sound tribal, WDFW and Northwest Indian Fisheries Commission staffs,

[1] In 2016 a total of three biological opinions related to the 2016-2017 Puget Sound fisheries were issued – NMFS (NMFS 2016f; 2016d; 2016e).

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 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. 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. Therefore, 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 2012a)	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's requirements for

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 2021-2022 Puget Sound Harvest Plan, and expenditure of funding to support implementation of federal court decisions including US v. Washington.[2] 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. Additionally this plan considers the total fishery-related impacts on Puget Sound Chinook salmon and steelhead from those fisheries within the greater Puget Sound area. The 2021-2022 Chinook Harvest Plan is based on the 2010-2014 Puget Sound Chinook harvest RMP, with revisions to the conservation objectives to address the current year's run forecasts. This 2021-2022 Chinook Harvest Plan details the current conservation and management objectives, including expected levels of impact to ESA-listed Puget Sound 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, subject to in-season adjustment, where applicable, anticipated to occur during the period (Mercier 2021). 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, for the 2021-2022 Season;
- the 2021-2022 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
- 2021 Green River Management actions,
- 2021 Puyallup River Management actions;
- a description of actions to be taken in the WDFW managed fishery season for 2021-2022 beneficial for Southern Resident Killer Whales;
- a summary assessment of the tribal salmon fishing impacts associated with the proposed 2021-2022 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;

[2] BIA's role is consistent with Secretarial Order #3206, Appendix Sec. 2 (c), 3 (c).

- Piscivorous predator assessment research study (WDFW).
- As part of the proposed May 1, 2021 through May 14, 2022 Puget Sound salmon and steelhead fishery management, the co-managers may propose to implement fisheries during the April, 2022-May 14, 2022 period, directed toward harvestable abundances of spring-timed (early) Chinook salmon returns from a number of areas in Puget Sound, including: the Nooksack River, the Skagit River, Tulalip Bay, the White River (Puyallup watershed), and the Dungeness River (Mercier 2021). In order to assess the impacts of the spring Chinook fisheries for the full management period and apply appropriate management constraints to the individual spring Chinook run years, the co-managers have proposed to utilize a set of conservation-based management objectives to manage the fisheries targeting spring Chinook stocks. Conservation objectives are proposed for assessment in this biological opinion, for use over the May 1, 2021-May 14, 2022 period.

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

USFWS*:*
The USFWS proposes to fund or carry out actions that are consistent with the implementation of the Hood Canal Salmon Management Plan (Hood Canal Salmon Management Plan 1986; HCSMP) from May 1, 2021 through May 14, 2022. 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 and tribal parties to the Hood Canal Plan establish management objectives for stocks originating in Hood Canal including listed Chinook and summer-run chum stocks. USFWS coordinates with and provides technical assistance to the state and tribal parties and also provides them with estimates of hatchery returns to Quilcene National Fish Hatchery. Some of the management actions under the HCSMP may affect 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, 2021 through May 14, 2022 (see (Mercier 2021)).

In addition, the USFWS Wildlife and Sport Fish Restoration program partially funds WDFW under the Sport Fish Restoration Act to conduct its Comprehensive Puget Sound Recreational Fisheries Sampling Program. Under this grant, WDFW designs and implements creel surveys for recreational fisheries for Chinook and Coho Salmon, halibut, and other marine fish to monitor Puget Sound fisheries catch by species, angling effort, stock composition, and fishery impacts. Methods may include dockside creel surveys, on-the-water boat surveys, test fishing, and voluntary Salmon Trip Reports/Catch Record Card data. Test fisheries will be conducted by WDFW staff to estimate the adipose mark rate of Chinook salmon during the mark-selective Chinook salmon fishery for both legal size and sub-legal size Chinook salmon. WDFW also collects collect coded-wire tag (CWT) information for Chinook and Coho salmon and biological data on salmon and other marine fish species (e.g., scales for age analysis, length measurements, tissue samples for genetic stock identification, weights for some species, lengths). This fishery monitoring data is summarized and results are communicated to both tribal co-managers and the public.

NMFS:

Between May 1, 2021 and May 14, 2022, NMFS will take three actions associated with the Puget Sound salmon and steelhead fisheries. Two are associated with NMFS' role, under the PST, for Fraser Panel fisheries occurring in U.S. Panel waters; the third action is the funding of activities by the Washington State (WDFW) for the implementation, management, and monitoring of Puget Sound fisheries, consistent with the PST.

The Fraser Panel of the Pacific Salmon Commission (PSC) manages 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 (PSC 2020). The Fraser Panel typically proposes regulations governing 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—all years, and pink salmon in odd-numbered years (e.g., 2013, 2015, 2017, 2019, 2021). 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 2021 fishing season to implement the PST's provisions regarding management of the 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 in-season 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 the Secretary of Commerce authority to issue regulations implementing the PST. 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 provides funding to WDFW which is used for activities associated with managing Puget Sound salmon fisheries. Primarily, this funding comes through a grant of a portion of funds appropriated for purposes of implementing the PST. Additionally, funds provided to WDFW through the Pacific Coastal Salmon Recovery Fund (PCSRF) program have been used for similar activities. In 2021 these funds are anticipated to be used for activities including fishery monitoring and sampling, coded-wire tag application, processing of coded-wire tags and data, and technical and management support for Puget Sound fisheries.

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. Under NMFS' regulations, an "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. The state of Washington and the Puget Sound treaty tribes have submitted a proposal for joint management[3] of the 2021-2022 Puget Sound salmon fisheries. 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 actions and are reasonably certain to occur. Non-tribal salmon fisheries and related enforcement, research, and monitoring projects associated with fisheries would also occur as a consequence of the proposed actions and are reasonably certain to occur. Collectively these federal actions allow the fisheries to operate in a manner that is consistent with the various plans, court orders, and applicable law. Without these actions the fisheries would not likely occur in the manner proposed under the co-management framework of the 2021-2022 Puget Sound annual harvest plan. Thus, NMFS finds that the proposed fisheries are an effect of the action as that term is defined under the new regulatory definitions. We consider 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 2021-2022 Puget Sound Harvest Plan are a mix of Southern United States[4] (SUS), total (all marine and freshwater) exploitation rate (ER), and escapement -based objectives. We consider the effects of Puget Sound fishery impacts to Puget Sound Chinook stocks in the context of their overall 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, and fisheries in the marine, estuarine, and freshwater areas of Puget Sound (Puget Sound salmon fisheries). The effects of all these fisheries were considered in this opinion in order to determine whether conservation objectives are being met. The Fraser Panel fisheries are included in the mix of Puget Sound salmon fisheries.

Puget Sound salmon fisheries are managed consistent with the provisions of the PST, 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

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[3] 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)).

[4] Southern United States or SUS fisheries are those salmon fisheries conducted in U.S. waters, including state waters, south of the Southern Canadian border. These fisheries do not include those fisheries conducted north of the Southern Canadian border, including those in the state or federal waters off Alaska.

Canadian waters. Fisheries off the U.S. West Coast and in inland waters, such as the Puget Sound, harvest salmon originating in U.S. West Coast and Canadian waters. The PST provides a framework for managing salmon fisheries in those waters of the U.S. and Canada 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. As Puget Sound Chinook salmon are listed under the ESA, and are subject to management under the PST, objectives for Puget Sound salmon fisheries are designed to be consistent with these laws.

The 2019-2028 PST Agreement includes reductions in harvest impacts for all Chinook fisheries within its scope, including Puget Sound. The 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). Provisions of the updated agreement were specifically designed to reduce fishery impacts in all fisheries to respond to conservation concerns for a number of U.S. and Canadian stocks.

In 2019, NMFS consulted on impacts to ESA-listed species from several U.S. domestic actions associated with the 2019-2028 PST agreement (NMFS 2019e), including federal funding of a conservation program for critical Puget Sound salmon stocks and Southern Resident Killer Whale (SRKW) prey enhancement. The 2019 opinion (NMFS 2019e) 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 SRKWs and $13.5 million was used to support Puget Sound Critical Stock Conservation and Habitat Restoration and Protection, consistent with the funding initiative. For Fiscal Year 2021, Congress has appropriated $39.5 million for activities in support of these activities. (166 Cong. Rec. 12/21/2020). 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 within 3-5 years following implementation. Site or project specific ESA and NEPA coverage for these activities is described in the Environmental Baseline. The harvest management provisions of the 2019-2028 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, or critical habitat for humpback whales. 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:

- *Evaluate 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.
- *Evaluate the environmental baseline of the species and critical habitat.* 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.
- *Evaluate 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 and 402.17(a)), 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.

- *In the integration and synthesis*, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly 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, or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- *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, SRKWs, 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)These changes will shrink the extent of the snowmelt-dominated habitat available to salmon and may restrict our ability to conserve diverse salmon and steelhead life histories, making 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 populations within the Puget Sound DPS may be more vulnerable to climate change since there are few summer run populations that belong to 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[5]. 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). Abundance of Puget Sound steelhead populations is at near historic lows (Moore et al. 2014). Climate changes have included increasing water temperatures, increasing acidity, more harmful algae, the loss of forage fish and some marine commercial fishes, changes in marine plants, and increased populations of some marine mammals (i.e. seals and porpoises) (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 the steelhead that did not survive, approximately 80 percent were consumed by predators that display deep diving behavior, such as pinnipeds (Moore and Berejikian 2019). Climate change plays a part in steelhead mortality, but more studies needed 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, and recent and unfavorable environmental trends are expected to continue. A positive pattern in the Pacific Decadal Oscillation[6] 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). Overall, the marine heat wave in 2014-2016 had the most drastic impact on marine ecosystems in 2015, with lingering effects into 2016 and 2017. Conditions had somewhat returned to "normal" in 2018, but another marine heat wave in 2019 again set off a series of marine ecosystem changes across the North Pacific. One reason for lingering effects of ecosystem response is due to biological lags. These lags result from species impacts at larval or juvenile stages, which are typically most sensitive to extreme temperatures or changes in food supply. It is only once these species grow to adult size or recruit into fisheries that the impact of the heat wave is apparent. (NWFSC 2020). Any rebound in VSP parameters for Puget Sound steelhead are likely to be constrained under these conditions (NWFSC 2015; 2020).

The potential impacts of climate and oceanographic change on SRKWs 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

[5] Long Live the Kings 2015: http://marinesurvivalproject.com/the-project/why/
[6] A positive pattern in the Pacific Decadal Oscillation (PDO) has been in place since 2014.

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. 2017a). In addition to predation by marine mammals, Fresh (1997) reported that 33 fish species and 13 bird species are predators of juvenile and adult salmon, particularly during freshwater rearing and migration stages. Recent analysis ranked the vulnerability of West Coast salmon stocks to climate change and, of the top priority prey stocks for SRKWs (NOAA and WDFW 2018), California Central Valley Chinook stocks, Snake river fall and spring/summer Chinook, Puget Sound Chinook, and spring-run Chinook stocks in the interior Columbia and Willamette River basins were ranked as "high" or "very high" vulnerability to climate change (Crozier et al. 2019).

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 having viable populations that are both widespread, to avoid concurrent extinctions from mass catastrophes, and spatially close, to allow functioning as metapopulations (McElhany et al. 2000).

This ESU was listed as a threatened species in 1999. Its threatened status was reaffirmed June 28, 2005 (70 FR 37160). The NMFS' 2015 five-year status review of all ESA-listed salmon and steelhead species on the West Coast was completed on May 26, 2016 (81 FR 33469), and concluded that 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 Puget Sound Chinook salmon ESU and issued a technical memorandum providing updated information and analysis of the biological status of the listed species (NWFSC 2015). The 2016 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 ESA listing factors (NMFS 2017a). On October 4, 2019 NMFS published notice of NMFS' intent to initiate a new 5-year status review for 28 listed species of Pacific salmon and steelhead and requesting updated information from the public to inform the status review (84 FR 53117). On March 24, 2020, NMFS extended the public comment period, from the original March 27, 2020, through May 26, 2020 (85 FR 16619). The Northwest Fishery Science Center (NWFSC), and NMFS' WCR are currently preparing the final status review documents, with anticipated completion in late 2021. In this section, we utilize some of the information in the draft 2020 status review, in order to provide the most recent information for our evaluation in this Opinion. These references are noted as "in prep" but are not expected to change substantively prior to finalization of the 5-year status review in 2021.

Where possible, particularly as new material becomes available, the latest final (2016) status review information is supplemented with more recent information and other population specific data that may not have been available during the status review, so that NMFS is assured of using the best available information for this Opinion.

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[7];

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

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

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

Spatial Structure and Diversity

The PSTRT determined that 22 historical populations within the Puget Sound ESU 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[8] (Ruckelshaus et al. 2006). This Puget Sound 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.

The ESU also includes Chinook salmon from certain artificial propagation programs. Artificial propagation (hatchery) programs (26) were added to the listed Chinook salmon ESU in 2005, as part of the final listing determinations for 16 ESUs of West Coast Salmon and Final 4(d) Protective Regulations for Threatened Salmonid ESUs (70 FR 37160). In October of 2016, NMFS proposed revisions to the hatchery programs included as part of some Pacific salmon ESUs and steelhead DPSs listed under the ESA (81 FR 72759). NMFS issued its final rule in

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[7] The number of populations required to be at low-risk status 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.

[8] 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.

December of 2020 (85 FR 81822). This final rule includes 25 hatchery programs as part of the listed Puget Sound Chinook salmon ESU: Kendall Creek Hatchery Program; Marblemount Hatchery Program (spring-run); Marblemount Hatchery Program (summer-run); Brenner Creek Hatchery Program (fall-run); Harvey Creek Hatchery Program (summer-run); Whitehorse Springs Hatchery Program (summer-run); Wallace River Hatchery Program (yearlings and subyearlings); Issaquah Creek Hatchery Program; White River Hatchery Program; White River Acclimation Pond Program; Voights Creek Hatchery Program; Clarks Creek Hatchery Program; Clear Creek Hatchery Program; Kalama Creek Hatchery Program; George Adams Hatchery Program; Hamma Hamma Hatchery Program; Dungeness/Hurd Creek Hatchery Program; Elwha Channel Hatchery Program; Skookum Creek Hatchery Spring-run Program; Bernie Kai-Kai Gobin (Tulalip) Hatchery-Cascade Program; North Fork Skokomish River Spring-run Program; Soos Creek Hatchery Program (subyearlings and yearlings); Fish Restoration Facility Program; Bernie Kai-Kai Gobin (Tulalip) Hatchery-Skykomish Program; and Hupp Springs Hatchery-Adult Returns to Minter Creek Program

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

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

NOTE: NMFS has determined that the **bolded** populations, in particular, are essential to recovery of the Puget Sound Chinook 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 within the ESU . 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 populations 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 and recovery. 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; 2016f; 2017b; 2018c;

2019b; 2020d)

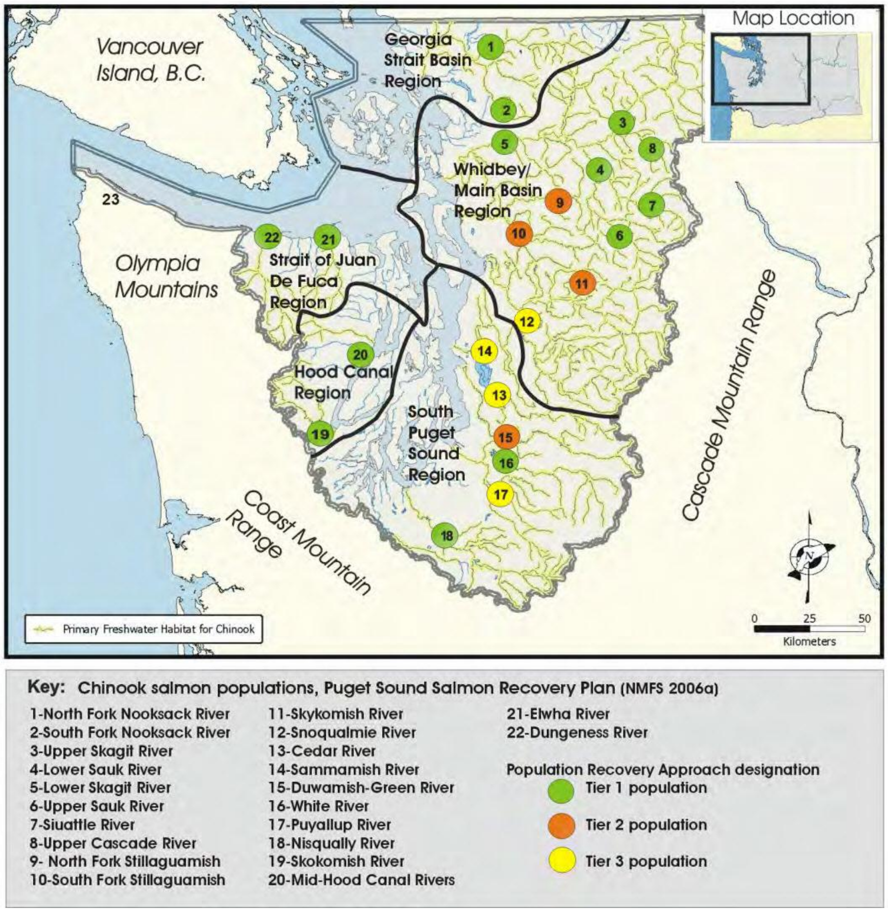

Figure 1. Puget Sound Chinook populations.

Measures of spatial structure and diversity can give some indication of the resilience of a population to sustain itself. Spatial structure can be measured in various ways, but here we assess the proportion of natural-origin spawners (wild fish) vs. hatchery-origin spawners on the spawning grounds (NWFSC 2020).

Over the long-term trend (since 1990), there is a general declining trend in the proportion of natural-origin spawners across the ESU (Table 3). While there are several populations that have maintained high levels of natural-origin spawner proportions, mostly in the Skagit and Snohomish basins, many others have continued the trend of high proportions of hatchery-origin spawners in the most recent available period (Table 3). It should be noted that the pre-2005-2009 estimates of mean natural-origin fractions occurred prior to the widespread adoption of mass marking of hatchery produced fish. Estimates of hatchery and natural-origin proportions of fish since the implementation of mass marking are considered more robust. Several of these populations have long-standing or more recent conservation hatchery programs associated with them—NF and SF Nooksack, NF and SF Stillaguamish, White River, Mid-Hood Canal, Dungeness, and the Elwha. These conservation programs are in place to maintain or increase the overall abundance of these populations, helping to conserve the diversity and increase the spatial distribution of these populations in the absence of properly functioning habitat. With the exception of the Mid-Hood Canal program, these conservation hatchery programs culture the extant, native Chinook stock in these basins. With the exception of the NF and SF Stillaguamish, the remainder of the populations included in these conservation programs are identified in NMFS (2006b) as essential for the recovery of the Puget Sound Chinook ESU (Table 3).

Table 3. Five-year mean of fraction of natural-origin spawners[9] (sum of all estimates divided by the number of estimates) (NWFSC 2020).

Population	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019
NF Nooksack R. spring	0.28	0.11	0.19	0.14	0.13
SF Nooksack R. spring	0.26	0.55	0.57	0.42	0.45
Low. Skagit R. fall	0.94	0.91	0.86	0.92	0.84
Up. Skagit R. summer	0.91	0.87	0.84	0.95	0.91
Cascade R. spring	0.98	0.92	0.89	0.94	0.86
Low. Sauk R. summer	0.94	0.97	0.95	0.91	0.98
Up. Sauk R. spring	0.99	1.00	0.98	0.97	0.99
Suiattle R. spring	0.99	0.97	0.99	0.99	0.97
NF Stillaguamish R. summer/fall	0.59	0.70	0.40	0.43	0.45
SF Stillaguamish R. summer/fall	0.59	0.70	0.40	0.54	0.46
Skykomish R. summer	0.49	0.52	0.76	0.69	0.62
Snoqualmie R. fall	0.81	0.89	0.81	0.78	0.75
Sammamish R. fall	0.29	0.36	0.16	0.07	0.16
Cedar R. fall	0.61	0.59	0.82	0.78	0.71
Green R. fall	0.55	0.47	0.43	0.39	0.30
White R. spring	0.54	0.79	0.43	0.32	0.15
Puyallup R. fall	0.88	0.79	0.52	0.41	0.32
Nisqually R. fall	0.80	0.61	0.30	0.30	0.47
Skokomish R. fall	0.40	0.46	0.45	0.10	0.16
Mid-Hood Canal fall	0.76	0.79	0.61	0.33	0.89
Dungeness R. summer	1.00	0.32	0.43	0.25	0.25
Elwha R. fall	0.41	0.53	0.35	0.06	0.05

In addition, spatial structure, or geographic distribution, of the White, Skagit, Elwha[10] and

[9] Estimates of hatchery and natural-origin spawning abundances, prior to the 2005-2009 period are based on pre-mass marking of hatchery-origin fish and, as such, may not be directly comparable to the 2005-2009 forward estimates.
[10] Removal of the two Elwha River dams and restoration of the natural habitat in the watershed began in 2011. Dam

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

Total abundance in the ESU over the entire time series shows that trends for individual populations are mixed. Generally, many populations experienced increases in total abundance during the years 2000-2008, and more recently in 2015-2017, but general declines during 2009-2014, and a downturn again in the two most recent years, 2017-2018 (Figure 2, below), The downturn in the most recent years was likely associated with the period of anomalously warm sea surface temperatures in the northeast Pacific Ocean that developed in 2013 and continued to persist through much of 2015; this phenomenon was termed "the Blob." During the persistence of the Blob, distribution of marine species was affected (e.g., tropical and subtropical species were documented far north of their usual ranges), marine mammals and seabirds starved, and a coastwide algal bloom that developed in the summer of 2015 resulted in demoic acid poisoning of animals at various trophic levels, from crustaceans to marine mammals. Chinook returning in 2017 and 2018 would have reached maturation in the ocean during these years, experiencing lower marine survival as a result of the hostile ocean conditions.

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removal was completed in 2014.

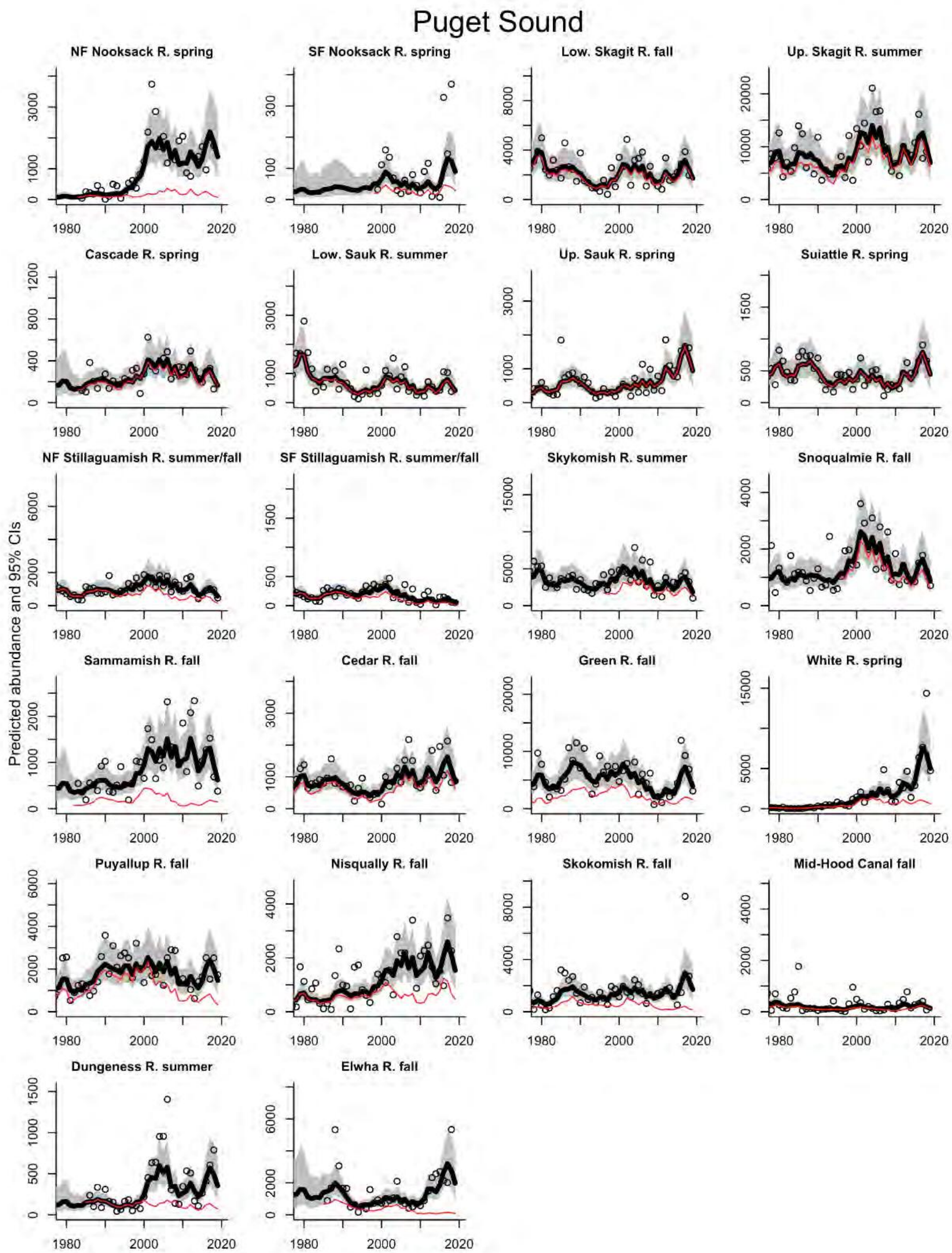

Figure 2. Smoothed trend in estimated total (thick black line) and natural-origin (thin red line) Puget Sound Chinook salmon ESU individual populations spawning abundance. Points show the annual raw spawning abundance estimates (NWFSC 2020).

Abundance across the Puget Sound ESU has generally increased since the last status review, with only 2 of the 22 populations (Cascade and North Fork Stillaguamish) showing a negative % change in the 5-year geometric mean natural-origin spawner abundances since the prior status review (Table 4). Several populations (North Fork and South Fork Nooksack, Sammamish, Green, White, Puyallup, Nisqually, Skokomish, Dungeness and Elwha) are dominated by hatchery returns. Fifteen of the remaining 20 populations with positive % change in the 5-year geometric mean natural-origin spawner abundances since the prior status review have relatively low natural spawning abundances of < 1000 fish, so some of these increases represent small changes in total abundance (NWFSC 2020). As with the table above (Table 3), showing the 5-year mean proportions of natural-origin spawners, it should be noted again that the pre-2005-2009 estimates of mean natural-origin fractions occurred prior to the widespread adoption of mass marking of hatchery produced fish, likely overestimating the proportion of natural-origin spawners. Estimates of hatchery and natural-origin proportions of fish since the implementation of mass marking are considered more robust.

Table 4. Five-year geometric mean of raw natural-origin spawner counts. This is the raw total spawner estimate times the fraction natural-origin estimate, if available. In parentheses, 5-year geometric mean of raw total spawner estimates (i.e., hatchery and natural) are shown. A value only in parentheses means that a total spawner estimate was available but no (or only one) estimate of natural-origin spawners was available. The geometric mean was computed as the product of estimates raised to the power 1 over the number of counts available (2 to 5). A minimum of 2 values were used to compute the geometric mean. Percent change between the most recent two 5-year periods is shown on the far right (NWFSC 2020).

Population	MPG	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	% Change
NF Nooksack R. spring	Strait of Georgia	51 (102)	95 (471)	229 (2186)	275 (1536)	136 (1205)	137 (1553)	1 (29)
SF Nooksack R. spring	Strait of Georgia			44 (87)	22 (41)	13 (35)	42 (106)	223 (203)
Low. Skagit R. fall	Whidbey Basin	1332 (1474)	971 (1035)	2531 (2774)	1916 (2228)	1416 (1541)	2130 (2640)	50 (71)
Up. Skagit R. summer	Whidbey Basin	3970 (5603)	5641 (6185)	10723 (12410)	8785 (10525)	7072 (7457)	9568 (10521)	35 (41)
Cascade R. spring	Whidbey Basin	151 (188)	209 (213)	340 (371)	302 (342)	298 (317)	185 (223)	-38 (-30)
Low. Sauk R. summer	Whidbey Basin	384 (409)	403 (429)	820 (846)	543 (569)	376 (416)	635 (649)	69 (56)
Up. Sauk R. spring	Whidbey Basin	404 (408)	265 (267)	427 (427)	506 (518)	854 (880)	1318 (1330)	54 (51)
Suiattle R. spring	Whidbey Basin	288 (302)	378 (382)	402 (415)	258 (261)	376 (378)	640 (657)	70 (74)
NF Stillaguamish R. summer/fall	Whidbey Basin	731 (913)	677 (1177)	1089 (1553)	493 (1262)	417 (996)	302 (762)	-28 (-23)

Population	MPG	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	% Change
SF Stillaguamish R. summer/fall	Whidbey Basin	148 (185)	176 (305)	196 (280)	51 (131)	34 (68)	37 (96)	9 (41)
Skykomish R. summer	Whidbey Basin	(2398)	1497 (3331)	2377 (4849)	2568 (3378)	1689 (2462)	1736 (2806)	3 (14)
Snoqualmie R. fall	Whidbey Basin	(963)	1427 (1279)	2036 (2477)	1308 (1621)	839 (1082)	856 (1146)	2 (6)
Sammamish R. fall	Central/ South PS	197 (576)	149 (564)	336 (1031)	171 (1278)	82 (1289)	126 (879)	54 (-32)
Cedar R. fall	Central/ South PS	385 (562)	276 (497)	379 (646)	1017 (1249)	699 (914)	889 (1253)	27 (37)
Green R. fall	Central/ South PS	2697 (5420)	3856 (7274)	2800 (6542)	1305 (3149)	785 (2109)	1822 (6373)	132 (202)
White R. spring	Central/ South PS	269 (378)	242 (616)	1159 (1461)	839 (2099)	652 (2161)	895 (6244)	37 (189)
Puyallup R. fall	Central/ South PS	2146 (2547)	2034 (2348)	1378 (1794)	1006 (2054)	450 (1134)	577 (1942)	28 (71)
Nisqually R. fall	Central/ South PS	610 (781)	577 (723)	689 (1296)	551 (1899)	481 (1823)	766 (1841)	59 (1)
Skokomish R. fall	Hood Canal	505 (993)	478 (1233)	479 (1556)	500 (1216)	136 (1485)	265 (2074)	95 (40)
Mid-Hood Canal fall	Hood Canal	94 (120)	78 (103)	169 (217)	47 (88)	80 (295)	196 (222)	145 (-25)
Dungeness R. summer	SJF	117 (117)	104 (104)	99 (520)	151 (374)	66 (279)	114 (476)	73 (71)
Elwha R. fall	SJF	428 (673)	275 (735)	491 (995)	140 (605)	71 (1349)	134 (2810)	89 (108)

Since 1999, most Puget Sound Chinook populations have mean natural-origin spawner escapement levels well below levels identified as required for recovery to low extinction risk (Table 5). Long-term, natural-origin mean escapements for eight populations are at or below their critical thresholds[11]. Both populations in three of the five biogeographical regions are below or near their critical threshold: Georgia Strait, Hood Canal and Strait of Juan de Fuca (Table 5). 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

[11] 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).

in these regions. Additionally, hatchery spawners help two of the remaining three of these populations achieve total spawner abundances above their critical threshold, reducing demographic risk. Nine populations are above their rebuilding thresholds[12], seven of them in the Whidbey/Main Basin Region. In 2018 NMFS and the NWFSC updated the rebuilding thresholds for several key Puget Sound populations. These thresholds represent the Maximum Sustained Yield estimate of spawners based on available habitat. The new spawner-recruit analyses for several populations indicated a significant reduction in the number of spawners that can be supported by the available habitat when compared to analyses conducted 10-15 years ago. This may be due to further habitat degradation or improved productivity assessment or, more likely, a combination of the two. For example, the updated rebuilding escapement threshold for the Green River is 1,700 spawners compared to the previous rebuilding escapement threshold of 5,523[13] 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.

[12] 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.

[13] The historic Green River escapement goal was established in 1977 as the average of estimated natural spawning escapements from 1965-1974. This goal does not reflect the lower productivity associated with the current condition of habitat. Reference the source for the historical objective from MUP (PSIT and WDFW 2017a)(Green River MUP).

Table 5. Long-term[13] 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**. Populations exceeding their rebuilding natural-origin escapement threshold are underlined.

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]	Natural-Origin (Productivity[2])	Critical[3]	Rebuilding[4]		
Georgia Basin	Nooksack MU	1,798	236	400	500		
	NF Nooksack	1, 532	**180** (0.3)	*200[6]*	-	3,800 (3.4)	86 (63-97)
	SF Nooksack	266	**56** (1.9)	*200[6]*	-	2,000 (3.6)	51 (19-82)
Whidbey/Main Basin	Skagit Summer/Fall MU						
	Upper Skagit River	9,349	8,314 (2.7)	738	5,740	5,380 (3.8)	11 (2-36)
	Lower Sauk River	560	531 (3.1)	*200[6]*	371	1,400 (3.0)	5 (0-33)
	Lower Skagit River	2,090	1,845 (2.8)	281	2,131	3,900 (3.0)	9 (0-23)
	Skagit Spring MU						
	Upper Sauk River	633	624 (2.2)	130	470	750 (3.0)	1 (0-5)
	Suiattle River	379	372 (2.0)	170	223	160 (2.8)	2 (0-7)
	Upper Cascade River	289	260 (1.5)	130	148	290 (3.0)	7 (0-25)
	Stillaguamish MU						
	NF Stillaguamish R.	1,029	472 (0.9)	300	550	4,000 (3.4)	51 (25-80)
	SF Stillaguamish R.	122	**58** (1.2)	*200[6]*	300	3,600 (3.3)	48 (9-79)
	Snohomish MU						
	Skykomish River	3,193	2,212 (1.5)	400	1,491	8,700 (3.4)	28 (0-62)
	Snoqualmie River	1,449	1,182 (1.3)	400	816	5,500 (3.6)	18 (0-35)
Central/South Sound	Cedar River	924	659 (2.7)	*200[6]*	*282[7]*	2,000 (3.1)	28 (10-50)
	Sammamish River	1,073	**161** (0.5)	*200[6]*	*1,250[6]*	1,000 (3.0)	80 (36-96)
	Duwamish-Green R.	4,014	1,525 (1.4)	400	1,700	-	59 (27-79)
	White River[9]	1,859	625 (0.8)	*200[6]*	488[7]	-	59 (14-90)
	Puyallup River[10]	1,646	784 (1.2)	*200[6]*	797[7]	5,300 (2.3)	54 (19-83)
	Nisqually River	1,670	621 (1.5)	*200[6]*	1,200[8]	3,400 (3.0)	56 (17-87)
Hood Canal	Skokomish River	1,398	**282** (0.8)	452	1,160	-	71 (7-96)
	Mid-Hood Canal Rivers[11]	**187**		*200[6]*	*1,250[6]*	1,300 (3.0)	36[11] (2-87)
Strait of Juan de Fuca	Dungeness River	411	**98**(1.0)	*200[6]*	925[8]	1,200 (3.0)	72 (39-96)
	Elwha River[12]	1,231	**171**(1.02)	*200[6]*	*1,250[6]*	6,900 (4.6)	74 (31-98)

[1] Includes naturally spawning hatchery fish (estimates represent 1999-2019 geo-mean for: NF and SF Stillaguamish, Skykomish, Snoqualmie, Cedar, Duwamish-Green, White, Puyallup, and Elwha).

[2] Source productivity is Abundance and Productivity Tables from NWFSC database; measured as the mean of observed recruits/observed spawners through brood year 2015, except: SF Nooksack through brood year 2013; and NF and SF Stillaguamish, Sammamish, Cedar, Duwamish-Green, Puyallup, White, Snoqualmie, Skykomish, through brood

year 2016. 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. Estimates represent hatchery fraction through 2019 for: NF and SF Stillaguamish, Skykomish, Snoqualmie, Cedar, Duwamish-Green, White, Puyallup, and Elwha)

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

[7]Based on spawner-recruit assessment (PSIT and WDFW 2017a).

[8] Based on alternative habitat assessment.

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

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

[11] The 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; total abundance estimates primarily based on returns to the Hamma Hamma River.

[12] 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 collection

[13] Differences in results reported in Tables 5 and 6 from those in the most recent status review (Tables 3 and 4, above) are related to the data source, method, and time period analyzed (e.g., 5-year vs 20-year estimates).

Trends in long-term 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 6). Since 1990, 13 populations show long-term growth rates that are at or above replacement for natural-origin escapement including populations in four of five regions. Currently, only five populations, in two regions, show long-term neutral to positive growth rates in natural-origin recruitment (Table 6). Additionally, most populations are consistently well below the productivity goals identified in the recovery plan (Table 5). Although long-term trends (1990 forward) vary for individual populations across the ESU, currently 20 populations exhibit a stable or increasing long-term trend in total natural escapement (Table 6). Thirteen of 22 populations show a growth rate in the 18-year geometric mean natural-origin spawner escapement that is greater than or equal to 1.00 (Table 6).

Table 6. Long-term trends[14] 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] (1990-2018)	
		NMFS		Recruitment (Recruits)	Escapement (Spawners)
Georgia Basin	NF Nooksack (early)	1.10	increasing	0.99	1.00
	SF Nooksack (early)	1.06	stable	0.96	0.96
Whidbey/Main Basin	Upper Skagit River (moderately early)	1.02	stable	1.01	1.00
	Lower Sauk River (moderately early)	1.01	stable	0.99	1.00
	Lower Skagit River (late)	1.02	stable	1.00	1.00
	Upper Sauk River (early)	1.05	increasing	0.97	1.02
	Suiattle River (very early)	1.02	stable	0.96	1.00
	Upper Cascade River (moderately early)	1.01	stable	0.96	1.00
	NF Stillaguamish R. (early)	0.99	stable	0.92	0.98
	SF Stillaguamish R (moderately early)	0.95	**declining**	0.90	0.96
	Skykomish River (late)	1.00	stable	0.99	0.99
	Snoqualmie River (late)	1.00	stable	1.00	1.00
Central/South Sound	Cedar River (late)	1.04	increasing	0.99	1.00
	Sammamish River[3] (late)	1.03	increasing	1.01	0.99
	Duwamish-Green R. (late)	0.98	stable	0.98	1.00
	White River[4] (early)	1.10	increasing	1.07	1.07
	Puyallup River (late)	0.98	**declining**	0.96	0.98
	Nisqually River (late)	1.05	increasing	0.97	1.00
Hood Canal	Skokomish River (late)	1.02	stable	0.93	0.97
	Mid-Hood Canal Rivers (late)	1.05	increasing	0.98	1.04
Strait of Juan de Fuca	Dungeness River (early)	1.05	increasing	0.96	0.98
	Elwha River (late)	1.05	increasing	0.89	0.92

[1] Total natural 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. Trends for NF and SF Stillaguamish, Skykomish, Snoqualmie, Cedar, Sammamish, Duwamish-Green, White, Puyallup, and Elwha are from 1999-2019.

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

[4] 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.

[14] Differences in results reported in Tables 5 and 6 from those in the most recent status review (Tables 3 and 4, above) are related to the data source, method, and time period analyzed (e.g., 5-year vs 20-year estimates).

Even given some of the incremental increases in natural-origin spawner abundances in the most recent five-year period (Table 4), the long-term trends in both abundance and productivity, in most Puget Sound populations, are well below the levels necessary for recovery (Table 6).

Limiting factors and other areas of concern

Limiting factors described in SSPS (2005) and reiterated in NMFS (2017a) relate to present or threatened set of conditions within certain habitat parameters that inhibit the viability of salmon as defined by the VSP criteria, including:

- 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.

Additional factors affecting Puget Sound Chinook viability:

- 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%), (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 a threatened species under the ESA on May 11, 2007 (72 FR 26722). Subsequent status assessments of the DPS after the ESA-listing decision have found that the status of Puget Sound steelhead regarding risk of extinction has not changed substantially (Ford et al. 2011a; NMFS 2016b)(81 FR 33468, May 26, 2016) (NWFSC 2020). As mentioned above, on October 4, 2019 NMFS published a Federal Register notice (84 FR 53117), announcing NMFS' intent to initiate a new 5-year status review for 28 listed species of Pacific salmon and steelhead and requesting updated information from the public to inform the most recent five-year status review. On March 24, 2020, NMFS extended the public comment period, from the original March 27, 2020, through May 26, 2020 (85 FR 16619). The NWFSC and the NMFS' WCR are currently preparing the final five-year status review documents, with anticipated completion in late 2021.

At the time of listing the PSSBRT 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 2011 the BRT identified degradation and fragmentation of freshwater habitat, with consequential effects on connectivity, as the primary limiting factors and threats facing the Puget Sound steelhead DPS (Ford et al. 2011a). The BRT also determined that most of the steelhead populations within the DPS continued to show downward trends in estimated abundance, with a few sharp declines (Ford et al. 2011a). The 2015 status review concurred that harvest and hatchery production of steelhead in Puget Sound were at low levels and not likely to increase substantially in the foreseeable future, thus these risks have been reduced since the time of listing. However, unfavorable environmental trends previously identified (Ford et al. 2011a) were expected to continue (Hard et al. 2015).

In this opinion, where possible, the 2015 status review information is supplemented with information and other population specific data available considered during the drafting of the 2020 five year status review for Puget Sound steelhead.

As part of the recovery planning process, NMFS convened The Puget Sound Steelhead Technical Recovery Team (PSSTRT) in 2011 to identify historic populations and develop viability criteria for the recovery plan. The PSSTRT delineated populations and completed a set of population viability analyses (PVAs) for these Demographically Independent Populations (DIPs) and Major Population Groups (MPGs) within the DPS that are summarized in the final draft viability criteria reports (Puget Sound Steelhead Technical Recovery Team 2011; PSSTRT 2013; NWFSC 2015). This framework and associated analysis provided a technical foundation for the recovery criteria and recovery actions identified in the subsequent Puget Sound Steelhead Recovery Plan (NMFS 2019h) at the watershed scale, and higher across the Puget Sound

Steelhead DPS.

The populations within the Puget Sound steelhead DPS are aggregated into three extant MPGs containing a total of 32 DIPs based on genetic, environmental, and life history characteristics (Puget Sound Steelhead Technical Recovery Team 2011). Populations include summer steelhead only, winter steelhead only, or a combination of summer and winter run timing (e.g., winter run, summer run or summer/winter run). Figure 3 illustrates the DPS, MPGs, and DIPs for Puget Sound steelhead.

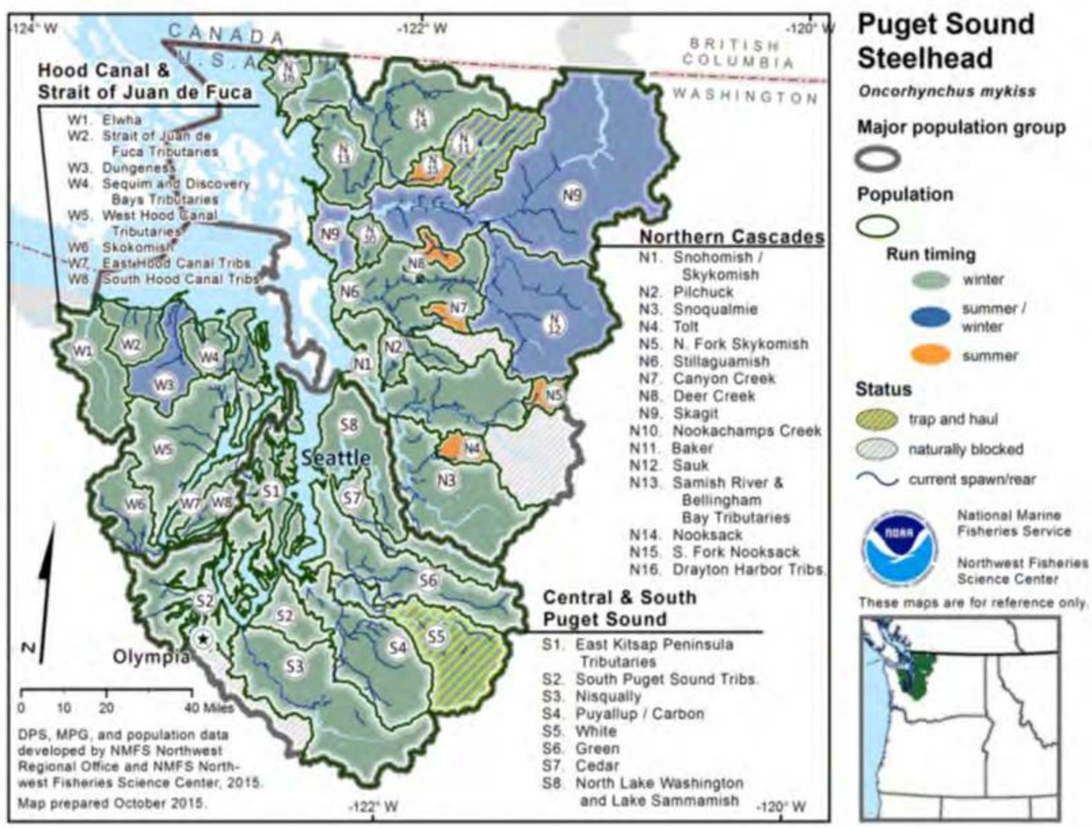

Figure 3. The Puget Sound Steelhead DPS showing MPGs and DIPs. The steelhead MPGs include the Northern Cascades, Central & Sound Puget Sound, and the Hood Canal & Strait of Juan de Fuca.

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 is using 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. Consultations, including this one, will incorporate information from the Plan (NMFS 2019h).

In the Plan, NMFS and the Puget Sound Steelhead Technical Recovery Team 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 3) must be viable (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. 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). In October of 2016, NMFS proposed revisions to the hatchery programs included as part of Pacific salmon ESUs and steelhead DPSs listed under the ESA (81 FR 72759). NMFS issued its final rule in December of 2020 (85 FR 81822). This final rule includes steelhead from five artificial propagation programs in the Puget Sound steelhead DPS: the Green River Natural Program; White River Winter Steelhead Supplementation Program; Hood Canal Steelhead Supplementation Program; the Lower Elwha Fish Hatchery Wild Steelhead Recovery Program; and the Fish Restoration Facility Program. (85 FR 81822, December 17, 2020).

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.[15] 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 (Puget Sound Steelhead Technical Recovery Team 2011). 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). The Puget Sound Steelhead Technical Recovery Team (PSSTRT) concluded that the Puget Sound DPS was at very low viability, considering the status of all three of its constituent MPGs, and many of its 32 DIPs (Hard et al. 2015). For spatial structure there were a number of events that occurred in Puget Sound during the last review period (2015-2019) that are anticipated to improve status populations within several of the MPGs within the DPS. These will be discussed further in the Environmental Baseline section 2.4.1.

Since the PSSTRT completed its 2013 review, the only additional spatial structure and diversity data that have become available have been estimates of the fraction of hatchery fish on the spawning grounds (NWFSC 2015). Since publication of the NWFSC report in 2015, and drafting of the 2020 NWFSC biological status review (NWFSC 2020), reductions in hatchery programs founded from non-listed and out of DPS stocks (i.e., Skamania) have occurred and, the magnitude of these changes will be discussed in detail in section 2.4.1. In addition, the fraction of out of DPS hatchery steelhead spawning naturally are low for many rivers (NWFSC 2015; NMFS 2016i; 2016h). The fraction of natural-origin steelhead spawners was 0.9 or greater for the 2005-2009 and 2010-2014 time periods for all populations where data was available, but the Snoqualmie and Stillaguamish Rivers. For 17 of 22 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). However, the fraction of natural-origin steelhead spawners could not be estimated for a substantial number of DIPs during the 2010 to 2014 period, or for the most recent 2015 – 2019 timeframe (NWFSC 2015; 2020). In some river systems, such as the Green River, Snohomish/Skykomish Rivers, and the Stillaguamish Rivers these estimates were higher than

[15] 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).

some guidelines recommend (e.g., no more than 5% hatchery-origin spawners on spawning grounds for isolated hatchery programs (HSRG 2009) over the 2005- 2009 and 2010 – 2014 timeframes. The draft 2020 NWFSC biological status review (NWFSC 2020) states that a third of the 32 Puget Sound steelhead populations continue to lack monitoring and abundance data, and in most cases it is likely that abundances are very low. Steelhead hatchery programs are discussed in further detail in the Environmental Baseline section (2.4.1).

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.[16] Summer-run fish produced in isolated hatchery programs were historically 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). However, the draft 2020 NWFSC biological status review (NWFSC 2020) states that risks to natural-origin Puget Sound steelhead that may be attributable to hatchery-related effects has decreased since the 2015 status review due to reductions in production of non-listed stocks, and the replacement with localized stocks. The three summer steelhead programs continuing to propagate Skamania derived stocks from outside of Puget Sound should be phased out completely by 2031 (NMFS 2019c; NWFSC 2020). Lastly, annual reporting from the operators and current science suggest that risks remain at the same low to negligible levels as evaluated in 2016 and 2019 (NMFS 2016b; 2019c; 2019g; 2019h).

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; 2020).

Abundance and Productivity

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,[17] 5 of the 8 winter-run DIPs in the Central and South Puget Sound MPG,[18] and 7 of the 8 winter-run DIPs in the Hood Canal and Strait of Juan de Fuca MPG.[19] Little or no data is available on summer run populations to evaluate extinction risk or abundance trends. Due to their small population size and the complexity of monitoring fish in headwater holding areas, summer steelhead have not been broadly monitored. Data continue to only be available for one summer-run DIP, the Tolt River steelhead population

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

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

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

[19] 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.

in the Northern Cascades MPG for the 2015 – 2019 time frame. Total abundance of steelhead in populations for which data are available (Figure 4) has shown a generally declining trend over much of the DPS over the full period of the abundance data available for each DIP.

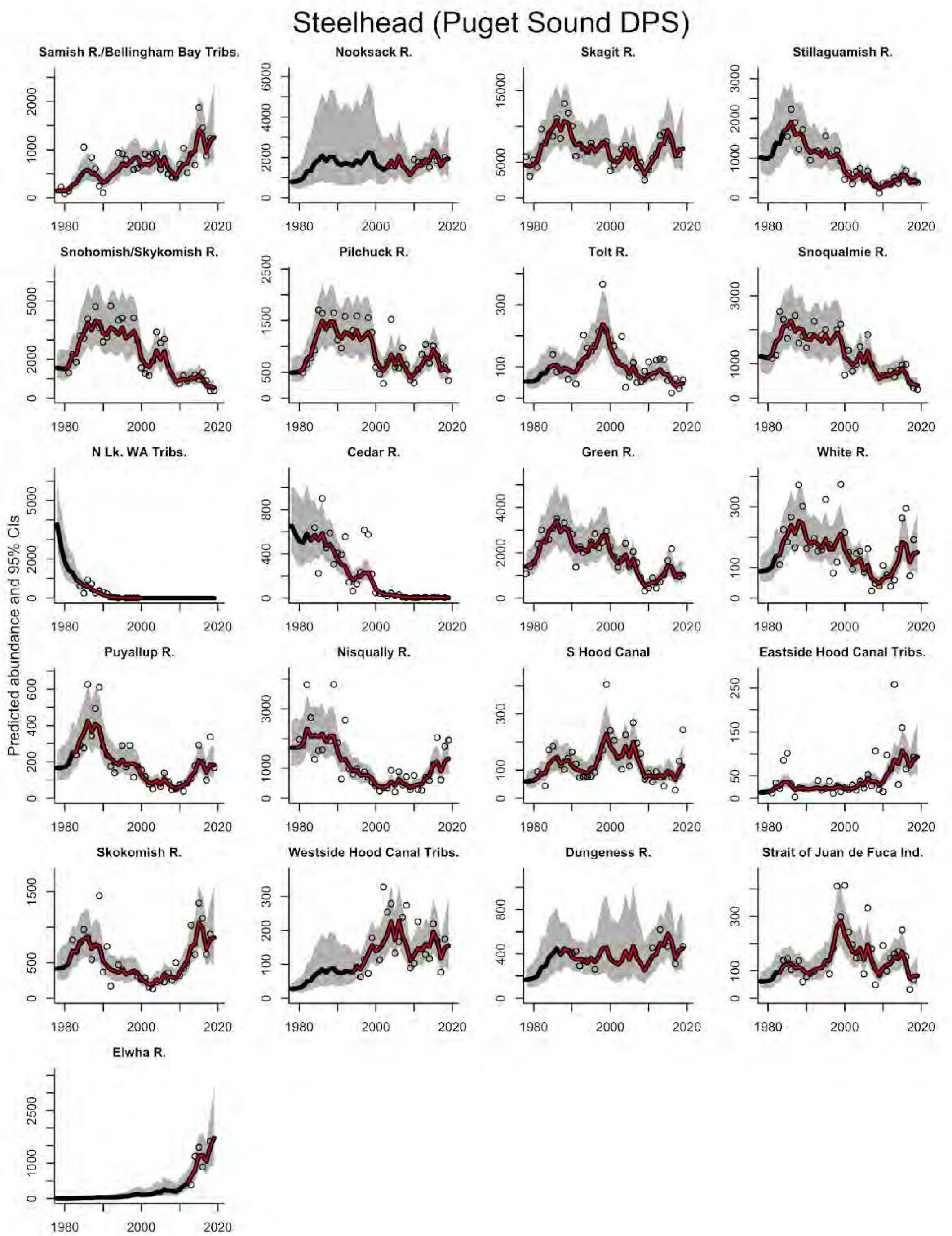

Figure 4. Smoothed trends in estimated total (thick black line) and natural (thin red line) Puget Sound

steelhead population spawning abundances. Points show the annual raw spawning abundance estimates. Greyed areas depict the 95% confidence intervals around the estimates. WR, winter run; SuR, summer run (NWFSC 2020).

However, since 2015, fifteen of the 21 populations indicate small to substantive increases in abundance.[20] However, most steelhead populations remain small. From 2014 to 2019, nine of the 21 steelhead populations had fewer than 250 natural spawners annually, and 12 of the 21 steelhead populations had 500 or fewer natural spawners (Table 7).

Table 7. Five-year geometric mean of raw natural spawner counts for Puget Sound steelhead. This is the raw total spawner count times the fraction natural estimate, if available. In parentheses, the 5-year geometric mean of raw total spawner counts is shown. A value only in parentheses means that a total spawner count was available but none or only one estimate of natural spawners was available. The geometric mean was computed as the product of counts raised to the power 1 over the number of counts available (2 to 5). A minimum of 2 values was used to compute the geometric mean. Percent change between the most recent two 5-year periods is shown on the far right. MPG, major population group; NC, Northern Cascades, SCC South and Central Cascades, HCSJF, Hood Canal and Strait of Juan de Fuca, W, winter run; S, summer run (NWFSC 2020).

Population	MPG	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	% Change
Samish R./Bellingham Bay Tribs. W	NC	316 (316)	717 (717)	852 (852)	535 (535)	748 (748)	1305 (1305)	74 (74)
Nooksack R. W	NC	-	-	-	-	1745 (1745)	1906 (1906)	9 (9)
Skagit R. S and W	NC	7202 (7202)	7656 (7656)	5419 (5419)	4677 (4677)	6391 (6391)	7181 (7181)	12 (12)
Stillaguamish R. W	NC	1078 (1078)	1166 (1166)	550 (550)	327 (327)	386 (386)	487 (487)	26 (26)
Snohomish/Skykomish R. W	NC	3629 (3629)	3687 (3687)	1718 (1718)	2942 (2942)	975 (975)	690 (690)	-29 (-29)
Pilchuck R. W	NC	1225 (1225)	1465 (1465)	604 (604)	597 (597)	626 (626)	638 (638)	2 (2)
Snoqualmie R. W	NC	1831 (1831)	2056 (2056)	1020 (1020)	1250 (1250)	706 (706)	500 (500)	-29 (-29)
Tolt R. S	NC	112 (112)	212 (212)	119 (119)	70 (70)	108 (108)	40 (40)	-63 (-63)
N. Lake WA Tribs. W	SCC	60 (60)	4 (4)	-	-	-	-	-

[20] Nooksack River, Samish River/Bellingham Bays Tributaries, Skagit River, Stillaguamish River, Pilchuck River, Cedar River, Green River, Puyallup River, Nisqually River, White River, S. Hood Canal, Eastside Hood Canal Tributaries, Westside Hood Canal Tributaries, , Skokomish River and Elwha River winter-run populations. The Skagit River and Elwha River summer-run steelhead are also showing increasing trends (NWFSC 2020).

Population	MPG	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	% Change
Cedar R. W	SCC	241 (241)	295 (295)	37 (37)	12 (12)	4 (4)	6 (6)	50 (50)
Green R. W	SCC	2062 (2062)	2585 (2585)	1885 (1885)	1045 (1045)	662 (662)	1282 (1282)	94 (94)
White R. W	SCC	169 (169)	183 (183)	147 (147)	57 (57)	79 (79)	182 (182)	130 (130)
Puyallup R. W	SCC	199 (199)	196 (196)	93 (93)	72 (72)	85 (85)	201 (201)	136 (136)
Nisqually R. W	SCC	1200 (1200)	754 (754)	409 (409)	446 (446)	477 (477)	1368 (1368)	187 (187)
S. Hood Canal W	HCSJF	97 (97)	148 (148)	176 (176)	145 (145)	69 (69)	91 (91)	32 (32)
Eastside Hood Canal Tribs W	HCSJF	27 (27)	21 (21)	25 (25)	37 (37)	60 (60)	93 (93)	55 (55)
Skokomish R. W	HCSJF	385 (385)	359 (359)	205 (205)	320 (320)	533 (533)	958 (958)	80 (80)
Westside Hood Canal Tribs W	HCSJF		97 (97)	208 (208)	167 (167)	138 (138)	150 (150)	9 (9)
Dungeness R. S and W	HCSJF	356 (356)				517 (517)	408 (408)	-21 (-21)
Strait of Juan de Fuca Independents W	HCSJF	89 (89)	191 (191)	212 (212)	118 (118)	151 (151)	95 (95)	-37 (-37)
Elwha R. W	HCSJF					680 (680)	1241 (1241)	82 (82)

The current abundance for Puget Sound steelhead populations, as estimated for the 2015 – 2019 time period (NMFS 2019g; NWFSC 2020; WDFW 2021) is based on data for less than 40 percent of the DIPs (WDFW 2021). However, these data indicate that the Puget Sound steelhead DPS is currently at less than 25% of recovery goals, as identified for the DIPs which had sufficient data to assess (WDFW 2021). Where recent five-year abundance information is available, within the 2020 status update (NWFSC 2020), 30% (6/20) of the populations are at less than 10% of their High Productivity Recovery Targets (lower abundance target), 65% (13/20) of the populations are between 10%<x 50% of lower abundance recovery targets, and 5% (1/20) one population is at 50%<x<100% of the recovery target, the Samish and Independent Tributaries, as shown in yellow (Table 8).

Table 8. Recent (2015-2019) 5-year geometric mean of raw wild spawner counts for Puget Sound steelhead populations and population groups compared with Puget Sound Steelhead Recovery Plan high and low productivity recovery targets (NMFS 2019h). (SR) – Summer run. An "*" indicates that the abundance is only a partial population estimate. Abundance is compared to the high productivity individual DIP targets. Colors indicate the relative proportion of the recovery target currently obtained: red (<10%), orange (10%>x<50%), yellow (50%>x<100%), green (>100%).

Major Population Group	Demographically Independent Population	Recent Abundance 2015-2019	Recovery Target High Productivity	Low Productivity
Northern Cascades	Drayton Harbor Tributaries	NA	1,100	3,700
	Nooksack River	1,906	6,500	21,700
	South Fork Nooksack River (SR)	NA	400	1,300
	Samish River & Independent Tributaries	1,305*	1,800	6,100
	Skagit River	7,181*	15,000	
	Sauk River	[1]		
	Nookachamps River	[1]		
	Baker River	NA		
	Stillaguamish River	487*	7,000	23,400
	Canyon Creek (SR)	NA	100	400
	Deer Creek (SR)	NA	700	2,300
	Snohomish/Skykomish River	690	6,100	20,600
	Pilchuck River	638	2,500	8,200

Major Population Group	Demographically Independent Population	Recent Abundance 2015-2019	Recovery Target High Productivity	 Low Productivity
	Snoqualmie River	500	3,400	11,400
	Tolt River (SR)	40*	300	1,200
	North Fork Skykomish River (SR)	NA	200	500
Central and South Sound	Cedar River	<10*	1,200	4,000
	North Lake Washington Tributaries	NA	4,800	16,000
	Green River	1,282	5,600	18,700
	Puyallup Carbon River	136* 735*	4,500	15,100
	White River	451	3,600	12,000
	Nisqually River	1,368	6,100	20,500
	East Kitsap Tributaries	NA	2,600	8,700
	South Sound Tributaries	NA	6,300	21,200
Strait of Juan de Fuca	East Hood Canal Tributaries	93*	1,800	6,200
	South Hood Canal Tributaries	91	2,100	7,100
	Skokomish River	958	2,200	7,300

Major Population Group	Demographically Independent Population	Recent Abundance 2015-2019	Recovery Target High Productivity	Low Productivity
	West Hood Canal Tributaries	150*	2,500	8,400
	Sequim and Discovery Bay Tributaries	NA	500	1,700
	Dungeness River	408	1,200	4,100
	Strait of Juan de Fuca Independent Tributaries	95*	1,000	3,300
	Elwha River	1,241	2,619	

Data Source: (NWFSC 2020)

Steelhead productivity has been variable for most populations since the mid-1980s (Figure 5). Since around 2000, productivity has fluctuated around replacement for Puget Sound steelhead populations, but the majority have predominantly been below replacement (NWFSC 2015; 2020). Some steelhead populations have shown signs of productivity that has been above replacement in the most recent years for which data are available (2015 -2019) (Figure 5). Steelhead populations with productivity estimates above replacement include the Samish River, Nooksack River, and Skagit River winter-run in the Northern Cascades MPG, the Nisqually River, White River, Puyallup River, Green River and Cedar River winter-run in the Central and South Puget Sound MPG, and the Elwha River, East, West, and South Hood Canal Tributaries and Skokomish River winter-run steelhead populations in the Hood Canal and Strait of Juan de Fuca MPG.

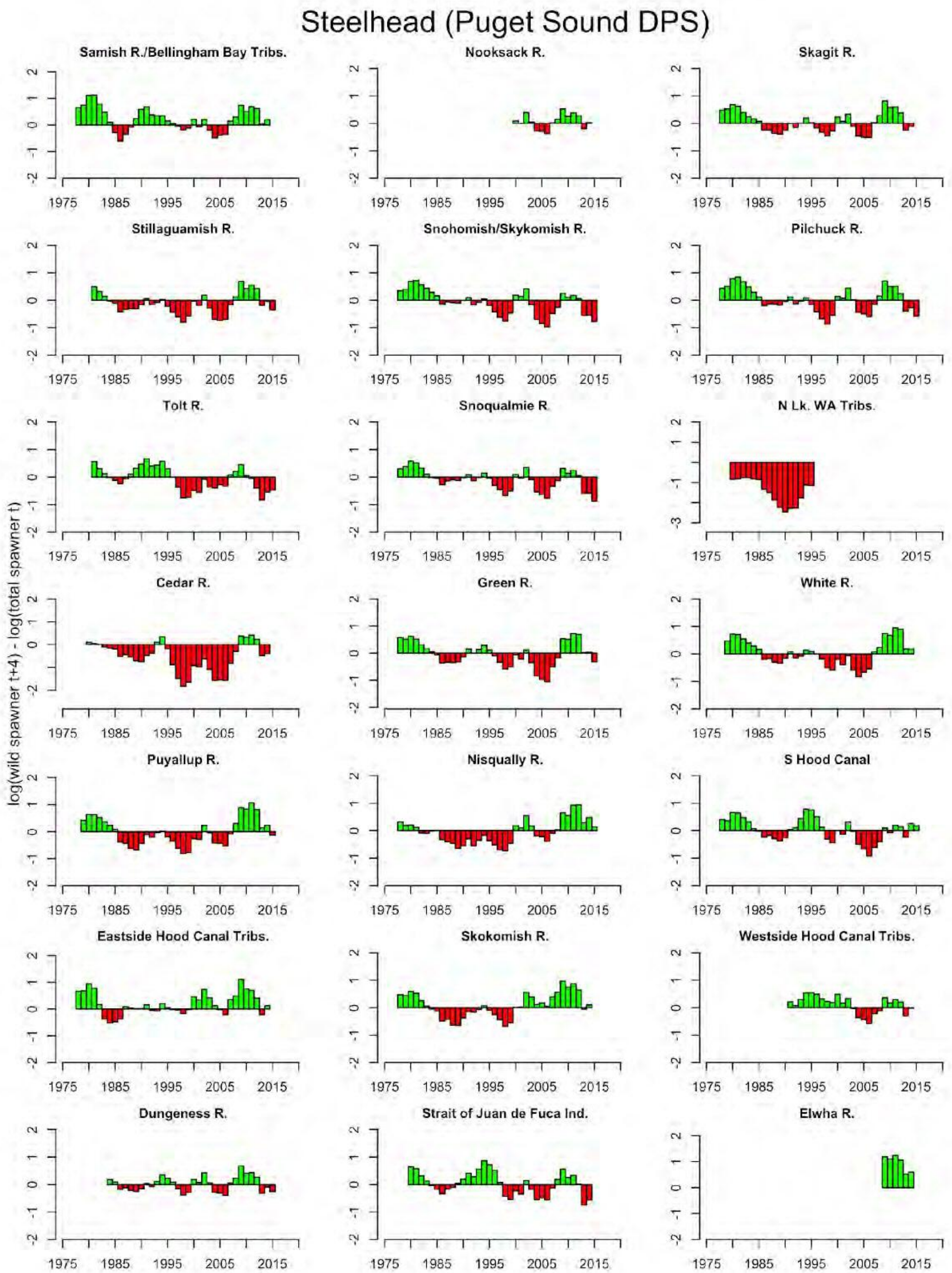

Figure 5. Trends in population productivity of Puget Sound steelhead, estimated as the log of the smoothed natural spawning abundance in year t minus the smoothed natural spawning abundance in year (t – 4) ((NWFSC 2020).

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[21] at over 60%. Harvest rates on natural-origin steelhead vary widely among watersheds, but have declined since the 1970s and 1980s, and are now stable at generally less than 5% (Figure 6)(NWFSC 2015; WDFW and PSTIT 2016a; 2017a; 2018; 2019; 2020).

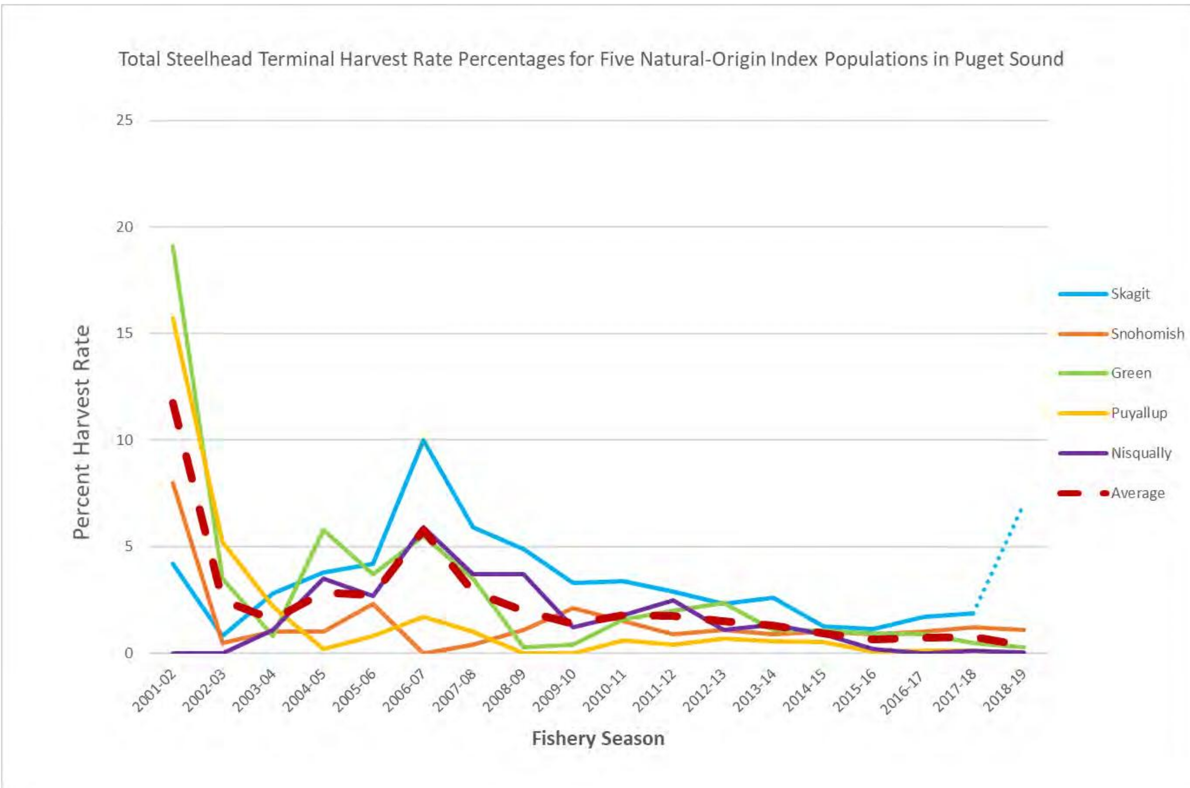

Figure 6. Total Steelhead Terminal Harvest Rate Percentages for Five Natural-Origin Index Populations in Puget Sound from 2001 – 2019 (NWFSC 2015; WDFW and PSTIT 2016a; 2017a; 2018; 2019; 2020). The dotted line represents harvest rates specific to natural-origin steelhead within the Skagit basin, as reported annually under the Skagit Steelhead Resource Management Plan (RMP) approved by NMFS in 2018 (NMFS 2018b).

Overall, the status of steelhead based on the best available data on spatial structure, diversity, abundance, and productivity has improved since the last status review in 2015 (NWFSC 2020). Recent increases in abundance observed for the majority of (15/21) steelhead DIPs where data are available from 2015 -2019 have been modest and generally within the range of variability observed in the time series for which data is available (NWFSC 2015). The production of

[21] Green River and Nisqually River populations.

hatchery fish founded from non-listed stocks of both run types (Chambers (EWS) winter and Skamania (ESS) summer) continues to pose risk to diversity to natural-origin steelhead in the DPS (Hard et al. 2007; Hard et al. 2015; NMFS 2019h; NWFSC 2020). However, hatchery production has declined in recent years across the DPS, especially for non-listed stocks, and the fraction of hatchery spawners are low for many rivers. Increasing estimates of productivity for a few steelhead populations from the 2011 - 2015 time frame are encouraging but included only one to a few years, thus, the patterns of improvement in productivity were not widespread, or considered certain to continue into the 2015 -2019 time frame (Hard et al. 2015). Total harvest rates continue to be at the low levels considered in the last two status updates (2015, 2020 in-prep), and the Recovery Plan (NMFS 2019h) to be unlikely to substantially reduce spawner abundance for most Puget Sound steelhead populations. These rates are unlikely to increase substantially in the foreseeable future. Recovery efforts in conjunction with improved ocean and climatic conditions have resulted in improved status for the majority of populations in this DPS; however, absolute abundances are still low, especially summer-run populations, and the DPS remains at high to moderate risk (NWFSC 2020).

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. Limiting factors are defined as impaired physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) and associated ecological processes and interactions experienced by the fish that result in reductions in VSP parameters (abundance, productivity, spatial structure, and diversity).This analysis, combined with NWFSC 2020 (In Prep) and the Puget Sound Steelhead Recovery Plan (NMFS 2019g), identified the following factors, as well as ten primary pressures associated with the listing decision for Puget Sound steelhead, and subsequent affirmations of the listing, as those limiting steelhead recovery:

- 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. This includes agriculture, residential, commercial and industrial development (including impervious surface runoff), timber management activities, water withdrawals and altered flows.
- Fish passage barriers at road crossings and dams.
- Reduced spatial structure for steelhead in the DPS.
- Reduced habitat quality through changes in river hydrology and temperature profile, which are expected to increase with continuing climate change.
- Reduced 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 low harvest rates,
- Threats to genetic diversity and of ecological interactions posed by use of two hatchery steelhead stocks (Chambers Creek and Skamania) inconsistent with wild stock recovery throughout the DPS. However, the risk to the species' persistence that may be attributable to hatchery-related effects has declined 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 reduce hatchery-related risks. Further, hatchery releases of steelhead founded from non-native or out of DPS stocks have declined, and are expected to decrease further or cease as a term of recent 4(d) authorizations.
- Declining diversity in the DPS, including the uncertain, but likely weak, status of summer run fish in the DPS.
- High rates of juvenile mortality in estuarine and marine waters of Puget Sound, attributed to marine mammal predation, parasite prevalence, and contaminant loads.
- 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 part of a larger inland waterway, the Georgia Basin, situated between southern Vancouver Island, British Columbia, Canada, and the mainland coast of Washington State. For the purposes of evaluating listed rockfish, NMFS subdivide 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, NMFS 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. NMFS 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).

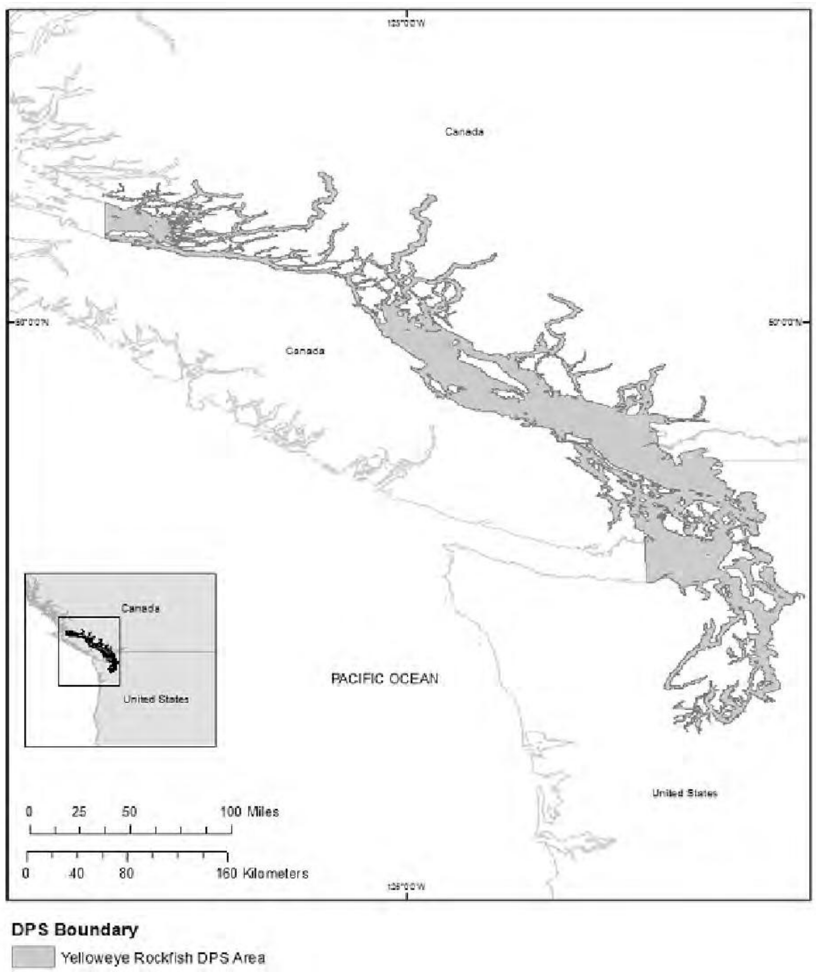

Figure 7. Yelloweye rockfish DPS area.

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[22].

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 here.

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 1980s (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

[22] 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). Direct harvest is no longer allowed under current Washington State (non-tribal) fishery regulations, though bycatch from some fisheries does occur.

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 at least some rockfish species, such as black rockfish , has been shown to enhance 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 estimate the total yelloweye population as 143,086 fish within the U.S. portion of the DPS. There is no single, reliable historical or contemporary abundance estimate for the yelloweye rockfish or bocaccio DPSs in the Puget Sound/Georgia Basin (Drake et al. 2010).

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

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 bocaccio is relatively imprecise, both abundance and productivity have been reduced largely by fishery removals within the range of the 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[23]. 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

[23] WDFW 2011: Unpublished catch data 3003-2009.

yelloweye rockfish because of their sedentary nature as adults.

Diversity

Characteristics of diversity for rockfish include fecundity, timing of the release of larvae and their condition, morphology, age at reproductive maturity, physiology, and molecular genetic characteristics. In spatially and temporally varying environments, there are three general reasons why diversity is important for species and population viability: (1) diversity allows a species to use a wider array of environments, (2) 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 2016c) 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).

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

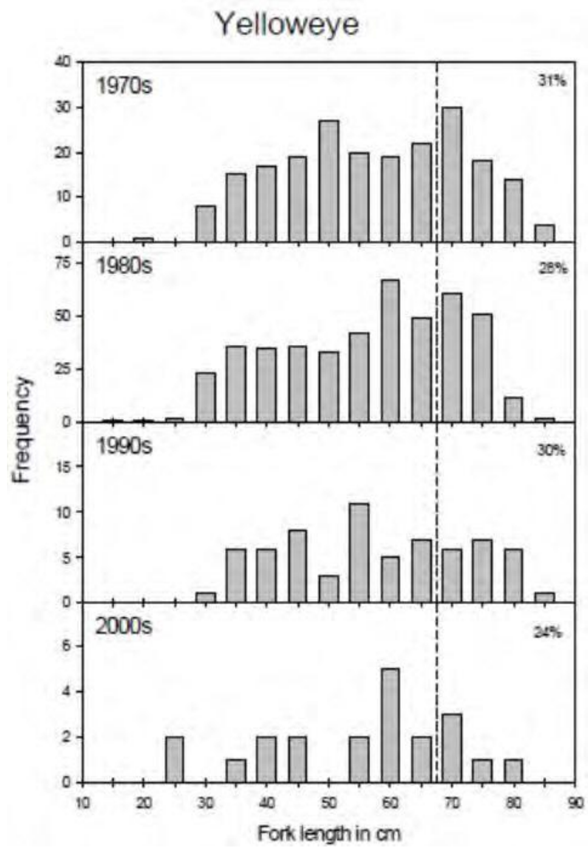

Figure 9. Yelloweye rockfish length frequency distributions (cm) binned within four decades.

<u>Bocaccio Diversity</u>

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).

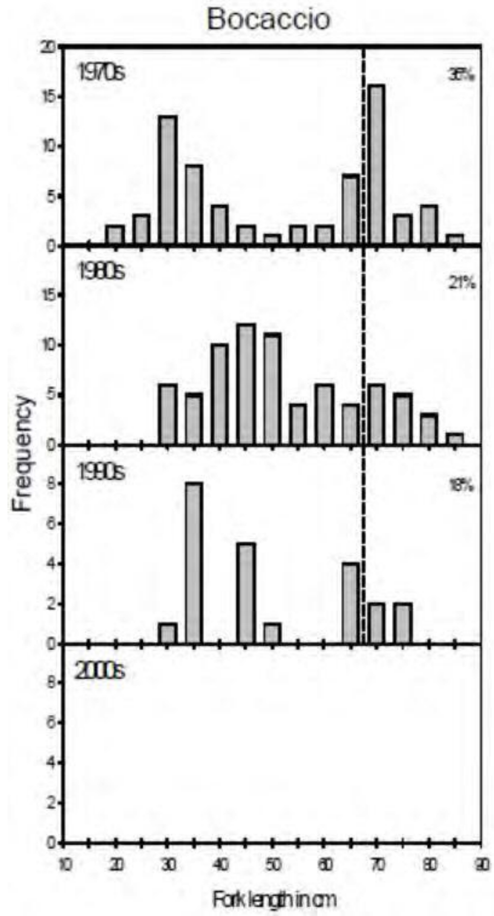

Figure 10. Bocaccio length frequency distributions (cm) within four decades. The vertical line depicts the size at which about 30 percent of the population comprised fish larger than the rest of the population in the 1970s, as a reference point for a later decade.

In summary, diversity for bocaccio has likely been adversely impacted by fishery removals. In turn, the ability of 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 influenced, and will continue to influence the habitat, include increased ocean temperature, increased stratification of the water column, and intensity and timing changes of coastal upwelling. These continuing changes will alter primary and secondary productivity, marine community structures, and in turn may alter listed rockfish growth, productivity, survival, and habitat usage. Increased concentration of carbon dioxide (CO_2) (termed Ocean Acidification, or OA) reduces carbonate availability for shell-forming invertebrates. Ocean acidification will adversely affect calcification, or the precipitation of dissolved ions into solid calcium carbonate structures, for a number or marine organisms, which could alter trophic functions and the availability of prey (Feely et al. 2010). Further research is needed to understand the possible implications of OA on trophic functions in Puget Sound to understand how they may affect rockfish. Thus far, studies conducted in other areas have shown that the effects of OA will be variable (Ries et al. 2009) and species-specific (Miller et al. 2009).

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

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

<u>Commercial and Recreational Bycatch</u>

Listed rockfish are caught in some recreational and commercial fisheries in Puget Sound. Recreational fishermen targeting bottom fish in the shrimp trawl fishery in Puget Sound can incidentally catch listed rockfish. In 2012, we issued an incidental take permit (ITP) to the WDFW for listed rockfish in these fisheries (Table 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 of yelloweye rockfish, and 40 bocaccio (all lethal) (NMFS 2018d). These estimates are used in the Integration and Synthesis analysis (section 2.7.3, Table 36).

Summary of Limiting Factors

The yelloweye rockfish DPS abundance is much lower than it was historically. These 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, while our knowledge of past abundance and specific current viability parameters has limitations, based on the best available information it is reasonable to characterize yelloweye rockfish and bocaccio as having 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 SRKWs should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2016m). A new 5-year review has been initiated on SRKW and a request for new information is currently open (86 FR 21282, April 22, 2021) and the review is planned to be completed by the end of 2021. NMFS considers SRKWs to be currently among nine of the most at-risk species as part of NMFS' Species in the Spotlight initiative[24] because of their endangered status, declining population trend, and because 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, which have generally been increasing since the 1970s (Carretta et al. 2020b).

The limiting factors described in the final recovery plan include 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 2016m), the PFMC SRKW Ad Hoc Workgroup's report (PFMC 2020a), 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). Subsequently, the population declined from 1995-2001 (from 98 whales in 1995 to 81 whales in 2001). The population experienced growth between 2001 and 2006. Except for a brief increase from 78 to 81 as a result of multiple successful pregnancies (n = 9) that occurred in 2013 and 2014, the population has been declining since 2006. At present, the Southern Resident population has declined to near historically low levels (Figure 11). The 2020 summer census number reported by the Center for Whale Research was 72 whales (one whale is missing and presumed dead since the 2019 summer census) and three new calves have been born following the census count. The previously published historical estimated abundance of SRKWs 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.

[24] https://www.fisheries.noaa.gov/resource/document/recovering-threatened-and-endangered-species-report-congress-fy-2017-2018

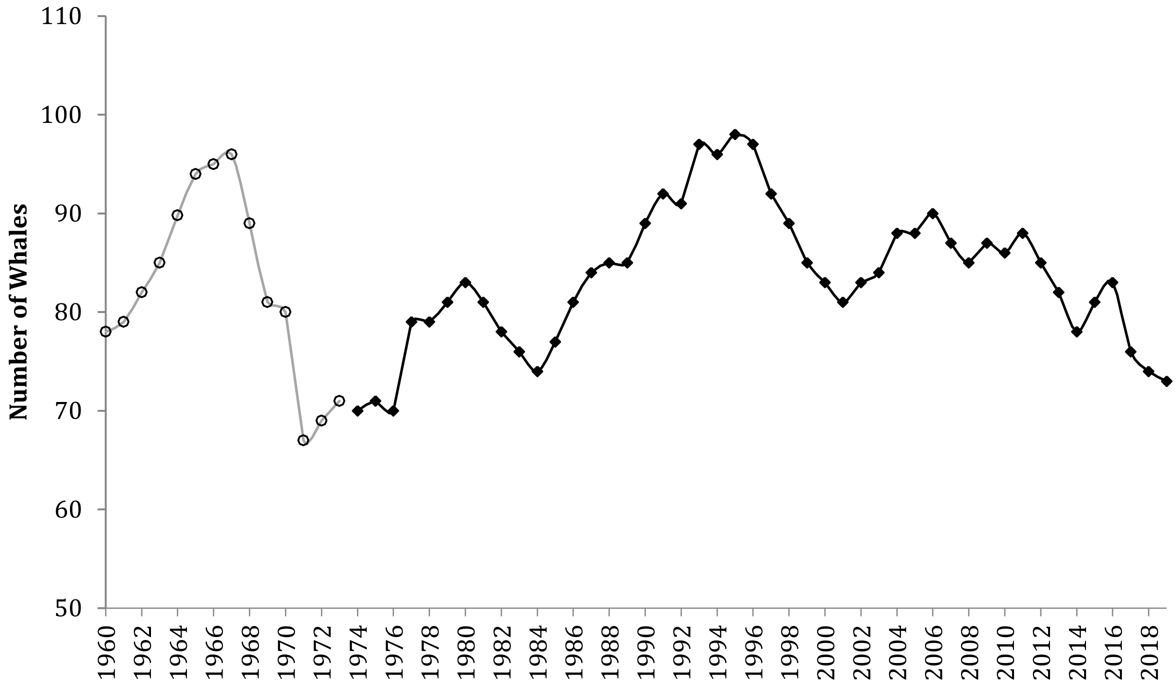

Figure 11. Population size and trend of Southern Resident killer whales, 1960-2019. Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of Olesiuk et al. (1990). Data from 1974-2019 (diamonds, black line) were obtained through photo-identification surveys of the 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, as a consequence inbreeding may be common within 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 the subject 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) and a recent review of killer whale strandings in the northeast Pacific provided insight into health, nutritional status and causes of mortality for all killer whale ecotypes (Raverty et al. 2020).

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) and the most recent 5-year review (NMFS 2016j). The updated analysis[25] described the recent changes in population size and age structure, change in demographic rates over time, and updated projections of population viability (Ward 2019). According to Ward (2019), the model results indicate that fecundity rates have declined and have changed more than male or female survival since 2010. Ward (2019) performed a series of projections: 1) projections using fecundity and survival rates estimated over the long term data series (1985 to 2019); 2) projections using fecundity and survival rates from the most recent 5 year period (2014 – 2019); and 3) projections using the highest fecundity and survival rates estimated (in the period 1985 – 1989). The most optimistic scenario, using demographic rates calculated from the 1985-1989 period, has a trajectory that increases and eventually declines after 2030, while the scenario with long-term demographic data, or the scenario only including the most recent years' demographic data, project declines. Additional runs for this scenario (1985-1989 data) indicated a similar trajectory with a 50:50 sex ratio. Thus, the downward trends are likely driven by the current age and sex structure of young animals in the population (from 2011-2016 new births were skewed slightly toward males with 64% male), as well as the number of older animals (Ward 2019)(Figure 12).

[25] There are several methodological changes from the projections done previously (Hilborn et al. 2012; Ward et al. 2013). First, because indices of salmon abundance available to whales is not included in the model (and none of the existing metrics of salmon abundance have been found to correlate with killer whale demography; (PFMC 2020b)), the estimation model was switched to a generalized additive model (GAM), which allows for smoother over year effects (Ward 2019).

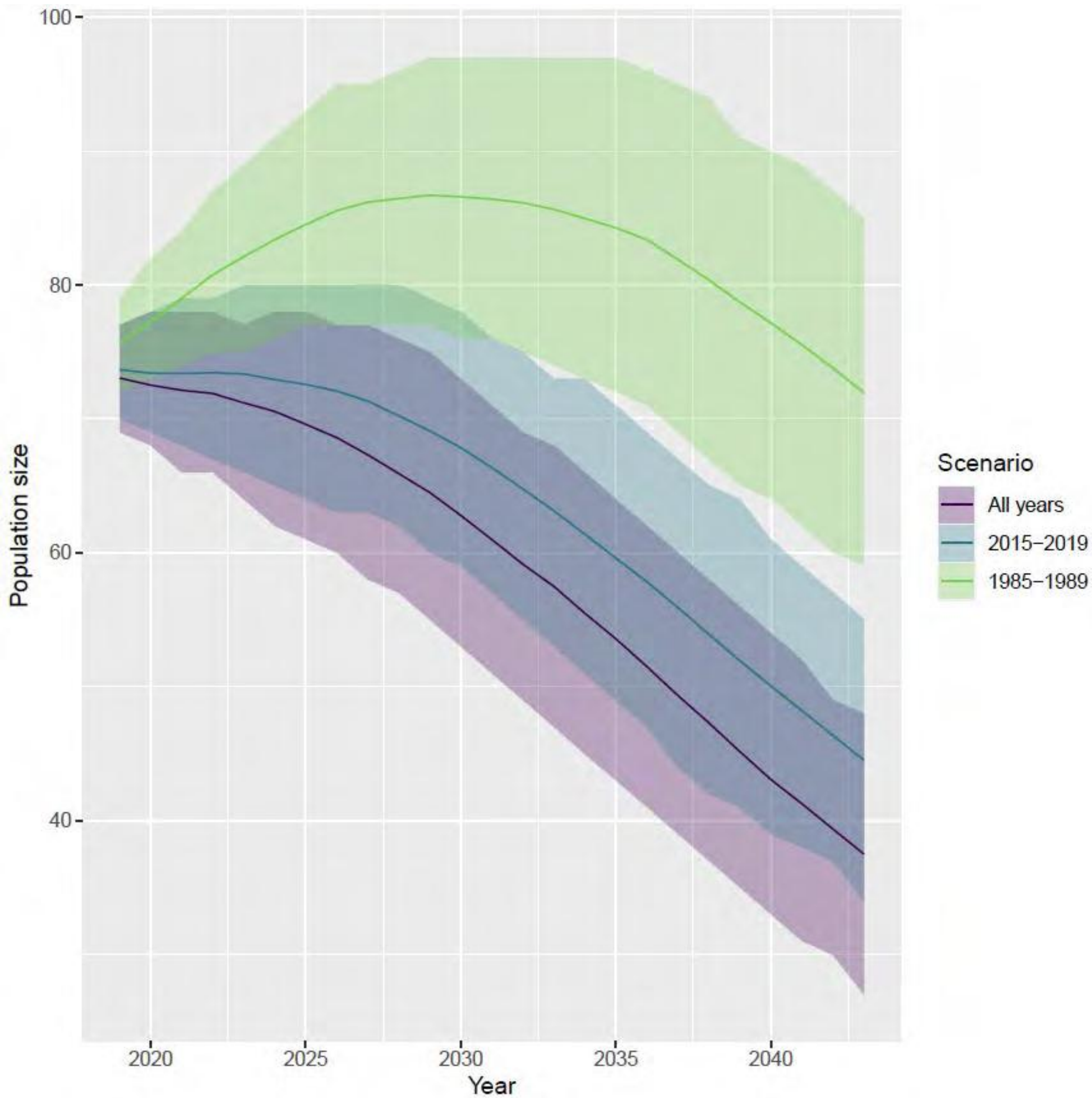

Figure 12. 25-year projections of the SRKW population, using NRKW age and stage data as prior distributions for the SRKW parameters, but not including priors on the year effects estimated from the NRKW population. The 3 scenarios run included (1) projections using demographic rates from the entire data series (1985-2019); (2) projections using demographic rates from 2015 to 2019; and (3) projections using the highest demographic rates in the period 1985-1989 (reprinted from Ward (2019)).

Because of this population's small abundance, it is 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 (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 of SRKWs 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, the overall number of reproductive females has been fluctuating between 25 and 35 for most of the last 40 years, and there have been contrasting changes by pod, with declines in L pod females and increases in J pod (Ward 2019) (Figure 13). At the start of the survey in 1976, the distribution of females was skewed toward younger ages with few older, post-reproductive females. The distribution in recent years is more uniform across female ages (in other words, more females in their 30s, (Ward 2019)). However, from 2014 through July 2019, only 7 calves were born and survived (3 in J pod and 4 in L pod) (Ward 2019). In a novel study, researchers collected SRKW feces to measure pregnancy hormones (progesterone and testosterone) (Wasser et al. 2017). The fecal hormone data showed that up to 69% of the detected pregnancies do not produce a documented calf, and an unprecedented half of those occurred relatively later in the pregnancy when energetic costs and physiological risk to the mother are higher (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). Although the rates of successful pregnancies in wild killer whale populations is generally unknown, a relatively high level of reproductive failure late in pregnancy is uncommon in mammalian species and suggests there may be cause for concern.

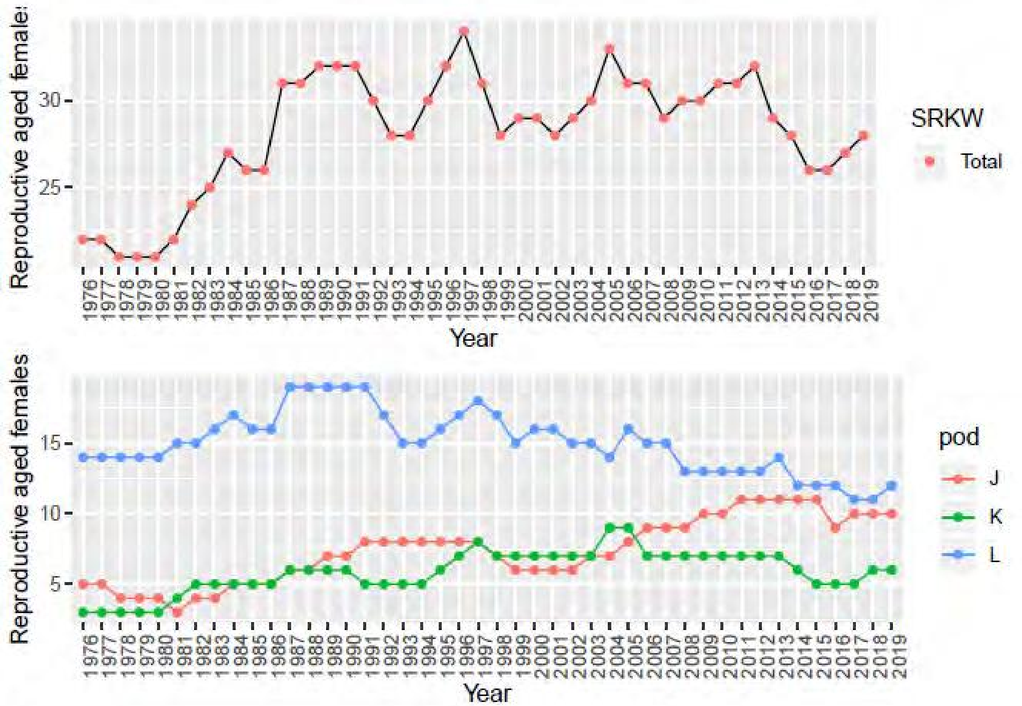

Figure 13. Time series of reproductive age females (10-42, inclusive) for Southern Residents by years since 1976 (reprinted from (Ward 2019)).

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; Carretta et al. 2020b)(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 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, SRKWs, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum, coho, and Chinook salmon runs (Osborne 1999; Hanson et al. 2010; Ford et al. 2016). 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).

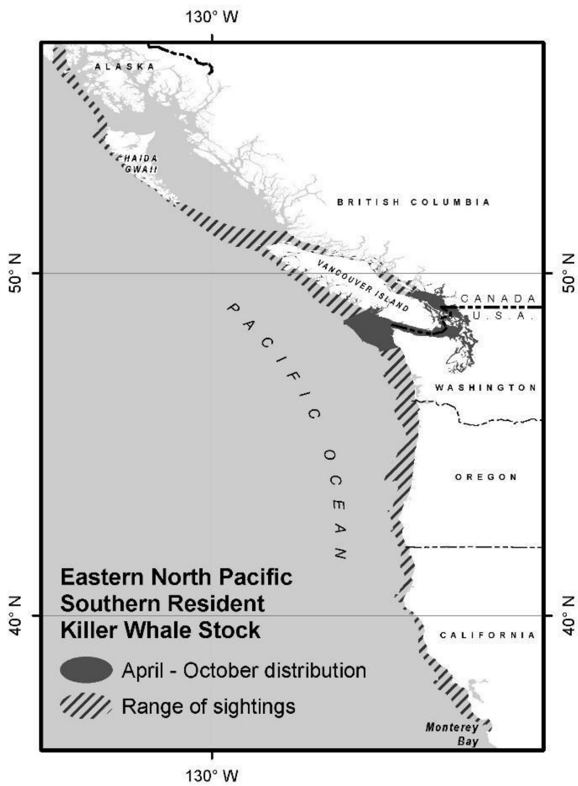

Figure 14. Geographic range of Southern Resident killer whales (reprinted from Carretta et al. (2020b)).

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 SRKWs (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 eight satellite tags deployed were monitored for a range of signal contact durations from 3 days to 96 days depending on the tag, with deployment 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). The tagging data from 2012 to 2016 provided general information on the home range and overlap of each pod, and areas that are used more frequently than others by each pod. Specifically, J pod had high use areas or hot spots (defined as 1 to 3 standard deviations based on a duration of occurrence model of the tagging data) in the northern Strait of Georgia and the west entrance to the Strait of Juan de Fuca where they spent approximately 30% of their time, but they spent relatively little time in other coastal areas (Figure 15). K/L pods on the other hand occurred almost exclusively on the continental shelf during December to mid-May, primarily on the Washington coast, with a hot spot area between Grays Harbor and the Columbia River and off Westport, spending approximately 53% of their time there (Figure 16) (Hanson et al. 2017; Hanson et al. 2018). These differences resulted in generally minimal overlap between J pod and K/L pods, with overlap in high use areas near the Strait of Juan de Fuca western entrance for only a total area of approximately 200 km^2, which comprised only 0.5% of the three pods' ranges (Figure 15 and Figure 16).

Satellite tagging can also provide details on preferred depths and distances from shore. Approximately 95% of the SRKW locations were within 34 km of the shore and 50% of these were within 10 km of the coast (Hanson et al. 2017). Only 5% of locations were greater than 34 km away from the coast, but no locations exceeded 75 km. Almost all (96.5%) outer coastal locations of satellite-tagged Southern Residents occurred in continental shelf waters of 200 m (656.2 ft) depth or less, 77.7% were in waters less than 100 m (328.1 ft) depth, and only 5.3% were in waters less than 18 m (59 ft).

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

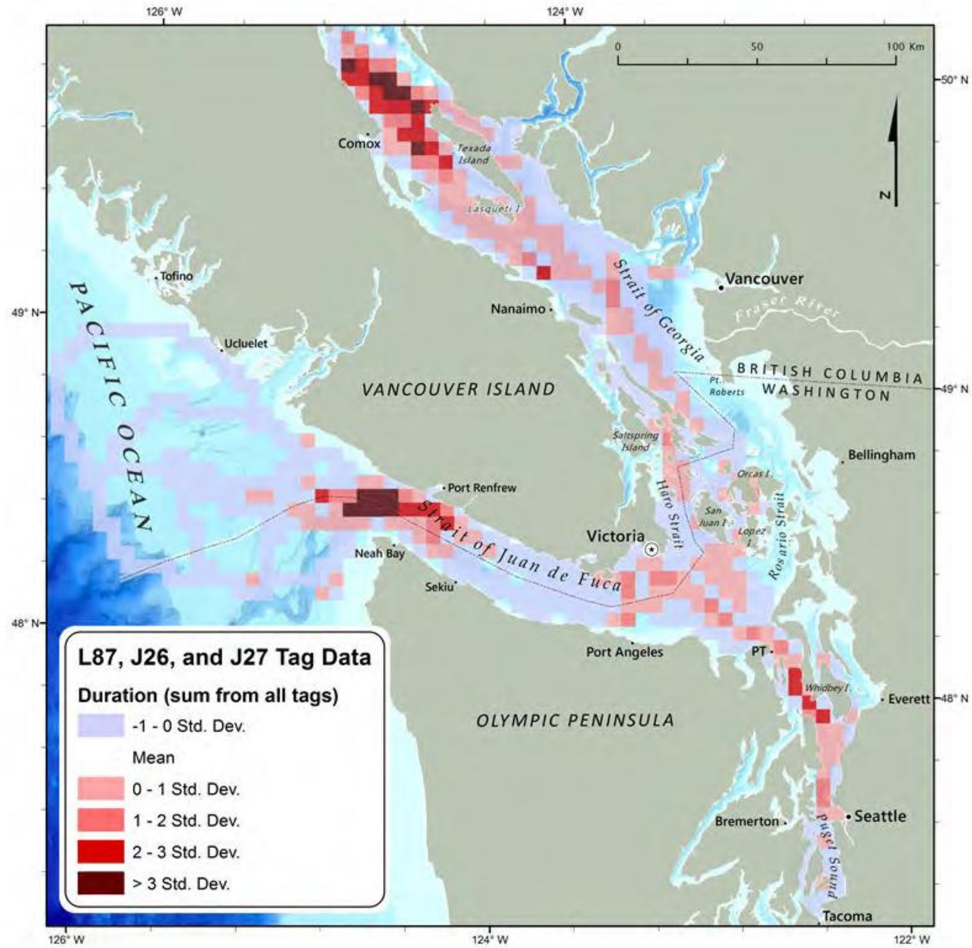

Figure 15. Duration of occurrence model output for J pod tag deployments (Hanson et al. 2017). "High use areas" or hot spots are illustrated by the 0 to > 3 standard deviation pixels.

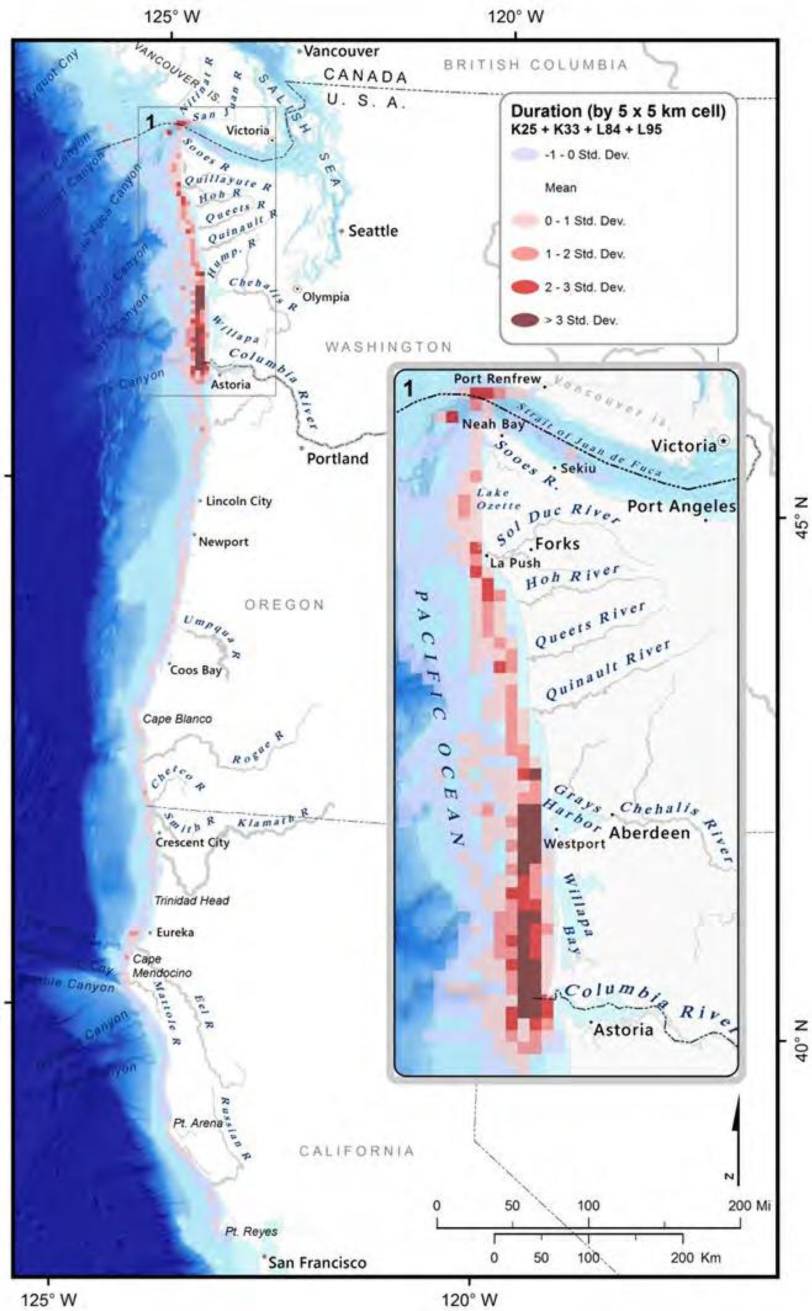

Figure 16. Duration of occurrence model for all unique K and L pod tag deployments (Hanson et al. 2017). "High use areas" or hot spots are illustrated by the 0 to > 3 standard deviation pixels.

Passive acoustic recorders were deployed off the coasts of California, Oregon and Washington in most years since 2006 to assess SRKW seasonal uses of these areas via the recording of stereotypic calls of the SRKWs (Hanson et al. 2013; Emmons et al. 2019). Passive aquatic listeners (PALs) were originally deployed from 2006 – 2008. Since 2008, Ecological Acoustic Recorders (EARs) have been deployed, with up to seven deployed from 2008-2011 (depending on year), and then additional deployments beginning in 2014, including 17 sites off the Washington coast in the fall of 2014 (Figure 17). From 2006 – 2011, passive acoustic listeners and recorders were deployed in areas thought to be used frequently by SRKWs based on previous sightings (Figure 17)(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 (Figure 17) were selected based on "high use areas" or hot spots identified in the duration of an occurrence model developed from the Southern Resident tagging information from Hanson et al. (2017) and sites within the U.S. Navy's Northwest Training Range Complex (NWTRC) in order to determine if SRKWs used these areas in seasons other than winter when satellite-linked tags were not deployed (Hanson et al. 2017; Emmons et al. 2019). Three primary hot spots identified through the winter satellite tagging data were used to place multiple additional recorders; specifically 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 19), 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, 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).

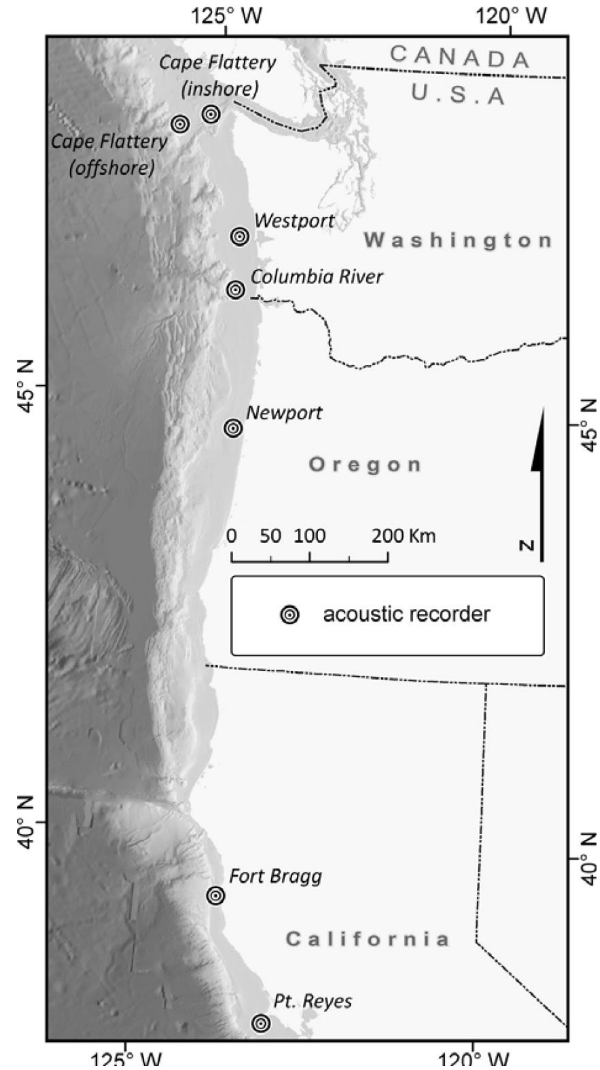

Figure 17. Deployment locations of acoustic recorders on the U.S. west coast from 2006 to 2011 (Hanson et al. 2013).

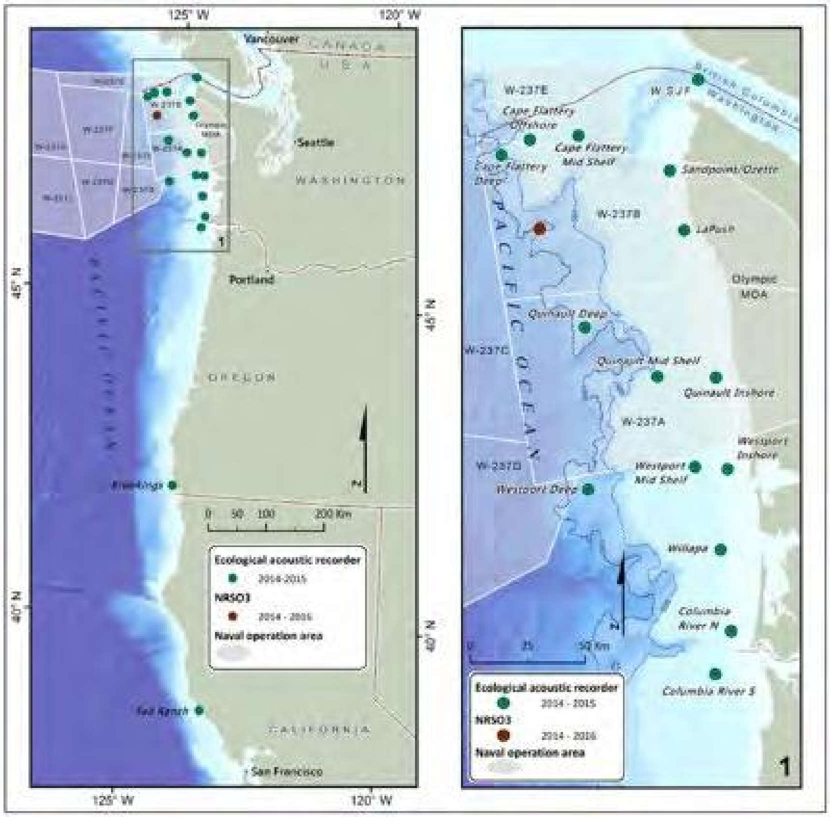

Figure 18. Locations of passive acoustic recorders deployed beginning in the fall of 2014 (Hanson et al. 2017).

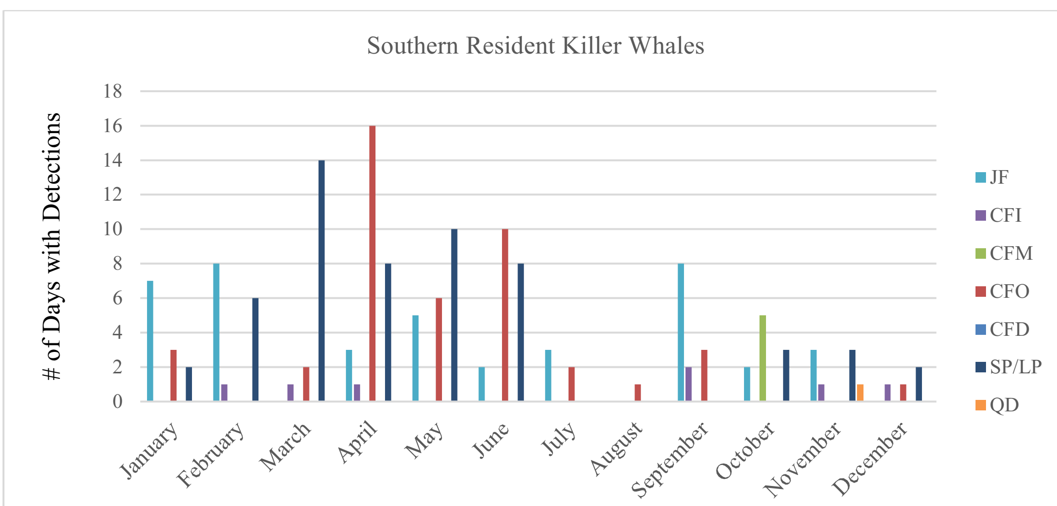

Figure 19. Counts of detections at each northern recorder site by month from 2014-2017 (Emmons et al. 2019). Areas include Juan de Fuca (JF); Cape Flattery Inshore (CFI); Cape Flattery Mid Shelf (CFM); Cape Flattery Offshelf (CFO); Cape Flattery Deep (CFD); Sand Point and La Push (SP/LP); and Quinault Deep (QD).

From August 2009 to July 2011, researchers collected data using an autonomous acoustic recorder deployed at Swiftsure Bank to assess how this area is used by Northern Resident and Southern Resident killer whales as shown in Figure 20 (Riera et al. 2019). SRKWs were detected on 163 days with 175 encounters (see Figure 21 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% of calls and 89% 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% of encounters longer than 2 hours occurring between June and September. L pod had the longest encounters in May, with 79% of encounters longer than 2 hours occurring during the summer (May through September). The longest J pod encounters were during winter, with 72% of encounters longer than 2 hours occurring between December and May (Riera et al. 2019).

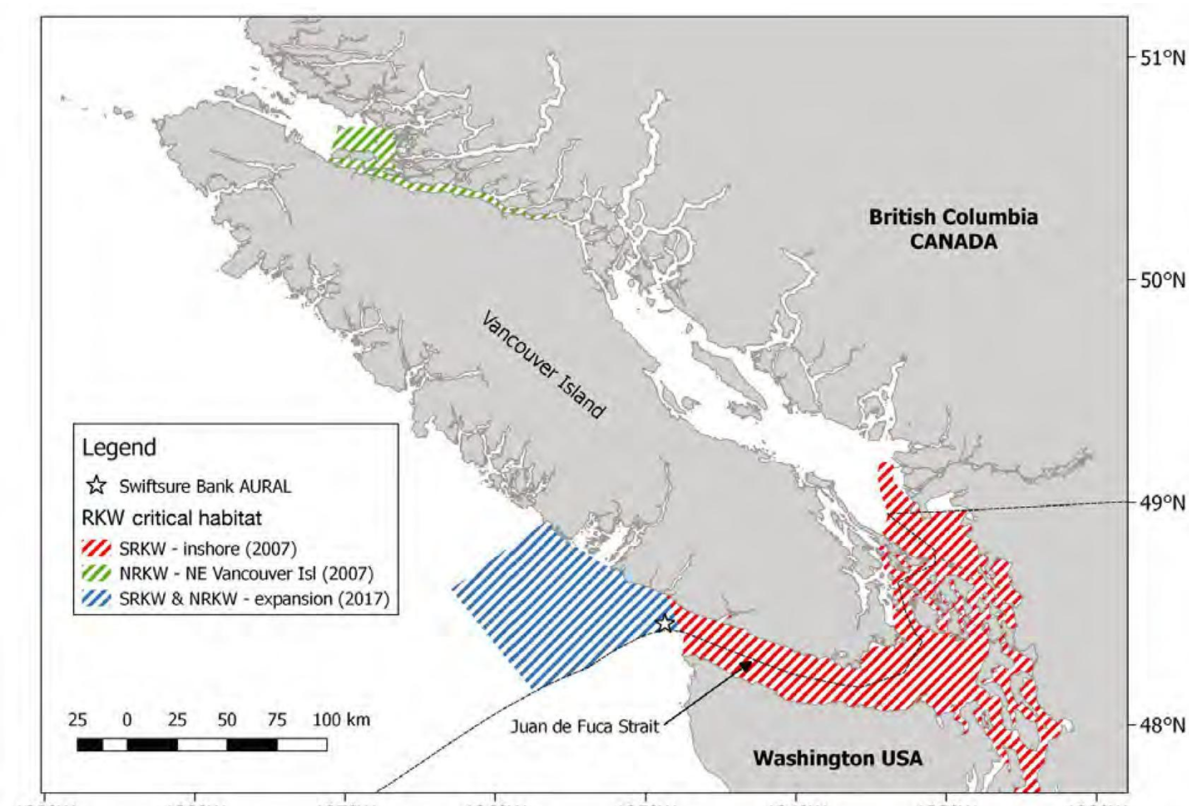

Figure 20. Swiftsure Bank study site off the coast of British Columbia, Canada in relation to the 2007 Northern Resident critical habitat (NE Vancouver Island) and 2007 Southern Resident killer whale critical habitat (inshore waters) and the 2017 Northern Resident and Southern Resident expansion of critical habitat (Riera et al. 2019).

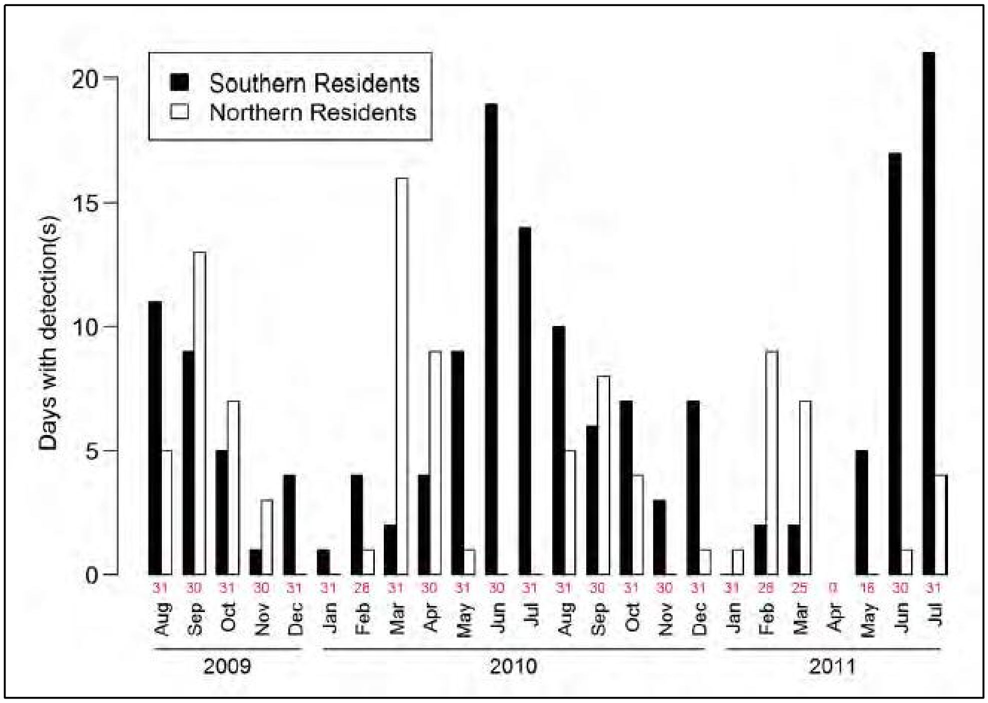

Figure 21. Number of days with acoustic detections of SRKWs at Swiftsure Bank from August 2009 – July 2011. Red numbers indicate days of effort (Riera et al. 2019).

Limiting Factors and Threats

Several factors identified in the final recovery plan for Southern Residents may be limiting recovery. The recovery plan identifies 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. The best available information suggests an overall preference for Chinook salmon (*Oncorhynchus tshawytscha)* during the summer and fall. Chum (*O. keta)*, coho (*O. kisutch)*, and steelhead (*O. mykiss*) may also be important in the SRKW diet at particular times and in specific locations. Rockfish (*Sebastes* spp.), Pacific halibut (*Hippoglossus stenolepis*), and Pacific herring (*Clupea pallasi*) were also observed during predation events (Ford and Ellis 2006), however, these data may underestimate the extent of feeding on bottom fish (Baird 2000). A number of smaller flatfish, lingcod (*Ophiodon* *elongatus*), greenling (*Hexagrammos* spp.), and squid have been identified in stomach content analysis of resident whales (Ford et al. 1998).

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 Chinook salmon's 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 on average approximately 2.7 coho, 3.1 chum, 3.1 sockeye, or 6.4 pink salmon (O'Neill et al. 2014). 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.

Recent stable isotope analyses of opportunistically collected scale samples (Warlick et al. 2020) continue to support and validate previous diet studies (Ford et al. 2016) and what is known of SRKW seasonal movements (Olson et al. 2018, see below), but highlight temporal variability in isotopic values. Warlick et al. (2020) continued to find that Chinook is the primary prey for all pods in summer months followed by coho and then other salmonids. Carbon signatures in samples varied by month, which could indicate variation in Chinook and coho consumption between months and/or differences in carbon signatures across salmon runs and life histories. Peaks in carbon signatures in samples varied between K/L pod and J pod. Though Chinook was the primary prey across years, there was inter-annual variability in nitrogen signature in samples, which could indicate variation in Chinook nitrogen content from year to year or greater Chinook consumption in certain years versus others and/or nutritional stress in certain years, but this is difficult to determine.

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. 2017b). In particular, southern Chinook salmon stocks ranging south from the Columbia River have been subject to the largest increases in predation, which Chasco et al. (2017b) suggest may be potentially due to large subsidies of hatchery produced fish. Due to Chinook salmon's northward migratory pathway and assumptions about their ocean residence, Chasco et al. (2017b) suggested that SRKWs, which prefer Chinook salmon as their primary prey source, may be at a competitive disadvantage to other resident killer whales and marine mammals that also prey on Chinook salmon. In other regions such as the Salish Sea, Chasco et al. (2017b) found that the combined mammal predation of Chinook salmon likely exceeds removal by harvest after accounting for the growth and survival of juvenile fish consumed. However, for modeled Northern Chinook salmon stocks (specifically off Washington, W. Coast Vancouver Island and coastal British Columbia, and Southeast Alaska) predation by marine mammals is near or below fishery harvest (Chasco et al. 2017b), and coastal Washington is an area of high use by SRKWs within their coastal habitat.

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 of SRKWs 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 preyshifting by SRKWs 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 whales' diet (Hanson et al. 2021). Diet data for the Strait of Georgia and coastal waters is limited.

January – April

Collection of prey and fecal samples have also occurred in coastal waters in the winter and spring months, as well as observations of SRKWs overlapping with salmon runs (Wiles 2004; Zamon et al. 2007; Krahn et al. 2009). Although fewer predation events have been observed and fewer fecal samples collected in coastal waters compared to inland 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. 2021). From 2013 to 2016, satellite tags were used to locate and follow the whales to obtain predation and fecal samples. A total of 57 prey sample items were collected from northern California to northern Washington (Figure 22). Results of the 57 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, and Pacific halibut were also detected in samples. Foraging on chum and coho salmon, steelhead, Big skate (*Rana binoculata*) and lingcod was also detected in recent fecal samples (Hanson et al. 2021). 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. 2021). Columbia River, Central Valley, Puget Sound, and Fraser River Chinook salmon collectively comprised over 90% of 33 Chinook salmon prey samples collected (for which genetic stock origin was determined, of a total 44 prey samples collected) for SRKWs 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 22). 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. 2021).

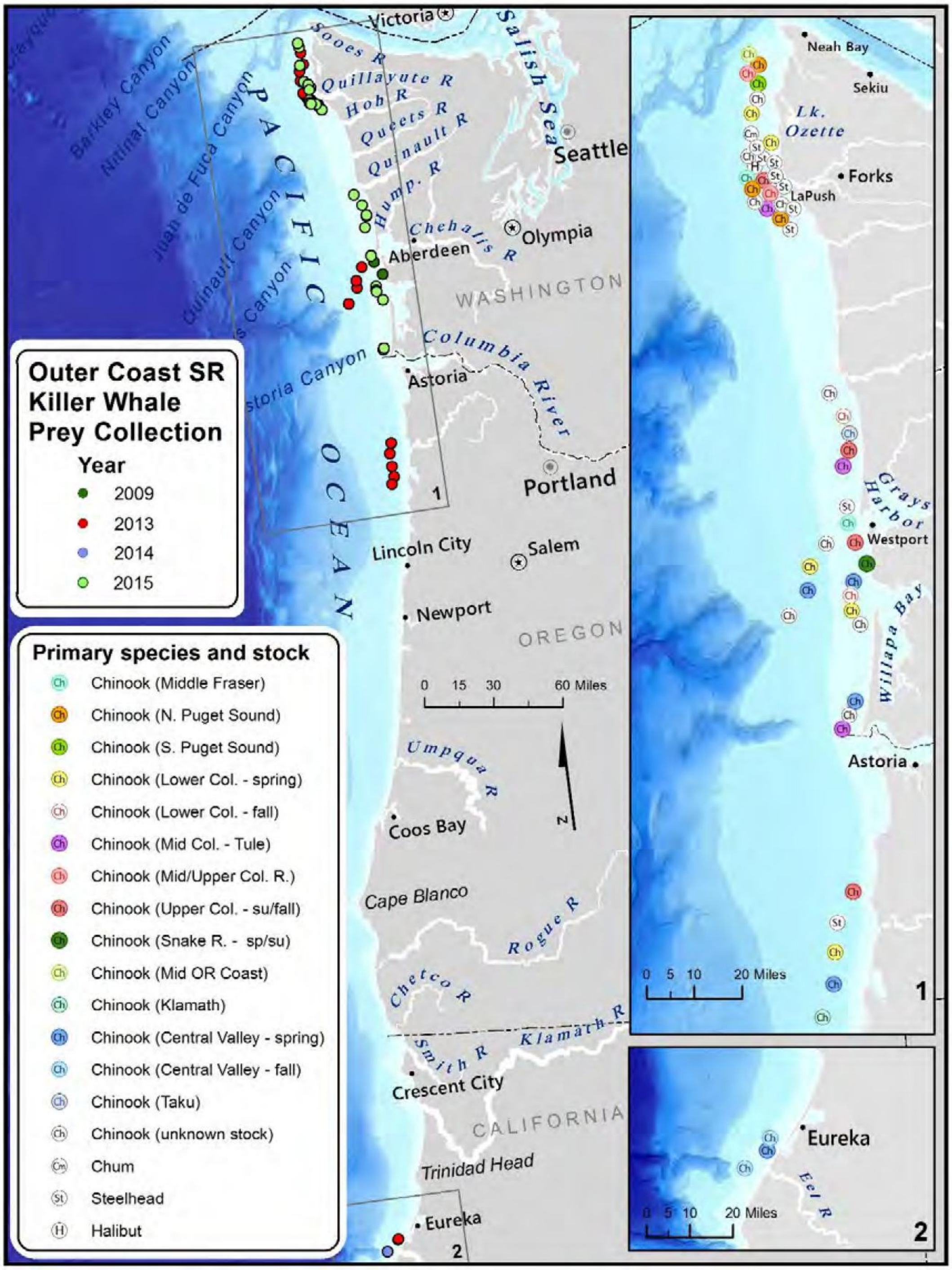

Figure 22. Location and species for scale/tissue samples collected from Southern Resident killer whale predation events in outer coastal waters (stock IDs are considered preliminary) (NMFS 2019i).

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 to offset some 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).

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)[26]. 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. 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. However, it important to note, this priority stock report will continue to get updated over time as new data become available. Given this was designed to prioritize recovery actions and there are no abundance estimates for each stock that are factored in, it is currently not designed to assess fisheries actions or prey availability by area.

[26]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 for prioritizing recovery actions (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

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 SRKWs were observed from boats to have a pronounced “peanut-head”; 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) has used aerial photogrammetry to assess the body condition and health of SRKWs, 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 SRKW 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. Furthermore, hormone analysis conducted by Ayres et al. (2012) from fecal samples collected in 2007-2009, suggests that prey availability may be a greater physiological stressor on SRKW than vessel presence (due to differences in concentrations of two hormones) but that also there could be cumulative physiological effects of prey availability and vessel presence, and also with pollutants.

Information collated on strandings for all killer whale ecotypes (Raverty et al. 2020) as well as 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. Across the Northeast Pacific, causes of death for stranded killer whales of various ages and ecotypes have included: congenital defects, malnutrition and emaciation, infectious disease, bacterial infections, and trauma from blunt force trauma (Raverty et al. 2020). For specific SRKW strandings, 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[27]. The cause of death of L112 was determined to be blunt force trauma to the head, however the source of the trauma (vessel strike, intraspecific aggression, or other unknown source) could not be established. In 2014, J32, an adult late to near term female killer whale, had stranded with moderate to fair body condition and had suffered in utero fetal loss and infection. In spring 2016, a young adult male, L95, was found to have died of a fungal infection related to a satellite tag deployment approximately 5 weeks prior to its death. In fall 2016 another young adult male, J34, was found dead in the northern Georgia Strait (Carretta et al. 2020b). The necropsy indicated that the whale died of blunt force trauma to the head, and Raverty et al. (2020) determined this was consistent with vessel strike.

The Raverty et al. (2020) paper reviewed reports on stranded killer whales from several different populations and different ecotypes (or forms) from 2004-2013 within the North Pacific Ocean and Hawaii. The authors examined cause of death for 53 stranded whales, 22 of which had a definitive diagnosis. They reported on both proximate (process, disease, or injury that initiated process that led to death) and ultimate (final process that led to death) causes of death. They confirmed that three whales (of 22 where a definitive diagnosis/cause of death could be determined) died from vessel strikes, including one Southern Resident (L98 who was habituated to people), one transient, and one Northern Resident. Three others died of blunt force trauma but with unknown origin (including L112 discussed above). In addition, one Alaskan resident killer whale calf died of sepsis as a result of ingestion and impalement of a halibut fishing hook (Raverty et al. 2020) and a previous paper reported fishing hooks and/or lures in the stomachs of four stranded resident whale carcasses (two with hooks/lures for salmon fishing, two with Pacific halibut hooks) (Ford et al. 1998).

Of the 22 stranded killer whales where a definitive diagnosis could be determined, nutritional causes were identified in 11 whales as either the proximate ($n = 5$) or ultimate cause of death ($n = 6$) (Raverty et al. 2020), though none of these whales were identified as SRKWs (some unknown but in unlikely locations for SRKW). But this does highlight that nutritional causes of mortality occur in killer whales. For those that died ultimately of nutritional causes, proximate causes that initiated the process leading to death were congenital problems, environmental incidents (out of habitat or mechanically stranded), or inflammatory. Of the five whales where proximate cause of death was nutritional, three were neonates where the ultimate cause of death was metabolic, likely hypoglycemia, and the definitive diagnosis was “failure to thrive”. Two of the five were sub-adults with ultimate cause of death either euthanasia or metabolic and definitive diagnoses of emaciation.

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). Ford and Ellis (2006) report that resident killer whales engage in prey sharing about 76%

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

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), so that effects of low prey availability may not be seen until prey is extremely low and may be observed in multiple individuals at the same time. Although not observed in the majority of individuals (or a large fraction of the population) body condition data collected to date has documented declines in condition for some SRKWs in some pods and these occurrences have been scattered across demographic and social groups (Fearnbach et al. 2018). Body condition and malnutrition in whales can be influenced by a number of factors, including reduced prey availability, reduced ability to successfully forage, increased energy demands, physiological or life history status, disease, or reduced intestinal absorption of nutrients (Raverty et al. 2020).

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).

Evidence of reduced growth and poor survival in Southern and Northern Resident killer whale populations at a time when Chinook salmon abundance was low suggests that low abundance may have contributed to nutritional deficiency with serious effects on individual whales. 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. Given that killer whales physically mature at age 20 and the body stops growing (Noren 2011), we would expect adult male killer whales to all have similar body lengths and all adult female killer whales to have similar body lengths. However, Groskreutz et al. (2019) 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 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 23)(Ford et al. 2010). The low Chinook salmon abundance and smaller growth in body size in whales coincided with an almost 20% 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).

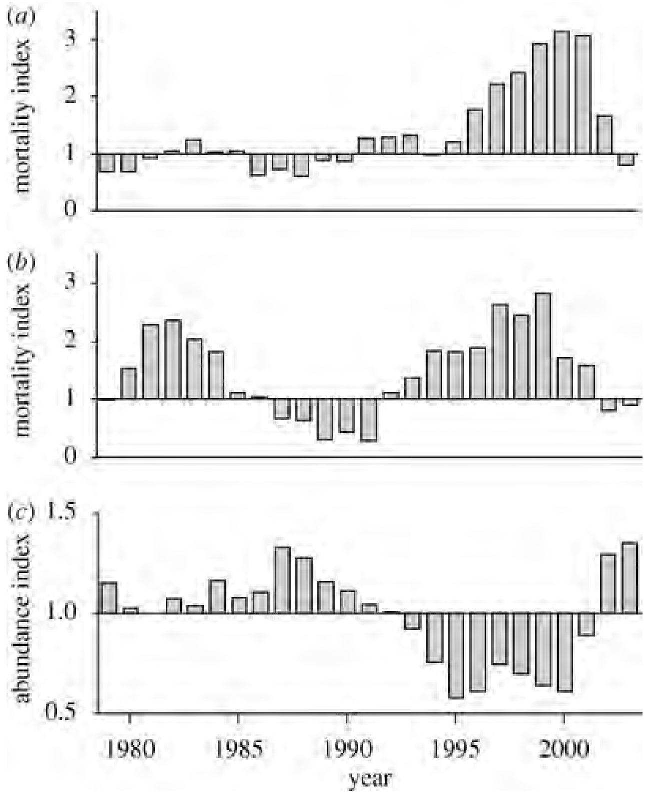

Figure 23. Annual mortality indices for a) Northern Resident and b) Southern Resident killer whales and c) abundance index of Chinook salmon from 1979 to 2003 (reprinted from Ford et al. (2010)).

During this same general period of time of low Chinook salmon 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. (Foster et al. 2012) similarly found a significant correlation between SRKW social network connectivity and Chinook prey abundance for the years 1984-2007, where in years with higher Chinook abundance, SRKW social network was more interconnected. The authors discuss that because of this result, years with higher Chinook abundance may lead to more opportunities for mating and information transfer between individuals.

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 (refer to Parsons et al. (2009). In social animals, once optimal group size occurs (that is based on intrinsic and 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. Parsons et al. (2009) 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.

Toxic Chemicals

Various adverse health effects in humans, laboratory animals, and wildlife have been associated with exposures to persistent pollutants. These pollutants have the ability to cause endocrine disruption, reproductive disruption or failure, immunotoxicity, neurotoxicity, neurobehavioral disruption, and cancer (Reijnders 1986; Subramanian et al. 1987; de Swart et al. 1996; Bonefeld-Jørgensen et al. 2001; Reddy et al. 2001; Schwacke et al. 2002; Darnerud 2003; Legler and Brouwer 2003; Viberg et al. 2003; Ylitalo et al. 2005; Fonnum et al. 2006; Viberg et al. 2006; Darnerud 2008; Legler 2008). SRKWs 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). More recently, these pollutants were measured in fecal samples collected from Southern Residents, and fecal toxicants matched those of blubber samples, so this provides another resource to evaluate exposure to these pollutants (Lundin et al. 2016a; Lundin et al. 2016b).

SRKWs 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. Fecal samples showed that toxicants were highest in concentration when prey availability was low, and the possibility of toxicity was therefore highest with low prey (Lundin et al. 2016b). Therefore, nutritional stress from reduced prey, including Chinook salmon populations, that may occur or may be occurring, may act synergistically with high pollutant levels in SRKWs and result in adverse health effects.

In April 2015, NMFS hosted a 2-day SRKW health workshop to assess the causes of decreased survival and reproduction in the killer whales. Following the workshop, a list of potential action items 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 SRKW and reference populations to better assess negative impacts of future health risks, as well as positive impacts of mitigation strategies on SRKW 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, SRKWs 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; 2016m; 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 and/or presence of motoring vessels up to 400 meters away has the potential to affect the echolocation abilities of foraging whales and their foraging dives and success (Holt 2008; Lusseau et al. 2009; Noren et al. 2009; Williams et al. 2010c; Holt et al. 2021). Models of SRKW behavior states showed that both males and females spent less time in foraging states, with fewer prey-capture dives and shorter dives, when vessels were near (within 400 yds on average), but also that females were more likely to switch from deep and intermediate dive foraging behaviors to travel/respiration when vessels were near (Holt et al. 2021). 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). Ayres et al. (2012) examined glucocorticoid and thyroid hormone levels in fecal samples collected from SRKWs in inland waters and their results suggest that the impacts from vessel traffic on hormone levels are lower than the impacts from reduced prey availability.

At the time of the SRKWs' 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 SRKWs. 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 SRKWs 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 2019, state regulations were updated to increase vessel viewing distances from 200 to 300 yards to the side of the whales and reduce vessel speed within ½ nautical mile of the whales to seven knots over ground (see RCW 77.15.740). In 2019 NMFS conducted a scoping meeting and public comment period to gather input on whether existing regulations and other measures adequately protect killer whales from the impacts of vessels and noise in the inland waters of Washington State and, if not, what actions NMFS should take (84 FR 57015; October 24th, 2019).

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, SRKWs are the most vulnerable marine mammal population to the risks imposed by an oil spill due to their overall small population size, strong site fidelity to areas with high oil spill risk, large groups of individuals together, 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 SRKWs 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 SRKWs 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. 2020b), report on estimated abundance and migratory destinations for North Pacific humpback whales (Wade et al. 2016; Wade 2017; Calambokidis and Barlow 2020a), and recent biological opinions to summarize the status of the species, as follows.

The 2015 status review relied in large part on the results from field efforts conducted on all known winter breeding regions (2004-2006) and all known summer feeding areas (2004, 2005) for humpback whales in the North Pacific (Structure of Populations, Levels of Abundance and Status of Humpbacks (SPLASH). This study, representing one of the largest international collaborative studies of any whale population ever conducted, was designed to determine the abundance, trends, movements, and population structure of North Pacific humpback whales as well as to examine human impacts on the population (Calambokidis et al. 2008). The SPLASH study continues to be relied upon for abundance estimates as well as movement proportions between wintering (breeding) and summer (foraging) grounds (Bettridge et al. 2015; Wade et al. 2016; Wade 2017), even though the field efforts took place nearly fifteen years ago.

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 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 2016l), however, more recent information is available in Wade (2017), and that guidance was updated in 2021 (NMFS 2021c). 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 Area	**Central America DPS (E)** (Nmin = 1,877 (6% growth))	**Mexico DPS (T)** (Nmin= 6,725 (6% growth))	**Hawaii (NL)**
California/Oregon	39%	61%	0%
Washington/SBC*	9%	28%	63%

*Source: Wade (2017)(Table 3b). Note that a portion of humpbacks that may be found off in the Salish Sea and off WA are moving north of the U.S. border and feeding off SBC. In addition, we are currently applying the same proportions of the two listed DPSs to both coastal and inland waters of WA until further analysis is completed.

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 an affected animal is from either DPS.

NMFS manages humpback whales that occur in waters under the jurisdiction of the U.S. as five separate stocks under the MMPA. Along the West Coast of the U.S., all humpback whales are considered part of the California-Oregon-Washington (CA/OR/WA) stock. The CA/OR/WA stock spends the winter (breeding season) primarily in coastal waters of Mexico and Central America, and the summer (foraging season) along the West Coast from California to British Columbia. However, there is overlap with the Central North Pacific stock in the action area. While NMFS is currently reviewing the humpback whale stock definitions, the most recent draft stock assessment report (SAR) for the CA/OR/WA stock (Carretta et al. 2020b) has not modified the MMPA definition of humpback whale stocks in response to the new ESA listings. For this opinion, we will analyze impacts at the ESA-listed DPS level but we will rely heavily upon information from the SARs for the CA/OR/WA stock of the humpback whale, as well as the most recent scientific information available regarding the abundance of humpback whales along the U.S. West Coast.

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 Central North Pacific 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.

Humpback whales in the North Pacific generally exhibit strong site fidelity and movement between feeding and breeding regions, but movements between feeding and breeding areas are complex and varied (Calambokidis et al. 2008; Barlow et al. 2011). An overall pattern of migration has recently emerged. Asia and Mexico/Central America are the dominant breeding areas for humpback whales that migrate to feeding areas in lower latitudes and more coastal areas on each side of the Pacific Ocean, such as California and Russia. The Revillagigedo Archipelago and Hawaiian Islands are the primary winter migratory destinations for humpback whales that feed in the more central and higher latitude areas (Calambokidis et al. 2008). However, there are exceptions to this pattern, and it seems that complex population structure and strong site fidelity coexist with lesser known, but potentially high, levels of plasticity in the movements of humpback whales (Salden et al. 1999; Bettridge et al. 2015).

Abundance, Productivity and Trends

CA/OR/WA Stock status

The growth rate of the CA/OR/WA stock of the North Pacific humpback whales, which consists of Hawaii, Mexico, and Central America DPS whales, has been estimated as increasing about 6-7 percent annually (Carretta et al. 2020b). The most recent stock assessment report, published in August 2020, used a best fit model based on mark-recapture estimates from 2011 through 2014 to produce an abundance estimate (including a minimum abundance estimate) for humpback whales in the CA/OR/WA stock. Calambokidis and Barlow (2020b) presented updated estimates of humpback whale abundances along the U.S. West Coast using photo-identification data collected through 2018. The report contained multiple abundance estimates based both on regions, capture-recapture models, years and datasets. That analysis suggests that there currently are 4,973 humpback whales found off of California and Oregon, which is used as an estimate for the entire U.S. West Coast, based on the Chao Mth model, which used rolling 4-year periods and accounting for heterogeneity of capture probability—Table 3 in Calambokidis and Barlow (2020b). With a standard error of 239, the lower (minimum estimate) 20th percentile value is 4,776 whales foraging off the U.S. West Coast. Therefore, the minimum abundance estimate of 4,776 whales in the CA/OR/WA stock is conservative and is based on the most recent available data (2014-2018), which represents the most accurate estimate to be used for this Opinion, as it will likely be included in a future SAR. Researchers are refining the latitudinal distribution of humpbacks along the U.S. West Coast, which, in the future, will likely further elucidate the proportion of humpbacks foraging off the coast of Washington and moving into the inland waters. Calambokidis and Barlow (2020b) did provide estimates for the humpback whale population that feeds in Washington-Southern British Columbia. The Chao Mth model estimates approximately 1,593 humpback whales use the region, but many of these individuals are likely included in the estimates for the California-Oregon population estimate of 4,773. Additionally, some of the 1,593 humpback whales estimated for Washington-Southern British Columbia are found outside of U.S. waters.

Mexico DPS

The Mexico DPS consists of whales that breed along the Pacific coast of mainland Mexico, the Baja California Peninsula and the Revillagigedos Islands. The Mexico DPS feeds across a broad geographic range from California to the Aleutian Islands, with concentrations in California-Oregon, northern Washington – southern British Columbia, northern and western Gulf of Alaska and Bering Sea feeding grounds. This DPS was determined to be discrete based on significant genetic differentiation as well as evidence for low rates of movements among breeding areas in the North Pacific based on sighting data. The Mexico DPS was determined to be significant due to the gap in breeding grounds that would occur if this DPS were to go extinct and the marked degree of genetic divergence to other populations. This DPS also differs from some other North Pacific populations in the ecological characteristics of its feeding areas (Bettridge et al. 2015).

Population Status and Trends

The Mexico DPS of humpback whales forages along the West Coast of North America as far north as the Aleutian Island and Bering Sea, AK. Recently, Wade (2017) estimated the abundance of the Mexico DPS to be 2,806 whales based on a revised analysis of the SPLASH data. Because these estimates are more than 8 years old, and humpback whales in the Pacific have recently experienced positive growth rates, they are not considered a reliable estimate of current abundance (NOAA 2016; Carretta et al. 2020b). 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 growth of this DPS, given its relative population size. Because the Mexico DPS forages widely in the North Pacific, including areas off British Columbia and Alaska, it is difficult to estimate the abundance of this DPS based on the recent MMPA minimum abundance estimate of the CA/OR/WA stock of humpbacks. Therefore, if we assume that the population estimated by Wade (2017) based on information from 2004-2006 (2,806 animals) has increased by 6 percent annually in the last 15 years, the current abundance estimate of the Mexico DPS would be 6,725 animals. However, there is uncertainty in this estimate.

Central America DPS

The Central America DPS is composed of whales that breed along the Pacific coast of Costa Rica, Panama, Guatemala, El Salvador, Honduras and Nicaragua. Whales from this breeding ground feed almost exclusively offshore of California and Oregon in the eastern Pacific, with only a few individuals identified at the northern Washington–southern British Columbia feeding grounds. This DPS was determined to be discrete based on re-sight data as well as findings of significant genetic differentiation between it and other populations in the North Pacific. The genetic composition of the DPS is also unique in that it shares mitochondrial DNA (mtDNA) haplotypes with some Southern Hemisphere DPSs, suggesting it may serve as a conduit for gene flow between the North Pacific and Southern Hemisphere. The breeding ground of this DPS occupies a unique ecological setting, and its primary feeding ground is in a different marine ecosystem from most other populations. Loss of this population would also result in a significant gap in the range of the species (Bettridge et al. 2015).

Population Status and Trends

The Central America DPS of humpback whales occurs along the U.S. West Coast, although individuals are more likely to be found off the coast of California and Oregon. Most recently, Wade (2017) estimated the abundance of the Central America DPS to be 783 whales based on a revised analysis of the SPLASH data. Because these estimates are greater than >8 years old, and humpback whales in the Pacific have recently experienced positive growth, they are not considered a reliable estimate of current abundance (NOAA 2016; Carretta et al. 2020b). The population trend for the Central America DPS is unknown (Bettridge et al. 2015), although 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 growth of this DPS, given its relative population size. It is also possible that some other factors are limiting or inhibiting population growth of this DPS given its relative small population size. Because there are three DPSs foraging off the West Coast, it is difficult to determine the abundance of the Central American DPS from the recent minimum abundance estimate of the CA/OR/WA stock of humpbacks. Therefore, if we assume that the population estimated by Wade (2017) based on information from 2004-2006 (783 animals) has increased by 6 percent annually in the last 15 years, the current abundance estimate of the Central America DPS would be 1,877 animals.

Current Assessment of Abundance and Distribution of ESA-listed Humpback Whale DPSs

Because the data used to determine the probability rates in summer feeding areas off of CA/OR in Wade (2017) are 15 years old, the probabilities and populations sizes calculated are assumed to be outdated. Therefore, to consider what probabilities/proportions of the DPSs would be off of our the U.S. west coast, we considered the combination of the most recent abundance estimates with reasonable assumptions of population growth rates since 2004-2006 to derive proportional estimates for the current populations of humpback whales off the coasts of CA, OR, and WA. Since we know that all of the Central America DPS forages off the U.S. West Coast, we assume that, with a 6 percent annual growth rate, approximately 1,876 (which is 39 percent of the 4,776 minimum abundance estimate above) feeding off the West Coast originate from Central America (endangered DPS).

For WA/SBC, we do not have an estimate of the abundance of humpbacks that may be foraging north of CA/OR and only within U.S. waters, only that they represent a small proportion of the minimum abundance estimate for the CA/OR/WA stock, as designated under the MMPA, with portions of the humpbacks feeding north of the U.S. border. Until we have updated information, we will continue to use the Wade (2017) movement probabilities of humpbacks feeding off

SBC/WA to breeding areas off Central America and Mexico, and assume that around 28 percent of whales feeding off WA/SBC originate from the Mexico DPS, and approximately 9 percent originate from the Central America DPS. The majority of the humpback whales (63 percent) feeding in this area would originate from the non-listed Hawaii DPS.

Limiting Factors and Threats

The humpback whale species was originally listed as endangered because of past commercial whaling. While commercial whaling of humpback whales no longer occurs, it continues to have lasting impacts on the populations. 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 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. Between 2014 and 2018, 292 large whales were reported as having human-caused serious injuries or mortalities. Of these, 177 were humpback whales (Carretta et al. 2020a). An additional 27 humpback whales were entangled from 2019 to 2020 (NOAA Fisheries 2020; 2021).. From 2013-2017 the serious injury/mortality estimates for the CA/OR/WA stock due to commercial fishery entanglements (17.3/yr), non-fishery entanglements (0.2/yr), recreational crab pot fisheries (0.35/yr), serious injuries assigned to unidentified whale entanglements (2.1/yr), tribal fisheries (0.2/yr), plus observed ship strikes (2.2/yr) equals 22.35 animals, which exceeds the stock's Potential Biological Removal (PBR) of 16.7 animals in U.S. waters (Carretta et al. 2020b). The estimates of whale entanglements and ship strikes are minimum counts since many of these interactions likely go unnoticed.

Humpback whales exhibit flexible feeding strategies, sometimes foraging alone and sometimes cooperatively (D'Vincent et al. 1985). In many locations, feeding in the water column can vary with time of day, with whales bottom feeding at night and surface feeding near dawn

(Friedlaender et al. 2009; Bettridge et al. 2015). Humpback whales have a diverse diet that slightly varies across feeding aggregation areas. The species is known to feed on both small schooling fish and on euphausiids (krill). Known prey organisms include species representing Clupea (herring), Scomber (mackerel), Ammodytes (sand lance), Sardinops (sardine), Engraulis (anchovy), Mallotus (capelin), and krills such as *Euphausia, Thysanoessa*, and Meganyctiphanes (Baker 1985; Geraci et al. 1989; Clapham et al. 1997; 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. 2017b). 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. (2017b) 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. Similarly, Sprogis et al. (2020) determined that vessel noise was a driver of behavioral disturbance to mothers and calves, leading to decreased resting and increased respiration rates and swimming speeds.

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[28]; 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).

[28] 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).

2.2.2.1 Puget Sound Chinook and Steelhead

Critical habitat has been designated in Puget Sound for Puget Sound Chinook salmon and Puget Sound steelhead. Major tributary river basins in the Puget Sound basin include the Nooksack, Samish, Skagit, Sauk, Stillaguamish, Snohomish, Lake Washington, Cedar, Sammamish, Green, Duwamish, Puyallup, White, Carbon, Nisqually, Deschutes, Skokomish, Duckabush, Dosewallips, Big Quilcene, Elwha, and Dungeness rivers and Soos Creek.

Critical habitat for PS Chinook salmon was designated on September 2, 2005 (70 FR 52630). The designation includes 1,683 miles of streams, 41 square mile of lakes, and 2,182 miles of nearshore marine habitat in Puget Sound. The Puget Sound Chinook salmon ESU has 61 freshwater and 19 marine areas within its range. Of the freshwater watersheds, 40 are rated high conservation value, 12 low conservation value, and nine received a medium rating. Of the marine areas, all 19 are ranked with high conservation value from NOAA Fisheries' Critical Habitat Analytical Review Team (CHART) (NMFS 2005c). Puget Sound Chinook critical habitat also includes estuarine areas and certain 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 occupied by the 22 populations, because of their importance to rearing and migration for Chinook salmon and their prey. The designation includes nearshore areas extending from the extreme high water point out to a depth of 30 meters and adjacent to watersheds, but does not otherwise include offshore marine areas. There are 61 watersheds within the range of this ESU. Of the stream and nearshore habitat eligible for designation, 3,865 miles are designated critical habitat while the remaining 740 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. Critical habitat information for Puget Sound Chinook can be found online at: https://www.govinfo.gov/content/pkg/FR-2005-09-02/pdf/05-16391.pdf

Critical habitat for Puget Sound steelhead was designated on February 24, 2016 (81 FR 9252). Steelhead critical habitat includes 2,031 stream miles. 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 from CHART (NMFS 2015a). Critical habitat for Puget Sound steelhead includes freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. Offshore marine waters were not designated critical habitat for this species. Additionally designated critical habitat for Puget Sound steelhead does not include nearshore areas, as this species does not make extensive use of these areas during the juvenile life stage. Approximately 138 stream miles, in areas where the conservation benefit to the species was relatively low (compared to the economic impacts of inclusion), were also excluded. Additionally an approximate 1,361 stream miles covered by four habitat conservation plans, and approximately 70 stream miles on tribal lands, were excluded because the benefits of exclusion outweighed the benefits of designation. NMFS also designated approximately 90 stream miles of critical habitat on the Kitsap Peninsula, which were originally proposed for exclusion, after considering public comments and determining 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.

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 for Puget Sound steelhead 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 PBFs 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.

Landslides can occur naturally in steep, forested lands, but inappropriate land use practices likely have accelerated their frequency within designated critical habitat and increased the amount of sediment delivered to streams. Fine sediment from unpaved roads has also contributed to stream sedimentation. Unpaved roads are widespread on forested lands in the Puget Sound basin, and to a lesser extent, in rural residential areas. Historical logging removed most of the riparian trees near stream channels. Subsequent agricultural and urban conversion permanently altered riparian vegetation in the river valleys, leaving either no trees, or a thin band of trees. The riparian zones along many agricultural areas are now dominated by alder, invasive canary grass and blackberries, and provide substantially reduced stream shade and large wood recruitment (SSPS 2007).

Diking, agriculture, revetments, railroads and roads in lower stream reaches have caused significant loss of secondary channels in major valley floodplains in this region. Confined main channels create high-energy peak flows that remove smaller substrate particles and large wood. The loss of side-channels, oxbow lakes, and backwater habitats has resulted in a significant loss of juvenile salmonid rearing and refuge habitat. When the water level of Lake Washington was lowered 9 feet in the 1910s, thousands of acres of wetlands along the shoreline of Lake Washington, Lake Sammamish and the Sammamish River corridor were drained and converted to agricultural and urban uses. Wetlands play an important role in hydrologic processes, as they store water that ameliorates high and low flows. The interchange of surface and groundwater in complex stream and wetland systems helps to moderate stream temperatures. Forest wetlands are estimated to have diminished by one-third in Washington State (FEMAT 1993; Spence et al. 1996; SSPS 2007).

Loss of riparian habitat, elevated water temperatures, elevated levels of nutrients, increased nitrogen and phosphorus, and higher levels of turbidity, presumably from urban and highway runoff, wastewater treatment, failing septic systems, and agriculture or livestock impacts, have been documented in many Puget Sound tributaries (SSPS 2007).

Peak stream flows have increased over time due to paving (roads and parking areas), reduced percolation through surface soils on residential and agricultural lands, simplified and extended drainage networks, loss of wetlands, and rain-on-snow events in higher elevation clear cuts (SSPS 2007). In urbanized Puget Sound, there is a strong association between land use and land cover attributes and rates of coho spawner mortality likely due to runoff containing contaminants emitted from motor vehicles (Feist et al. 1996).

Dams constructed for hydropower generation, irrigation, or flood control have substantially affected Puget Sound salmon and steelhead populations in a number of river systems. The construction and operation of dams have blocked access to spawning and rearing habitat (e.g., Elwha River dams block anadromous fish access to 70 miles of potential habitat) changed flow patterns, resulted in elevated temperatures and stranding of juvenile migrants, and degraded downstream spawning and rearing habitat by reducing recruitment of spawning gravel and large wood to downstream areas (SSPS 2007). These actions tend to promote downstream channel incision and simplification (Kondolf 1997), limiting fish habitat. Water withdrawals reduce available fish habitat and alter sediment transport. Hydropower projects often change flow rates, stranding and killing fish, and reducing aquatic invertebrate (food source) productivity (Hunter 1992).

Juvenile mortality occurs in unscreened or inadequately screened diversions. Water diversion ditches resemble side channels in which juvenile salmonids normally find refuge. When diversion headgates are shut, access back to the main channel is cut off and the channel goes dry. Mortality can also occur with inadequately screened diversions from impingement on the screen, or mutilation in pumps where gaps or oversized screen openings allow juveniles to get into the system. Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in many Puget Sound tributary basins (SSPS 2007).

The nearshore marine habitat included in the critical habitat designations has been extensively altered and armored by industrial and residential development near the mouths of many of Puget Sound's tributaries. A railroad runs along large portions of the eastern shoreline of Puget Sound, eliminating natural cover along the shore and natural recruitment of beach sand (SSPS 2007).

Degradation of the near-shore environment has occurred in the southeastern areas of Hood Canal in recent years, resulting in late summer marine oxygen depletion and significant fish kills. Circulation of marine waters is naturally limited, and partially driven by freshwater runoff, which is often low in the late summer. However, human development has increased nutrient loads from failing septic systems along the shoreline, and from use of nitrate and phosphate fertilizers on lawns and farms. Shoreline residential development is widespread and dense in many places. The combination of highways and dense residential development has degraded certain physical and chemical characteristics of the near-shore environment (HCCC 2005; SSPS 2007).

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; NMFS 2014f; 2019f; 2020g).

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[29]. 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.

In summary, critical habitat for salmon and steelhead throughout the Puget Sound basin has been degraded by numerous management activities, including hydropower development, loss of mature riparian forests, increased sediment inputs, removal of large wood, intense urbanization, agriculture, alteration of floodplain and stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, dredging, armoring of shorelines, marina and port development, road and railroad construction and maintenance, logging, and mining. Changes in habitat quantity, availability, and diversity, and flow, temperature, sediment load and channel instability are common limiting factors in areas of critical habitat.

2.2.2.2 Puget Sound/Georgia Basin Rockfish

Critical habitat was designated for all three species of ESA-listed 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

[29]https://www.epa.gov/sites/production/files/2017-01/documents/puget-sound-federal-task-force-action-plan-interim-draft-2017-2021.pdf

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, NMFS 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:
NMFS 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:
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.

2.2.2.3 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 SRKWs 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 SRKW 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, September 19, 2019). 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. 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. The final revised critical habitat rule is expected to publish in 2021.

Additional information on the physical or biological features essential to conservation can be found in the 2006 critical habitat designation (71 FR 69054, November 29, 2006) and the recent purposed critical habitat designation (84 FR 49214, September 19, 2019), and is incorporated into information provided in the status for the species (section 2.2.1.4). We briefly summarize information on each of the three features here.

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. 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 SRKWs and their prey resources, despite bans in the 1970s of some harmful substances and cleanup efforts. Also, oil spill risk exists throughout the SRKW's coastal and inland range. 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 species of sufficient quantity, quality and availability is essential to conservation as Southern Resident killer whales need to maintain their energy balance all year long to support daily activities (foraging, traveling, resting, socializing), as well as gestation, lactation, and growth. Most wild salmon stocks throughout the whales' geographic range are at fractions of their historic levels and 28 ESUs and DPSs of salmon and steelhead are 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. In addition to sufficient quantity of prey, fish need to be accessible and available to the whales, which can be related to the density and distribution of salmon, and competition from other predators and fisheries.

Vessels and sound may reduce the effective zone of echolocation and also reduce availability of fish for the whales in their critical habitat (Holt 2008). As mentioned above, contaminants and pollution also affect the quality of SRKW prey in Puget Sound and in coastal waters of Washington, Oregon, and California. The size of Chinook salmon is also an important aspect of prey quality (i.e., SRKWs primarily consume large Chinook), so changes in Chinook size (for instance as shown by Ohlberger et al. (2018)) may affect the quality of this feature of critical habitat.

Finally, SRKWs require open waterways that are free from obstruction (e.g., physical, acoustic) to move within and migrate between important habitat areas throughout their range, communicate, find prey, and fulfill other life history requirements ("Passage" habitat feature). In particular, vessels may present both physical and/or acoustic 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), and see "Disturbance by Vessels and Sound" in the SRKW status section 2.2.1.4).

Human activities managed under a variety of legal mandates have the potential to affect the habitat features essential to the conservation of Southern Resident killer whales, including those that could increase water contamination and/or chemical exposure, decrease the quantity, quality, or availability of prey, or inhibit safe, unrestricted passage between important habitat areas to find prey and fulfill other life history requirements. Examples of these types of activities include (but are not limited to), in no particular order: (1) salmon fisheries and bycatch; (2) salmon hatcheries; (3) offshore aquaculture/mariculture; (4) alternative energy development; (5) oil spills and response; (6) military activities; (7) vessel traffic; (8) dredging and dredge material disposal; (9) oil and gas exploration and production; (10) mineral mining (including sand and gravel mining); (11) geologic surveys (including seismic surveys); and (12) activities occurring adjacent to or upstream of critical habitat that may affect essential features, labeled "upstream activities" (including activities contributing to point-source water pollution, power plant operations, liquefied natural gas terminals, desalinization plants) (see NMFS (2019i)).

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. 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.

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 area where the abundance of Chinook salmon is expected to be 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 U.S./Canada Southern border at the southern Strait of Georgia (below Vancouver and Nanaimo B.C.) to southern Puget Sound and the Strait of Juan de Fuca (Figure 23), therefore any portion of this area extending beyond the action area described for the fish species is also included in the action area. Effects of the action to humpback whales are expected to occur within this area as well.

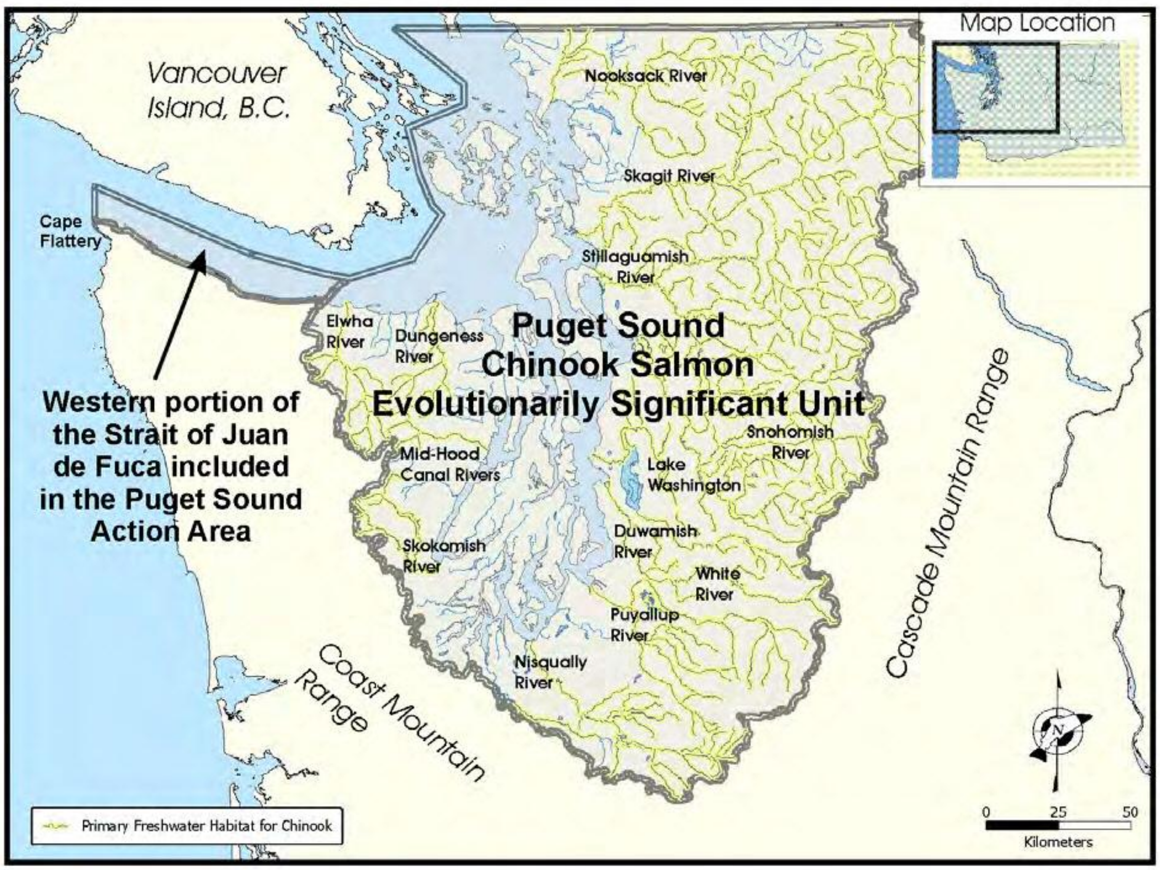

Figure 24. Puget Sound Action Area, which includes the Puget Sound Chinook ESU and the western portion of the Strait of Juan de Fuca in the United States.

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 various legal principles regarding sharing established in *United States v. Washington*. 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

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, as well as biological opinions on the Snohomish Basin Salmonid Hatchery Operations (NMFS 2017c) and the implementation of the Mitchell Act (NMFS 2017d). The University of Washington Climate Impacts Group summarized the current state of knowledge of climate change and anticipated trends on Puget Sound and its environs including those that would affect salmon (Mauger et al. 2015). Warmer streams, ocean acidification, lower summer stream flows, and higher winter stream flows are projected to negatively affect salmon. The persistence of cold water "refugia" within rivers and the diversity among salmon populations will be critical in helping salmon populations adapt to future climate conditions. Similar types of effects on salmon may occur in the marine ecosystem including warmer water temperatures, loss of coastal habitat due to sea level rise, ocean acidification, and changes in water quality and freshwater inputs (Mauger et al.

2015).

Harvest

Chinook salmon Harvest

In the past, fisheries in Puget Sound and fisheries in the ocean that harvest Puget Sound stocks 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. Selective gear types and time and area closures are some of the management tools used to reduce catches of weak stocks, and to reduce Chinook salmon and steelhead bycatch in fisheries targeting other salmon species. Other management measures (i.e. 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 – 1992-1998 (average reduction = -29%, range of change= -53 to +42%)(FRAM validation runs, version 6.2, April 2019). 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 for Puget Sound Chinook and steelhead. 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 annually since that time (Grayum and Anderson 2014; Redhorse 2014; Grayum and Unsworth 2015; Shaw 2015; 2016; Speaks 2017; Shaw 2018; Norton 2019b; Mercier 2020). 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 and historical reference rates are summarized in Table 13 **(**FRAM validation runs, version 6.2, April 2019**)**.

Fifty percent or more of the harvest of 7 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 and Canadian domestic law. Ocean salmon fisheries in contiguous U.S. federal waters are managed by NMFS and the PFMC, under the MSA and 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) has delegated its management authority to the State of Alaska. These fisheries are also managed under the terms of the PST. The effects of the Northern fisheries (Canada and SEAK) on Puget Sound Chinook were assessed in previous biological opinions (NMFS 2004a; 2008e; 2019e). As with Puget Sound fisheries, in recent years these ocean fisheries have been reduced through agreements under the PST in the case of the northern fisheries, and in order to address impacts to ESA listed stocks and other stocks in the case of the PFMC fisheries.

Table 13. Average 2009 to 2016 SUS and total % Exploitation Rates and % of total ER in Northern fisheries for Puget Sound Chinook management units (see Table 5 for correspondence to populations). This encompasses the provisions of the 2009-2018 Pacific Salmon Treaty Chinook Annex – a new PST Chinook Annex was adopted for use in the 2019-2028 period.

Management Unit	Avg % of total annual ER in AK/CAN fisheries (2009-2016)	**SUS Exploitation Rate (PFMC and PS fisheries)**	**Total Exploitation Rate**	Avg Total ER Pre-listing (1992-1998)
Nooksack early	77%	7%	30%	37%
Skagit spring	49%	11%	21%	22%
Skagit summer/fall	59%	19%	45%	45%
Stillaguamish	65%	8%	23%	33%
Snohomish	63%	7%	19%	41%
Lake Washington	49%	15%	28%	44%
Duwamish-Green River	45%	18%	31%	51%
White River	35%	15%	22%	29%
Puyallup River	30%	32%	45%	59%
Nisqually River	18%	43%	52%*	74%
Skokomish River	21%	45%	57%*	40%
Mid-Hood Canal rivers	52%	11%	23%	32%
Dungeness River	71%	4%	15%	13%
Elwha River	75%	4%	14%	19%

*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-present).

Steelhead Harvest

Similar to Chinook, fishery impacts on Puget Sound steelhead have declined since the DPS was listed in 2007, based on the available harvest data from the Puget Sound co-managers prior to listing through 2021 (WDFW and PSTIT Post Season Data 2004-2021). Puget Sound tribal marine salmon fisheries encounter listed summer and winter steelhead in fisheries targeting other salmon species. An annual average of 126 (hatchery and wild combined) (range 7 – 266) summer and winter steelhead were landed incidentally in tribal marine fisheries (commercial and ceremonial and subsistence) from all Puget Sound marine areas combined during the 2001/2002 to 2006/2007 time period[30]. An annual average of 51 (hatchery and wild combined) (range 1 – 128) summer and winter steelhead were landed incidentally in tribal marine fisheries from all Puget Sound marine areas combined during the 2008/2009 to 2019/2020 time period (WDFW and PSTIT 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

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

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 Puget Sound marine non-tribal recreational fisheries, an annual average of 198 (range 102 – 263) hatchery summer and winter steelhead were landed from all Puget Sound marine areas combined during the 2000/2001 to 2006/2007 time period (Leland 2010). Since ESA listing in 2007, an annual average of 114 (range 15 – 213) hatchery summer and winter steelhead have been landed in non-tribal marine recreational fisheries, from all Puget Sound marine areas combined during the 2007/2008 to 2019/2020 time period (WDFW and PSTIT 2020). The catch of steelhead in Puget Sound marine recreational fisheries has therefore declined by 43% in the years since listing. Washington State prohibits the retention of natural-origin steelhead (those without a clipped adipose fin) in both marine and freshwater recreational fisheries. 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 2000/01 to 2006/07seasons, an average of 324 steelhead were caught in marine tribal and non-tribal commercial, ceremonial and subsistence (C&S), and marine recreational fisheries (i.e., 125 tribal marine (all fisheries); 1 non-tribal marine commercial; 198 non-tribal marine recreational). Since listing, an average of 165 steelhead were caught in marine tribal and non-tribal commercial, ceremonial and subsistence, and recreational fisheries (i.e., 50 tribal marine; 1 non-tribal commercial; 114 non-tribal recreational) for the most recent time period (2007/2008to 2019/2020) (Table 14). The steelhead caught in these marine area fisheries include ESA-listed natural-origin and hatchery steelhead, unlisted hatchery steelhead, non-listed Olympic Peninsula steelhead, and hatchery and natural-origin fish from Canada. Overall, the average tribal and non-tribal catch in marine area fisheries has declined by 49% compared with the earlier, pre-listing period.

Table 14. Average annual (seasonal) marine area catch of steelhead from 2000/01 to 2006/07 and 2007/08 to 2019/20 time periods.

	Marine Catch			
Time Period	**Tribal commercial & C&S**	**Non-Tribal Commercial**	**Non-Tribal Recreational**	**Total**
2000/01 to 2006/07	125	1	198	324
2007/08 to 2019/20	50	1	114	165

In Puget Sound freshwater areas, with the exception of the Skagit River, the non-tribal harvest of steelhead occurs in recreational hook-and-line fisheries targeting adipose fin-clipped hatchery summer run and winter run steelhead. Tribal fisheries typically retain both natural-origin and hatchery steelhead. The tribal 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. Freshwater 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 steelhead 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 tribal 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 sliding scale 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 Skagit steelhead RMP met the requirements of the ESA 4(d) Rule. Therefore, the directed steelhead freshwater fisheries in the Skagit basin, as described within the Skagit steelhead RMP, are not part of the proposed actions consulted on within this Opinion, but are considered in this Environmental Baseline. However, marine fisheries which may impact Skagit steelhead populations are considered part of the proposed action, and will be considered in the overall effects assessment for the Puget Sound steelhead DPS.

Table 15. Steelhead impact levels as proposed by the Skagit River RMP. Impact levels include both tribal 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%

Recreational steelhead fishing occurred under the Skagit steelhead RMP 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, including the April 2018 directed recreational steelhead fishery, 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 did not implement any steelhead-directed fisheries in the Skagit basin for the 2019/2020 season, which ended on June 30, 2020 (WDFW 2020a; 2020b). All incidental impacts to Skagit steelhead in fisheries directed at other species were managed under the 4% limit (Table 15).

As described in section 2.2.1 (status of the species), available data on escapement of summer and summer/winter steelhead populations in Puget Sound are limited. 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. Therefore, these five steelhead populations (Skagit, Snohomish, Green, Puyallup and Nisqually) will further be referred to within the opinion as reference populations. The use of terminal harvest rates to calculate impacts to natural-origin steelhead populations closely approximates stock-specific rates as almost all harvest occurs within the terminal areas and the mixed-stock pre-terminal harvest is very low when spread across the DIPs in the DPS (WDFW and PSTIT 2017a; 2018; 2019; 2020; 2021). NMFS calculated that the harvest rate on these five natural-origin steelhead reference populations averaged 4.2% annually in Puget Sound terminal fisheries during the 2001/2002 to 2006/2007 time period, just prior to listing (NMFS 2010b) (Table 16). Average harvest rates on the same natural-origin steelhead reference populations, excluding the Skagit due to the existing RMP which limits harvest rates annually based on pre-season escapement estimates (NMFS 2018), have demonstrated a reduction to 0.96% in Puget Sound fisheries during the 2007/2008 to 2019/2020 time period, a 78% decline (Table 16). 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 five reference Puget Sound winter steelhead populations (2001/02 – 2006/07), and four[c] reference Puget Sound winter steelhead populations 2007/08 – 2019/2020) (NMFS 2015c; WDFW and PSTIT 2017a; 2018; 2019; 2020; 2021).

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

Year	Skagit	Snohomish	Green	Puyallup	Nisqually[a]
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[d]				
2007-08		0.40	3.50	1.00	3.70
2008-09		1.10	0.30	0.00	3.70
2009-10		2.10	0.40	0.00	1.20
2010-11		1.50	1.60	0.60	1.80
2011-12		0.90	2.00	0.40	2.50
2012-13		1.10	2.38	0.70	1.10
2013-14		0.89	1.09	0.56	1.33
2014-15		1.00	1.05	0.54	0.89
2015-16		0.90	0.92	0.06	0.20
2016-17		1.00	0.90	0.10	0.00
2017-18		1.20	0.50	0.10	0.10
2018-19	--[c]	1.10	0.30	0.00	0.05
2019-20	--[c]	0.90	0.35	0.08	0.00
Avg HRs 2007-20	**--[c]**	**1.08**	**1.18**	**0.32**	**1.27**
Total Avg HR		**0.96%** total average harvest rate across populations from 2007-08 to 2019-20			

[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 managed under the Skagit Steelhead Harvest RMP beginning in 2018.
[d] The average historical (pre-listing) rate across the population, not including the Skagit, is still equal to 4.2%

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 last two status reviews concurred that consistently low natural-origin steelhead harvest rates since ESA-listing are not likely to substantially affect steelhead spawner abundance in the DPS (NWFSC 2015; 2020). The 2019 Puget Sound Steelhead Recovery Plan also concurred with this assessment (NMFS 2019h).

Halibut Fisheries

Commercial and recreational halibut fisheries occur in the Strait of Juan de Fuca and San Juan Island areas of Puget Sound. In a recent biological opinion, NMFS concluded that salmon are not likely to be caught incidentally in the commercial or tribal halibut fisheries when using halibut gear (NMFS 2018d). The total estimated non-retention mortality of Chinook salmon in Puget Sound recreational halibut fisheries is extremely low, averaging just under two Chinook salmon per year. Of these, the estimated catch of listed fish (hatchery and wild) is between one and two Puget Sound Chinook per year. Given the very low level of impacts and the fact that the fishery occurs in mixed stock areas, different populations within the ESUs are likely affected each year. No steelhead have been observed in the fishery.

Puget Sound bottomfish and shrimp trawl fisheries

Recreational fishers targeting bottom fish and the shrimp trawl fishery in Puget Sound can incidentally catch listed Puget Sound Chinook. In 2012 NMFS issued an incidental take permit to the WDFW for listed species caught in these two fisheries, including Puget Sound Chinook salmon (NMFS 2012a). 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.

Coastal Groundfish Fishery

Puget Sound Chinook are incidentally caught in small numbers in the U.S. West coast groundfish fishery. NMFS reviewed this bycatch and determined that the numbers of Puget Sound Chinook that are caught constitute a very small portion (<1.0%) of the total abundance of the populations, even under the most impactful scenario. NMFS determined that due to the small numbers of Puget Sound Chinook caught, inclusive of hatchery-produced with no take prohibition and the lack of indication of any disproportionate impacts to specific populations, that the coastal groundfish fisheries were not likely to jeopardized Puget Sound Chinook (NMFS 2017e).

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. The goals of conservation hatchery programs are to restore and support natural populations; other programs are intended augment harvest. 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. 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.

Chinook Hatchery Production

Nearly half 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 30 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 also 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. Funding for these programs was included in the PST funding initiative, which NMFS addressed in the consultation on domestic actions associated with implementation of the 2019-2028 PST Agreement (NMFS 2019e). Federal funding appropriated in 2020 and 2021 for the PST funding initiative 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 2016j; 2019a). Review and development of a renewed approach to the Mid-Hood Canal hatchery program is currently ongoing.

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 to the PST critical stock programs, there are new initiatives to increase hatchery production to further enhance the SRKW's prey base. For example, in response to recommendations from the Washington State Southern Resident Killer Whale Task Force (2018), the Washington State Legislature provided ~$13 million of 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). Further, NMFS allocated $5.6 million of the PST federal appropriation for FY 20 to increase prey availability for SRKW through regional hatchery production. As a result of the additional funding for hatchery production to support SRKW (FY20 PST funding and 2019-2021 Washington State Legislature funding), over 11.6 million additional hatchery-origin Chinook salmon were released in 2020, just over 6.0 million from Puget Sound, and over 18.3 million additional hatchery-origin Chinook salmon are expected to be released in 2021 relative to the base period considered in NMFS' 2019 biological opinion on domestic actions associated with implementation of the new PST Agreement (NMFS 2021d). For Fiscal Year 2021, Congress has appropriated $39.5 million for activities in support of these activities. (166 Cong. Rec. 12/21/2020). In that 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 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.

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

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

NMFS has and will continue to work with hatchery operators and funders to ensure that all increased hatchery production to support SRKWs has been thoroughly reviewed under the ESA (and NEPA as applicable) to ensure that it does not jeopardize the survival and recovery of any ESA-listed species or adversely modify critical habitat. For example, NMFS completed an ESA consultation (NMFS 2020c) for the release of hatchery fish into streams and rivers that flow into Puget Sound to identify potential impacts to SRKW and other non-salmonid listed species. This analysis looked at all of the proposed hatchery production in the Puget Sound region. We determined that in the short-term (within 3-5 years), as hatchery fish mature and become available as prey, the whales are likely to benefit from an increase in high priority prey stocks. Consultations on site-specific hatchery production increases have been completed on much of the increased hatchery production and are listed in Table 17. All of the completed analyses have determined that the hatchery programs will not jeopardize listed salmonids. 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 while minimizing the risk to listed salmonid species.

Table 17. Puget Sound Hatchery programs that have been addressed in 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		

Biological Opinion	**Programs Authorized in Opinion**	**Signature Date**	**Citation**
	Lower Elwha Fish Hatchery odd and even year pink salmon		
Three Dungeness River Hatchery Programs	Dungeness River Hatchery spring Chinook	May 31, 2016	(NMFS 2016j)
	Dungeness River Hatchery coho		
	Dungeness River Hatchery pink		
Ten Hood Canal Hatchery Programs	Hoodsport Fall Chinook	September 30, 2016	(NMFS 2016g)
	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		
Three Early Winter Steelhead Programs in Dungeness, Nooksack, and Stillaguamish River Basins	Dungeness early winter steelhead	April 13, 2016	(NMFS 2016h)
	Kendall Creek winter steelhead		
	Whitehorse Ponds (Stillaguamish) early winter steelhead		
Two Hatchery Programs for Early Winter Steelhead in the	Wallace/Reiter early winter steelhead	April 15, 2016	(NMFS 2016i)
	Tokul Creek winter steelhead		

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
Snohomish River basin			
Ten Hatchery Programs in the Green/Duwamish Basin	Soos Creek Hatchery fall Chinook	April 15, 2019	(NMFS 2019c)
	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 2019a)
	Stillaguamish fall Chinook		
	Stillaguamish coho		
	Stillaguamish fall chum		
Seven Hatchery Programs in the Snohomish River Basin	Bernie Kai-Kai Gobin Salmon Hatchery "Tulalip Hatchery" subyearling summer Chinook	September 27, 2017; May 3, 2021	(NMFS 2017c)

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
	Wallace River Hatchery summer Chinook		
	Tulalip Bay Hatchery coho		
	Wallace River Hatchery coho		
	Everett Bay net pen coho		
	Tulalip Bay Hatchery chum		
	Wallace River Hatchery chum		
One Program for Summer Steelhead in the Snohomish Basin	Skykomish summer steelhead	April 23, 2020	(NMFS 2021b)

Steelhead Hatchery Production

There are currently 13 hatchery programs in Puget Sound that propagate steelhead. Five of these programs produce hatchery-origin steelhead that are similar to the natural-origin steelhead populations. These programs are designed to conserve and rebuild ESA-listed populations, and allow for natural spawning of hatchery-origin fish. They use broodstock founded from, and integrated with the natural population, for steelhead conservation purposes. Fish produced through these five programs are also designated as part of the listed Puget Sound Steelhead DPS (79 FR 20802, April 14, 2014). In the Central/Southern Cascade MPG, one program operates to rebuild the native White River winter-run steelhead population. In the Green River basin, upon construction of a new Fish Restoration Facility, (NMFS 2019c) a new conservation program, in addition to the one that already exists in the Green, will operate to rebuild the native Green River winter-run steelhead population, and mitigate for lost natural-origin steelhead abundance and harvest levels associated with the placement and operation of Howard Hanson Dam (Jones 2015). One additional rebuilding program is operated to conserve steelhead populations that are part of the Hood Canal and Strait of Juan de Fuca MPG. An initial Hood Canal Steelhead Supplementation Program functioned to rebuild native stock winter-run steelhead abundances in the Dewatto, Duckabush, and South Fork Skokomish river watersheds. However, that program has now sunset, 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 is currently supporting the recovery of native Skokomish River winter steelhead. The fifth program, the Elwha River Native Steelhead program, preserves and assists in the recbuilding of native Elwha River winter-run steelhead.

In 2016 five early winter steelhead hatchery programs producing non-listed fish and operating within the Dungeness, Nooksack, Stillaguamish, Snohomish, and Skykomish river basins received approval by NMFS under ESA 4(d) rule, limit 6 for effects on ESA-listed steelhead and Chinook salmon (NMFS 2016h; 2016k). In evaluating and approving the Early Winter Steelhead (EWS) programs, founded with Chambers Creek stock,for effects on listed fish (NMFS 2016h; 2016k), 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. One important element to consider for the evaluation of effects of fisheries targeting EWS hatchery returns 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).

Lastly, there are three harvest augmentation programs currently propagating non-listed early summer-run steelhead (ESS), which were derived from Columbia River, Skamania stock, in the Green (Soos Creek), Skykomish (Reiter Ponds) and Stillaguamish (Whitehorse Ponds) river basins. WDFW has started phasing out these Skamania-origin (Columbia River) programs, the only programs that propagate stock from outside of Puget Sound. The last releases occurred in 2020 for the Whitehorse Ponds program, and will occur in 2022 for the Reiter Ponds program. The Soos Creek Hatchery summer steelhead program will be transitioned to a within-Puget Sound stock by 2031(NMFS 2019). A newly developed summer steelhead hatchery program in the South Fork Skykomish has been submitted for approval by NMFS under limit 6 of the 4(d) rule. This program will transition to the use of a localized within-basin natural-origin broodstock, and is intended to maintain a locally-adapted population comprised of hatchery broodstock and naturally spawning fish from within the Puget Sound DPS (NWFSC 2020).

The EWS and ESS stocks historically reared and released as smolts through the eight non-listed programs were 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 2016k). However, these risks have been assessed through the 4(d) approval process, and were determined to be minimal. 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 (NMFS 2016h; 2016k). Genetic assessment for the summer Green River program was complete in 2019, and risk from gene flow was determined to be low (NMFS 2019c). Genetic assessment for the Skykomish summer program is currently on-going, and risk is expected to be low based on the assessment within the recently drafted biological opinion for the Skykomish Summer Steelhead Hatchery

Program and the Sunset Falls Trap and Haul Program (NMFS 2021b).

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). Reductions since 2014 from this average total have largely been in response 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 in response to the risk of introgression between native steelhead populations and hatchery-origin. In addition, Chambers Creek (EWS) releases were discontinued in the Elwha and Skagit River basins during the last five year period (NWFSC 2020). Currently hatchery programs propagating unlisted steelhead in Puget Sound total 1,076,000 annually (this total includes 350, 000 summer steelhead and 531,000 winter steelhead) in the Puget Sound DPS (NWFSC 2020), which have been approved under Limit 6 of the 4(d). There have also been recent changes associated with several integrated rebuilding programs, including increased production goals for the Green River Native Winter Steelhead and White River Winter Steelhead Supplementation programs; and addition of the North Fork Skokomish Winter Steelhead program, which first released fish in 2017 (NWFSC 2020). Once the non-listed programs have sunset, as required by 4(d) authorization (NMFS 2019c; 2021b), and the integrated programs rebuilding listed populations have achieved their intended release goals, in 2031, Puget Sound steelhead hatchery releases will total 1.3M. This release level represents a 52 percent total reduction in hatchery releases since listing, and a transition away from programs releasing non-listed and out of DPS stocks.

Future production from the ESS as well as other on-going non-Chinook and non-steelhead programs, currently operated by the State of Washington, that have not been analyzed in an ESA consultation is described 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 damaging 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).

Land use 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.), polluted 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; NWIFC 2016; 2020).

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; NWIFC 2016; 2020). 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 basin until 2014 (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 Chinook and steelhead in the Puget Sound area has been historically limited by large dams and other manmade barriers in a number of drainages, including the Nooksack, Skagit, White, Nisqually, Skokomish, and Elwha river basins (Appendix B in NMFS (2015a)). In addition to limiting habitat accessibility, dams affect habitat quality through changes in river hydrology, altered temperature profile, reduced downstream gravel recruitment, and the reduced recruitment of large woody debris. Such changes can have significant negative impacts on salmonids (e.g., increased water temperatures resulting in decreased disease resistance) (Spence et al. 1996; McCullough 1999). However, over the past several years modifications have occurred to existing barriers, which have reduced the number of basins with limited anadromous access to historical habitat. The completion of the Elwha and Glines Canyon dam removals occurred in 2014. The response of fish populations to this action is still being evaluated. It is clear; however, that Chinook and steelhead are accessing much of this newly available habitat (Pess et al. 2020). Passage operations have begun on the North Fork Skokomish River to reintroduce steelhead above Cushman Dam, although juvenile collection efficiency is still relatively low, and further improvements are anticipated. Similarly, improvements in the adult fish collection facility at Mud Mountain Dam (White River basin) are near completion, with the expectation that improvements in adult survival will facilitate better utilization of habitat above the dam (NMFS 2014f). The recent removal of the diversion dam on the Middle Fork Nooksack Dam (16 July 2020) and the Pilchuck River Dam (late 2020) will provide access to important headwater salmonid spawning and rearing habitats. Similarly, the proposed modification of Howard Hanson Dam for upstream fish passage and downstream juvenile collection in the longer term (NMFS 2019f) will allow winter steelhead to return to historical habitat (NWFSC 2020).

As of 2019 approximately 8,000 culverts that block steelhead habitat have been identified in

Puget Sound (NMFS 2019g), with plans to address these blockages being extended over many years. Smaller scale improvements in habitat, restoration of riparian habitat and reconnecting side- or off-channel habitats, will allow better access to habitat types and niche diversification. While there have been some significant improvements in restoring access, it is recognized that land development, loss of riparian and forest habitat, loss of wetlands, demands on water allocation all continue to degrade the quantity and quality of available fish habitat (NWFSC 2020).

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 during storm events, and decreases in groundwater driven summer flows (Moscrip and Montgomery 1997; Booth et al. 2002; May et al. 2003). River braiding and sinuosity have also 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). Due to 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), the National Flood Insurance Program (NMFS 2008d), the Elwha River Fish Restoration Plan (Ward et al. 2008), the Washington State Department of Transportation Preservation, Improvement, and Maintenance Activities (NMFS 2013a), and the Salish Sea Nearshore Programmatic with the Corps (NMFS 2020). 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 in the opinions on these actions. The environmental baselines in these documents consider the effects from timber, agriculture and irrigation practices, urbanization, hatcheries and tributary habitat, estuary, and large-scale environmental variation. These biological opinions and HCPs, in addition to the watershed specific information in the Puget Sound Salmon Recovery Plan mentioned above, provide a current and comprehensive overview of baseline habitat conditions in Puget Sound and are incorporated here by reference.

On November 9, 2020, NMFS issued a biological opinion for 39 habitat modifying projects in the nearshore marine areas of Puget Sound (NMFS 2020g). This biological opinion concluded that the proposed action would not jeopardize the continued existence of, nor adversely modify the critical habitat of Puget Sound steelhead, Hood Canal Summer Run (HCSR) chum salmon, PS/GB yellow rockfish, or PS/GB bocaccio. The opinion concluded that the proposed action would jeopardize the continued existence of, and adversely modify critical habitat for, PS Chinook salmon and SRKWs. The biological opinion provided a RPA to the proposed action. The RPA utilized a Habitat Equivalency Analysis methodology and the Nearshore Habitat Values Model to establish a credit/debit target of no-net-loss of nearshore habitat quality. The RPA was designed to achieve, at a minimum, a reduction of these debits to zero. The RPA provides a range of options for achieving this goal and avoiding jeopardy of PS Chinook salmon. The expected improvements to Chinook salmon abundance resulting from implementation of the RPA are expected to improve the amount of prey available for SRKWs. As a result, the RPA avoids jeopardy and adverse modification for SRKWs.

In addition to increased hatchery production, the funding initiative for U.S. domestic actions associated with the new PST Agreement includes funding for habitat restoration projects to improve habitat conditions for specified populations of Puget Sound Chinook salmon (NMFS 2019e). By improving conditions for these populations, we anticipate Puget Sound Chinook abundance would increase, also benefiting SRKW. The FY20 and FY21 appropriated funds for implementation of U.S. domestic actions associated with the new PST Agreement includes $10.4 million in support of this habitat restoration effort. 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

The projects funded through 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. These projects are reviewed for consistency with the Habitat Restoration Program 4(d) Rule, Limit 8 design constraints specified in NMFS biological opinion (NMFS 2006c). These constraints are expected to limit the adverse effects of constructing the projects to ESA listed fish. NMFS is ensuring projects have ESA and NEPA coverage before they can utilize federal funds.

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[31], 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

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

at levels that can affect adult and juvenile rockfish habitat and/or the prey that support them. Toxic pollutants in Puget Sound include oil and grease, PCBs, phthalates, PBDEs, and heavy metals that include zinc, copper, and lead. Several urban embayments in Puget Sound have high levels of heavy metals and organic compounds (Palsson et al. 2009). There are no studies to date that define specific adverse health effects thresholds for specific toxicants in any rockfish species; however, it is likely that PCBs pose a risk to rockfish health and fitness (Palsson et al. 2009). About 32 percent of the sediments in the Puget Sound region are considered to be moderately or highly contaminated (PSAT 2007), though some areas are undergoing clean-up operations that have improved benthic habitats (Sanga 2015).

Washington State has a variety of marine protected areas managed by 11 Federal, state, and local agencies (Van Cleve et al. 2009), though some of these areas are outside of the range of the rockfish DPSs. The WDFW has established 25 marine reserves within the DPSs' boundary, and 16 host rockfish (Palsson et al. 2009), though most of these reserves are within waters shallower than those typically used by adult yelloweye rockfish or bocaccio. The WDFW reserves total 2,120.7 acres of intertidal and subtidal habitat. The total percentage of the Puget Sound region within reserve status is unknown, though Van Cleve et al. (2009) estimate that one percent of the subtidal habitats of Puget Sound are designated as a reserve. Management of reserves varies greatly by region, including conservations areas with prohibited fishing enforced by WDFW, to voluntary no-take areas monitored by the local community (Van Cleve et al. 2009). 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).

NMFS 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).

In 2020, NMFS conducted a programmatic consultation resulting in a biological opinion (NMFS 2020f) on the effects to rockfish and other non-salmonid listed species for the proposed action to determine that salmon and steelhead hatchery production and release in Puget Sound watersheds within the next 10 years meet the criteria described under limit 6 of the ESA 4(d) rules (50 CFR § 223.203(b)(6)). This analysis looked at 19 bundled hatchery genetic management plans (HGMPs) in the Puget Sound region, and analyzed the estimated consumption of Puget Sound/Georgia Basin yelloweye rockfish or bocaccio larval rockfish by juvenile Chinook and coho salmon produced in those hatchery programs. The model developed to estimate consumption of larval rockfish produced conservative annual take estimates equivalent to four yelloweye and seven bocaccio adult equivalents, and NMFS concluded that the proposed action is not likely to jeopardize the continued existence of Puget Sound/Georgia Basin yelloweye rockfish or bocaccio.

Listed Puget Sound rockfish are taken as bycatch in fisheries for other species in the action area.

In its five year review of Puget Sound rockfish, NMFS discussed cumulative fisheries management effects pertinent to rockfish that is part of the environmental baseline in the Puget Sound area (NMFS 2016a). These included the analysis of impacts from bycatch of Puget Sound/Georgia Basin yelloweye rockfish or bocaccio in the halibut and other bottom fish fisheries (NMFS 2018e). These estimates are used in consideration of Integration and Synthesis (section 2.7.3, Table 36). In addition, NMFS briefly summarized 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, to limit impacts to rockfish that also inhabit those waters. The WDFW extended the closure west of the rockfish DPSs' boundary to prevent commercial fishermen from concentrating gear in that area. The previously active commercial fisheries closures listed above were originally enacted on a temporary basis and WDFW permanently enacted them in February 2011. The inactive pelagic trawl fishery was closed by permanent rule on the same date.

The DPS area for yelloweye rockfish and bocaccio includes areas across the Georgia Basin (Figure 7 and Figure 8), thus the status of the environmental baseline is influenced by rockfish management within both Puget Sound and Georgia Strait. 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 no more than half of natural mortality (Walters and Parma 1996; PFMC 2000).

These conservation 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

RCAs 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. As 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 low 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 SRKWs, 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. It is likely that the three primary threats are acting together to impact the whales rather than any one of the threats being primarily responsible for the status of SRKWs. In addition, a number of other factors have been identified as potential threats to SRKWs. These include, but are not limited to: additional anthropogenic threats (risks of ship strikes, potential effects of oil spills,), disease, ecosystem effects (competition from other populations of fish-eating killer whales, and other marine mammals including seals and sea lions), inherent risks associated with small populations (inbreeding depression, demographic stochasticity, skewed sex ratios at birth with unknown causes), and behavioral risks (infanticide, Allee effects)(NMFS 2008g; 2016m). Available data suggests that all the threats are potential limiting factors. Subsequent sections describe conditions in the Environmental Baseline resulting from the primary threats. The majority of the factors that affect the whales' status throughout their geographic range, also affect the whales and their critical habitat within the action area. As a result, most of the topics addressed in the species' status section and critical habitat status sections are also relevant to the Environmental Baseline and we therefore, refer to the descriptions in the status or include only brief summaries in this section. Below, we briefly discuss prey availability, prey quality, vessels and noise, entrapment and entanglement in fishing gear, and oil spills in the action area.

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). Similar to past biological opinions (NMFS 2018c; 2019e; 2020d) our analysis of Puget Sound salmon fisheries focuses on effects to Chinook salmon availability to SRKWs (compared to other salmonids) because the best available information indicates that Chinook salmon are the SRKWs primary prey and that other prey species are much more abundant than Chinook (as described in section 2.2.1.4 Status of Southern Resident Killer Whales), therefore, in the Environmental Baseline, we focus on Chinook salmon prey availability. 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. Also as described in the Status of the Species, changing ocean conditions driven by climate change may influence ocean survival and distribution of Chinook and other Pacific salmon further affecting the prey available to SRKWs. Details regarding baseline conditions of ESA-listed Puget Sound Chinook salmon in inland waters 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 previous ESA Section 7(a)(2) consultations covering effects to SRKWs from activities whose effects in the action area were sufficiently large in terms of reducing available prey that they were found likely to adversely affect or jeopardize the continued existence of the whales. We also consider ESA Section 7(a)(2) consultations on hatchery actions that are contributing prey to the whales. We then qualitatively assess the remaining prey available to Southern Resident killer whales in the action area.

Harvest Actions

Directed salmon fisheries that intercept fish that would otherwise pass through the action area and become available prey for SRKWs occur all along the Pacific Coast, from Alaska to California. In past harvest consultations including Puget Sound salmon fisheries—(NMFS 2010c; 2014b; 2015c; 2016f; 2017b; 2018c; 2019b; 2020d), Council-area salmon fisheries (NMFS 2008a; 2020b; 2021a), and salmon fisheries managed consistent with provisions of the PST (NMFS 2008e; 2019e)— we characterized the short-term and long-term effects these salmon fisheries have on the SRKWs via prey reduction from fishery operation. We considered the short-term direct effects to whales resulting from reductions in Chinook salmon abundance that occur during a specified year, and the long-term indirect effects to whales that could result if harvest affected viability of the salmon stock over time by decreasing the number of fish that escape to spawn.

Fisheries other than directed salmon fisheries may also catch Chinook salmon as bycatch, and this may include Chinook that would otherwise pass through the action area, but this is likely very limited. Specifically, the PFMC groundfish fisheries catch Chinook salmon as bycatch, but this is likely a very small number of Chinook from the action area as the majority of this bycatch is of Oregon/California stocks and the most recent biological opinion found the PFMC groundfish fishery is not likely to jeopardize ESA-listed Puget Sound Chinook (NMFS 2017e).

Salmon fisheries off Alaska, Canada, Washington, and Oregon are managed under the PST. The Treaty has annex agreements that provide detailed implementation provisions that are renegotiated periodically for multi-year periods ("PST Agreement"). The 2019 – 2028 PST Agreement currently in effect includes provisions limiting harvest impacts in all Chinook fisheries and refining the management of coho, sockeye, chum, and pink salmon within its scope. This 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 (2009-2018) 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). These reductions should result in more salmon 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, the fisheries should have a smaller effect in terms of reducing SRKW prey than under the previous agreement. This smaller effect was seen in the analysis described below.

In its 2019 opinion on domestic actions related to the 2019-2028 PST Agreement (NMFS 2019e), NMFS assumed that the State of Alaska would manage its SEAK salmon fisheries consistent with the provisions of the Agreement. Using methodology similar to previous biological opinions completed up to that time (e.g. NMFS 2019b), NMFS estimated that the percent reductions of Chinook salmon in inland waters of WA from the SEAK fisheries were expected to range from 0.1% to 2.5% with the greatest reductions occurring in July – September. Percent reductions in coastal waters of WA and OR from the SEAK fisheries were expected to range from 0.2% to 12.9%[32] and similarly the greatest reductions would occur in July – September. Percent reductions from Canadian salmon fisheries were expected to range up to 13.2% in coastal waters and up to 12.9% in inland waters, with greatest reductions in July to September, and also greater inland water reductions in May-June than Puget Sound or PFMC fisheries (NMFS 2019e). 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 2019e). Percent reductions of Chinook salmon from the Canadian salmon fisheries under the 2009 PST Agreement ranged up to 13.5% in inland waters and up to 14.6% in coastal waters (NMFS 2019e).

Salmon fisheries in the Southern US are managed to meet specific objectives for ESA-listed and non-listed salmon ESUs and, as a result, can have impacts lower than what is allowed by the PST Agreement, particularly for Chinook. Fisheries in the EEZ off the US West Coast are managed by the Pacific Fishery Management Council and NMFS under the MSA. NMFS has issued biological opinions addressing the effects of these fisheries on all affected ESA-listed salmon ESUs, and on SRKWs, and fisheries are managed consistent with the proposed actions and ITSs

[32] 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 (PFMC 2020b). We provide general percent reductions from SEAK and Canadian salmon fisheries, but this warrants caution in comparing these reductions to those estimated by the Workgroup.

in these opinions.

The 2009 biological opinion on the Pacific Coast Salmon Plan (NMFS 2009b) for SRKW examined the direct effects from vessels and indirect effects from prey reduction by the PFMC ocean salmon fishery in the U.S. Pacific EEZ and determined that the action was not likely to jeopardize SRKW or adversely modify critical habitat. On April 12, 2019, NMFS reinitiated consultation to consider the effects of the fisheries on SRKWs given the change in the whales' status and the 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 SRKWs and 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 SRKWs.

In June 2020, The Workgroup finalized its risk assessment to help inform the Council of potential impacts on SRKWs as a result of implementing the FMP (PFMC 2020b). In the final SRKW Ad Hoc report (PFMC 2020b), 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 PFMC salmon fisheries. They found that the PFMC salmon fisheries reduced Chinook salmon prey availability in the Salish Sea by up to 3.1 percent (see (PFMC 2020b), Appendix E Table 3). In its 2020 biological opinion, NMFS used the best available science and relied heavily on the PFMC Workgroup's draft risk assessment at the time and concluded the proposed action (PFMC's recommended fishery management measures for 2020) was likely to adversely affect but was not likely to jeopardize the continued existence of SRKWs and not likely to destroy or adversely modify current or proposed critical habitat (NMFS 2020a). Reduction of Salish Sea Chinook salmon by PFMC fisheries were expected to be 1.8% in 2020.

In 2021, NMFS consulted on the authorization of the West Coast Ocean salmon fisheries through approval of the Pacific Salmon Fishery Management Plan including Amendment 21 and implementation of the Plan through regulations. The PFMC, in November 2020, adopted proposed Amendment 21 to address effects of Council-area ocean salmon fisheries on the Chinook salmon prey base of SRKWs. The proposed Amendment, if approved by NMFS, would establish a threshold representing a low pre-fishing Chinook salmon abundance in the North of Falcon (NOF) area (including the EEZ and state ocean waters), below which the Council and states would implement specific management measures (NMFS 2021a). The NOF abundance threshold is equal to the arithmetic mean of the seven lowest years of time step 1 (TS1, see (PFMC 2020b) for details) starting abundance from the FRAM (1994 – 1996, 1998 – 2000 and 2007, updated for validated run size abundance estimates). The threshold based on these years is currently estimated[33] at 966,000 Chinook salmon. Each year, the preseason estimate of Chinook

[33] This threshold is the arithmetic mean of the seven lowest years of pre-fishing Chinook salmon abundance estimated to be present on October 1 in the area North of Cape Falcon (1994 – 1996, 1998 – 2000, and 2007). Should updates or changes occur to models that affect these historic estimates of abundance, the threshold should be recalculated using the same approach.

salmon abundance for TS1 for the upcoming fishing year would be compared to the threshold. In years when the projected preseason abundance of Chinook salmon in the NOF area falls below the low abundance threshold, multiple management actions (e.g. quota adjustments and spatial/temporal closures) will be implemented through annual regulations within the NOF area, with the goal of limiting effects of the fishery on SRKWs. NMFS' 2021 biological opinion concluded that the FMP including Amendment 21 is responsive to the abundance of Chinook salmon by requiring that fisheries be designed to meet FMP conservation objectives and addresses the needs of the whales by limiting prey removal from the fisheries in NOF areas during years with low Chinook abundance. Amendment 21 will also reduce the potential for competition between fisheries and SRKW in times and areas where/when the fisheries and whales overlap, and when Chinook abundance is low. Therefore, NMFS concluded the proposed action is not likely to jeopardize the continued existence of the Southern Resident killer whale DPS or destroy or adversely modify its designated or proposed critical habitat (NMFS 2021a). This action may limit the reductions in prey availability by PFMC fisheries on Salish Sea (action area) prey in years with low salmon abundance, compared to the FMP without Amendment 21, but the extent of the impacts of the amendment on inland prey availability specifically is unknown. In years when Chinook abundance is above the threshold, we anticipate similar reductions in prey availability attributed to the PFMC fisheries as that observed in the most recent 10-yr period into the foreseeable future (similar to the approximate 1-3% reduction in Chinook abundance in Salish Sea).

Recent biological opinions considering the effects of Puget Sound salmon fisheries on SRKWs have similarly considered percent reductions in Chinook prey expected from the fisheries. Based on retrospective analyses similar to earlier biological opinions, the range in percent reductions in prey that occurred from Puget Sound salmon fisheries from 1999 – 2014 was estimated to be 0.5% - 9.3% in inland waters and up to 1.1% in coastal waters (NMFS 2019e). In the most recent biological opinion on federal actions related to the salmon fisheries in Puget Sound (NMFS 2020d), NMFS estimated that the percent reductions of Chinook salmon from the tribal and state Puget Sound fisheries in 2007-2016 in inland waters of WA annually were estimated to range from 2.6% to 4.7%[34] with the greatest reductions occurring in July – September. Percent reductions in overall abundance from the Puget Sound salmon fisheries of Chinook in the Salish Sea in 2020/2021 were predicted to be similar to average reductions and were estimated to be 3.3% relative to the starting abundance (Cunningham 2021). The pre-season estimate for abundance of age 3-5 Chinook salmon in inland waters (Salish Sea) for 2020/2021 was 628,000—slightly higher than estimated abundance for the retrospective time period (2007-2016) post-season average of 612,000 fish. Although some of the prey reduction due to the Puget Sound fisheries occurs in an area known for its high SRKW use and is considered a foraging hot spot (an area where SRKWs are frequently detected or sighted such as the west side of San Juan Island), in recent years recreational fishery restrictions in the summer and winter, very limited commercial fishing, and minor tribal fishing, were expected to limit the impacts in this hot spot. Also, additional management measures were implemented to reduce impacts of vessel and noise

34 Similar to the SEAK salmon fisheries (NMFS 2019e), the methodology to estimate this percent reduction differs from the PFMC SRKW Ad Hoc workgroup and warrants caution in comparing impacts.

disturbance.

Finally, recreational halibut fisheries in the action area have very limited bycatch mortality of Chinook (less than 2 Chinook on average each year), commercial and tribal halibut fisheries likely do not have incidental catch, and bottomfish and shrimp trawl fisheries have limited authorized incidental take (lethal take of up to 50 Chinook) (see section 2.4.1 Environmental Baseline for Puget Sound Chinook and Steelhead).

In summary, these analyses suggested that in the short term, prey reductions from ocean and past Puget Sound fisheries within the action area were small relative to remaining prey available in the action area, though the reductions of Salish Sea prey attributable by most fisheries are mainly highest in summer months (July-September) when the whales primarily occur in the action area. The directed salmon harvest biological opinions referenced above all concluded that the harvest actions cause prey reductions in a given year and were likely to adversely affect but were not likely to jeopardize the continued existence of ESA-listed Chinook salmon or SRKWs. Additionally, proposed Amendment 21 to the Fishery Management Plan for the ocean salmon fisheries, if approved by NMFS, would incorporate the needs of the whales by limiting prey removal from the fisheries in NOF areas, and could limit reduction of Salish sea prey availability by PFMC fisheries in low abundance years.

Hatchery Actions

Hatchery production of salmonids has occurred for over 100 years.   There are approximately 104 hatchery programs that release hatchery fish into streams and rivers that flow into the Puget Sound and many more that contribute salmon to Washington, Oregon coastal waters that may move into the action area. Roughly 60% of the SUS West Coast hatchery production comes from Washington state hatcheries, including: Chinook, coho, steelhead, sockeye, and chum juveniles, totaling over 150 million combined juveniles released (NMFS unpubl. Data). Puget Sound Chinook salmon stocks are the dominant Chinook populations present throughout the action area, with Fraser River Chinook stocks contributing significantly to the Strait of Juan de Fuca and north Puget Sound areas and non-Salish stocks contributing to a lesser degree (based on catch, see Appendix E Pacific Salmon Commission 2019; also see (Shelton et al. 2019)). Puget Sound hatcheries have current releases of almost 70 million juvenile Chinook and coho each year (in addition to hatcheries for sockeye, chum, steelhead, and pink as well) (see (NMFS 2020f). Many of these fish contribute to both fisheries and the SRKWs' prey base in the action area.

NMFS has completed section 7 consultation on over 200 hatchery programs in over 45 biological opinions (see Table 17 in section 2.4.1 and refer to Appendix A (NMFS 2021a)). A detailed description of the effects of these hatchery programs can be found within the site-specific biological opinions referenced in NMFS (2021a) (Appendix A, Table A.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 SRKWs (Barnett-Johnson et al. 2007; NMFS 2008h). Prey availability has been identified as a threat to SRKW recovery, and we expect these hatchery programs to continue benefiting SRKWs by contributing to their prey base.

Hatchery programs to support critical Chinook populations and increase SRKWs' prey base

As discussed in detail in the Environmental Baseline for Puget Sound Chinook and steelhead (section 2.4.1), there are initiatives to increase hatchery production to further enhance prey availability for SRKWs. The Washington State Legislature provided ~$13 million of 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) and NMFS allocated $5.6 million of the PST federal appropriation for FY 20 to increase prey availability for SRKW through hatchery production. These new initiatives are expected to result in the release of over 18 million additional hatchery-origin Chinook in 2021, and to contribute towards the goal of increasing adult fish abundance by 4-5 percent in both inside (Puget Sound) areas in the summer and coastal areas in the winter. NMFS has and will continue to work with hatchery operators and funders to ensure that all increased hatchery production to support SRKWs has been thoroughly reviewed under the ESA (and NEPA as applicable) to ensure that it does not jeopardize the survival and recovery of any ESA-listed species or adversely modify critical habitat. All of the completed analyses have determined that the hatchery programs will not jeopardize listed salmonids.

Habitat Actions

As discussed in Section 2.4.1, activities that affect salmon habitat such as agriculture, forestry, marine construction, levy maintenance, shoreline armoring, dredging, hydropower operations and new development continue to limit the ability of the habitat to produce salmon, and thus limit 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 nearly all met the standard of not jeopardizing the continued existence of the listed salmonids or adversely modifying their critical habitat, and when they did not meet that standard, NMFS identified RPAs. 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 past activities that pre-date the salmon listings. Since the SRKWs were listed, federal agencies have consulted on impacts to the whales from actions affecting salmon by way of habitat modification.

Activities that NMFS has consulted on that affect salmon habitat and therefore also likely limit prey available to SRKWs are discussed in detail in the Puget Sound Chinook salmon Environmental Baseline section (see section 2.4.1). Briefly, these include hydropower projects (Mud Mountain Dam (NMFS 2014d); Howard Hanson Dam, Operation, and Maintenance (NMFS 2019d)), the National Flood Insurance program (NMFS 2008g), and 39 habitat modifying projects in the nearshore marine areas of Puget Sound (NMFS 2020g). When actions did not meet the standard of not jeopardizing the continued existence of the listed salmonids or SRKWs or not adversely modifying their critical habitat, NMFS identified RPAs.

In addition to increased hatchery production, the funding initiative for U.S. domestic actions associated with the new PST Agreement (NMFS 2019e) includes funding for habitat restoration projects to improve habitat conditions for specified populations of Puget Sound Chinook salmon. By improving conditions for these populations, we anticipate Puget Sound Chinook abundance would increase and thereby benefit SRKWs. See specifics on this action in Section 2.4.1 in the Environmental Baseline for Chinook salmon.

A proportion of Chinook salmon from coastal Washington/Oregon and Columbia River likely move into the action area, and could be available to SRKW as prey. In 2020, NMFS consulted on the operation and maintenance of 14 dams and also reservoir projects within the Columbia River System (CRS). Actions analyzed in the biological opinion included both operational (hydropower generation, flood risk management, navigation, and fish passage) and non-operational (habitat improvements, predator management, and hatchery programs) actions and the effects on eight salmon ESUs, five steelhead DPSs, and one DPS of Pacific Eulachon and associated critical habitat (NMFS 2020e). The consultation concluded that the action is not likely to jeopardize the continued existence of the species/populations or destroy or adversely modify critical habitat. The CRS opinion also included NMFS concurrence with the action agencies determination of not likely to adversely affect for the Southern North American green sturgeon DPS and for SRKW and critical habitat. The determination for SRKW considered the potential to affect prey availability through negative effects on the direct survival of juvenile and adult salmonids, including Chinook salmon, through the hydrosystem, however, concluded that any effects to SRKW prey base are insignificant or extremely unlikely because the CRS-funded hatchery production more than offsets any adverse effects of CRS operations and maintenance (NMFS 2020e).

In 2012, we consulted on the Environmental Protection Agency's Proposed Approval of Certain Oregon Administrative Rules Related to Revised Water Quality Criteria for Toxic Pollutants (NMFS 2012b). The opinion concluded that the proposed action would jeopardize the continued existence of several Chinook salmon ESUs including Lower Columbia River (LCR) Chinook salmon, Upper Willamette River Chinook salmon, Upper Columbia River (UCR) spring-run Chinook salmon, Snake River (SR) spring/summer Chinook salmon, SR fall-run Chinook salmon, and SRKWs. An RPA was identified in order to avoid jeopardy and not adversely modify or destroy designated critical habitat (NMFS 2012b).

On November 9, 2020, NMFS issued a biological opinion for 39 habitat modifying projects in the nearshore marine areas of Puget Sound. This biological opinion concluded that the proposed action would not jeopardize the continued existence of, nor adversely modify the critical habitat of Puget Sound (PS) steelhead, HCSR chum salmon, PS/GB yellow rockfish, or PS/GB bocaccio. The opinion concluded that the proposed action would jeopardize the continued existence of, and adversely modify critical habitat for, PS Chinook salmon and SRKWs. The biological opinion provided a RPA to the proposed action. The RPA utilized a Habitat Equivalency Analysis methodology and the Nearshore Habitat Values Model to establish a credit/debit target of no-net-loss of nearshore habitat quality. The RPA was designed to achieve, at a minimum, a reduction of these debits to zero. The RPA provides a range of options for achieving this goal and avoiding jeopardy of PS Chinook salmon. The expected improvements to Chinook salmon abundance resulting from implementation of the RPA are expected to improve the amount of prey available for SRKWs. As a result, the RPA avoids jeopardy and adverse modification for SRKWs.

Assessing Baseline Prey Availability

We assessed Chinook salmon abundance in the action area by referring to the approach described in the PFMC SRKW Ad Hoc Workgroup Report (PFMC 2020b). Here, we briefly describe the method the Workgroup developed to estimate the starting abundance of Chinook available (age 3 and older) for fishery management years 1992-2016[35] within the action area (for more information see (PFMC 2020b)). Here, we make the assumption that the range of Chinook salmon abundance experienced since 1992 is likely representative of the range of abundances we expect to see in future years and that Chinook salmon availability will continue to be variable as observed during this retrospective time period (1992 – 2016). However, the hatchery production component of the funding initiative related to U.S. domestic actions associated with the new PST Agreement is expected to increase the prey base in 3 - 5 years following initial implementation of increased production. The time frames for realizing benefits from improvements to habitat are longer. We recognize that there is a degree of uncertainty regarding whether Congress will provide the funding, in whole or in part, that was agreed to by the U.S. Section in a timely manner. The Puget Sound Chinook Environmental Baseline section (2.4.1.) and the biological opinion on PFMC ocean salmon fisheries provide details on funding levels for FY20 and FY21 as well as criteria to guide selection of hatchery and habitat projects to (NMFS 2021a). In the event future years of funding are not provided in time for actions to take effect during the agreement, or if the anticipated actions are not otherwise implemented through other means (e.g., non-fishing related restoration activities, other funding sources) this may constitute a modification to how effects on Puget Sound Chinook salmon and SRKW are considered in this and other opinions and reinitiation of consultations that incorporate the PST funding initiative would therefore need to be considered. As mentioned above, the goal of this funding initiative was a 4-5% increase in available prey in both inland areas in the summer and coastal areas in the winter, but these assumptions were not included in the Workgroup's prey availability assessment. Finally, for proposed Amendment 21 to the Fishery Management Plan for the ocean salmon fisheries, we do not assume any effect of this to prey availability in inland waters because such effect is uncertain.

Coastwide adult abundance estimates for most Chinook salmon stocks were generated using the Chinook FRAM (PFMC 2008a) post-season runs (Round 6.2 of base period calibration;

[35] This retrospective time period was chosen because the analysis is anchored to data from FRAM model runs, and 1992-2016 is the time period for which FRAM model runs were available at the time of the analysis.

10.29.2018[36]). 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 (2020a).

Rangewide ocean abundances were distributed among spatial boxes, including the Salish Sea, (see PFMC for the full descriptions of all the areas) based on estimates of the proportion of each stock found in each area each season, using combinations of FRAM and the state-space model from Shelton et al. 2019. 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 2020b) (and see (NMFS 2021a)). Estimated Chinook salmon abundance aggregated in the Salish Sea for each time step during the retrospective time period are provided in Table 18 (for abundance estimates in other spatial areas, refer to (PFMC 2020b)). These starting abundances are prior to natural mortality estimates or fishery mortality estimates for each time step, but are time step starting abundances for retrospective "validation" runs (so include all fisheries as they occurred in the past, see (PFMC 2020b)). The Workgroup agreed to use starting abundances as this was the most appropriate initial abundance estimate for the purpose of estimating reductions in area-specific abundance attributable to fishery removals. In the Effects section (section 2.5.4), to determine the effects of the Puget Sound fisheries, Puget Sound fishery mortalities from the season are removed and compared to the validation runs with all fisheries that occurred (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 from FRAM validation runs (refer to (PFMC 2020b); Appendix E for starting abundances Oct-April) and average across 1992-2016.

Year	Abundance (Oct-April)	Abundance (May-Jun)	Abundance (Jul-Sep)
1992	617,503	536,131	505,884
1993	597,917	516,769	477,551
1994	432,911	391,463	371,927
1995	499,009	433,619	400,785
1996	511,282	456,223	427,106
1997	685,887	613,734	585,095
1998	501,983	460,981	445,437
1999	638,095	564,870	521,409
2000	434,603	376,683	346,302
2001	706,838	636,786	578,708
2002	689,788	641,364	562,357
2003	677,026	637,947	574,859

[36] FRAM base period calibration gets updated periodically to incorporate updated information.

Year	Abundance (Oct-April)	Abundance (May-Jun)	Abundance (Jul-Sep)
2004	665,994	619,977	575,218
2005	600,369	533,457	480,767
2006	676,420	608,243	572,807
2007	546,292	471,641	417,635
2008	599,589	538,132	494,163
2009	441,117	407,882	370,880
2010	823,667	755,308	694,515
2011	607,614	565,745	512,867
2012	521,929	473,203	409,287
2013	740,847	714,636	635,368
2014	634,667	606,983	533,533
2015	639,575	626,729	562,006
2016	568,810	517,557	462,585
Average	602,389	548,242	500,762

We are able to estimate the prey energy requirements for all members of the SRKW 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; methodologies described in previous biological opinions; (e.g. NMFS 2019b). 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) modeled annual SRKW prey requirements and found that the whole population requires approximately 211,000 to 364,100 Chinook salmon per year, Based on dietary/energy needs and 2015 SRKW abundances, Chasco et al. (2017b) also modeled SRKW prey requirements and found that in Salish Sea and U.S. West Coast coastal waters[37], the population requires approximately 393,109, adult (age 1+) Chinook salmon annually on average across model simulations, including 217,755 in the Salish Sea (discussed in more detail below). These estimates can vary based on several underlying assumptions including the size of the whale population and the caloric density of the salmon, but 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.

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

[37] These estimates do not include prey requirements off British Columbia, Canada.

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 2019b), 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. Specifically, ratios of food energy from Chinook available compared to the whales' Chinook needs 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 from 1992-2016 (assuming a SRKW population size of 75 individuals, using maximum daily prey energy estimates, and using Chinook abundance derived from the FRAM validation scenario based on post season information that approximates what actually occurred; 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. 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 to develop the abundance estimates assumed constant adult mortality throughout the year and from one year to the next; 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 analyses suggest. Salmonids are prey for pelagic fishes, birds, and marine mammals (including SRKWs).

Specifically, marine mammal consumption of Chinook salmon in coastal waters has likely increased over the last 40 years. Chasco et al. (2017b) used a spatial, temporal bioenergetics model to estimate Chinook salmon consumption by four marine mammals - harbor seals, California sea lions, Steller sea lions, and fish-eating killer whales - within eight regions of the Northeast Pacific, including areas off the U.S. West Coast. This model represents a scenario where the predation is an additive effect and there is an adequate supply of salmon available to predators (i.e., there is almost never a deficit of salmon relative the predator demands), which may not reflect true prey availability to predators. Chasco et al. (2017b) determined that the number of individual salmon, including smolts, consumed by marine mammals in the entire Northeast Pacific (including inland waters of Salish sea) has increased from 5 to 31.5 million individual salmon from 1975-2015 (including juveniles). This includes an increase from 1.5 to over 3.9 million adult salmon consumed in the Northeast Pacific on average across model parameter uncertainty. Consumption of all salmon ages by pinnipeds in the Puget Sound has increased from 68 to 625 metric tons from 1970 to 2015 Chasco et al. (2017b). There is uncertainty around these specific values due to model parameter uncertainty, but the model predicted increase in predation on salmon from 1975 to 2015 does not change with variation in model parameters. With this increase, based on dietary/energy needs and 2015 marine mammal abundances, Chasco et al. (2017b) calculated that when species occur in inland waters of the Salish Sea, Southern Residents would consume approximately 190,215 adult salmon (age 2 and older), harbor seals 346,327 salmon age 2+, California sea lions and Steller sea lions combined would consume approximately ~60 adult salmon (sea lions mainly consume smolts). Again, these values represent a model scenario where there is a consistent abundance of salmon for consumption and are only based on the energetic demands and diet preferences of marine mammals, not necessarily true prey availability or consumption. These estimates provide a general indication of how many Chinook salmon need to be consumed to meet the biological needs of these marine mammals.

In summary, though abundance of Chinook salmon available at the beginning of a year (pre-fishing and pre-natural mortality) is substantially greater than the required amount of salmon needed by the Southern Resident killer whales, there is likely competition between Southern Residents and other predators and natural mortality of Chinook salmon may be high, further greatly reducing Chinook availability to SRKWs. The estimate of Chinook abundance available to the whales in the beginning of the year for the retrospective time period (1992-2016) in the action area (maximum estimates of prey available, Table 18) on average was roughly 602,400 Chinook salmon ages 3-5. However availability to the Southern Resident killer whales in the action area would be reduced based on dietary needs of other marine mammals as well as other predators (e.g. pelagic fish and sharks, and birds) though some of these predators are likely mainly consuming smolts. In addition, the available information suggests coastwide prey availability is substantially lower in the winter than summer in coastal waters and opposite in inland waters.

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 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 (a tributary to the Fraser River in British Columbia, Canada) (Mongillo et al. 2016). These populations are primarily distributed within the urbanized waters of the Salish Sea (DFO 1999; Weitkamp 2010). However, populations of Chinook salmon that originated from the developed Fraser River and had a more northern distribution in the coastal waters of British Columbia and Alaska (DFO 1999) had much lower concentrations of certain contaminants than salmon populations with more southern distributions like those from the Salish Sea and southern U.S. West Coast (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). Therefore, SRKW prey is highly contaminated, causing contamination in the whales themselves. Build-up of pollutants can lead to adverse health effects in mammals (see Toxic Chemical section in section 2.2.1.4). Nutritional stress, potentially due to periods of low prey availability or in combination with other factors, could cause SRKW to metabolize blubber, which can redistribute pollutants to other tissues and may cause toxicity. Pollutants are also released during gestation and lactation which can impact calves.

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 shown declines in the 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). The authors suggest the 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. 2019b). Smaller fish would have less caloric content (lower quality), so decreases in size of older Chinook salmon that are preferred by SRKWs could lead to SRKWs needing to consume more Chinook salmon than historically, in order to consume enough to match their caloric needs

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 SRKWs' 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 studies concluded that vessel traffic 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, although the true effect of vessel collisions on mortality is unknown.

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. Commercial shipping was also identified as a significant source of low frequency ambient noise in the ocean, which has long-range propagation and therefore can be heard over long distances. Additionally, over the past few decades the contribution of shipping to ambient noise has increased by as much as 12dB (Hildebrand 2009). Ship noise was identified as a concern because of its potential to interfere with SRKWs communication, foraging, and navigation (Veirs et al. 2016). In a study that measured ambient sound in a natural setting, SRKWs increased their call amplitude in a 1:1 dB ratio with louder background noise, which corresponded to increased vessel counts (Holt et al. 2009)(Holt et al. 2009). It should be noted that vessel speed also strongly predicts received sound levels by the whales (Holt et al. 2017)(Holt et al. 2017). It is currently unclear if SRKWs 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 SRKW whale behaviors in inland waters. 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 SRKWs.

In 2017, the Vancouver Fraser Port Authority conducted a voluntary slow-down trial through Haro Strait (Joy et al. 2019). They determined that a speed limit of 11 knots would achieve positive noise reduction results without compromising navigational safety through the Strait. Hydrophones were deployed at sites adjacent to the northbound and southbound shipping lanes to measure noise levels through the trial period from August to October. During that period, 61% of piloted vessels, including bulk carriers, tugs, passenger vessels, container ships, and tankers, participated in the trial by slowing to 11 knots through the Strait. When compared to the pre-trial control period, the acoustic intensity of ambient noise in important SRKW foraging habitat off the west coast of San Juan Island was reduced by as much as 44% (corresponding to a 2.5 dB reduction in median sound pressure level) when vessels slowed down through Haro Strait (Joy et al. 2019). The results of this *in situ* trial show that vessel speed can be an effective target for the management of vessel impacts.

Recent evidence indicates there is a higher energetic cost of surface active behaviors and vocal effort resulting from vessel disturbance in the Salish Sea (Williams et al. 2006; Noren et al. 2012; Noren et al. 2013; Holt et al. 2015). For example, Williams et al. (2006) estimated that changes in activity budgets in Northern Resident killer whales in British Columbia's inland waters in the presence of vessels result in an approximate 3% increase in energy expenditure compared to when vessels are 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.

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). SRKWs spent 17 to 21% less time foraging in inland waters in the presence of vessels for 12 hours, depending on vessel distance (see (Ferrara et al. 2017)). Although the impacts of short-term behavioral changes on population dynamics is unknown, it is likely that because SRKWs are exposed to vessels the majority of daylight hours they are in inland waters, and that the whales in general spend less time foraging in the presence of vessels, there may be biologically relevant effects at the individual or 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 SRKWs 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, 2019 and 2020 likely due to decreased viewing effort on SRKWs by commercial whale watching vessels, with an average of 10, 9, and 10.5 vessels with the whales at any given time, respectively (Frayne 2021). 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 (Frayne 2021), the maximum in 2020 was 39 (Frayne 2021). However, fishing vessels are also found in close proximity to the whales and vessels that were actively fishing were responsible for 7% of the incidents inconsistent with the Be Whale Wise Guidelines and federal regulations in 2020 (Frayne 2021). In 2020, 92% of all incidents (inconsistent with Be Whale Wise guidelines and non-compliant with federal regulations, see (Frayne 2021)) of vessel activities were committed by private/recreational motor vessels, 4% private sailing vessels, 3% U.S. commercial vessels, <1% commercial kayaks, <1% Canadian commercial vessels (possibly related to closures due to COVID-19 orders) and <1% by commercial fishing vessels (Frayne 2021). An overall decrease in incidents was recorded in 2020, but incidents by private recreational vessels increased as the season progressed possibly in response to reductions in COVID-19 restrictions. These incidents 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. For example, Kuehne et al. (2020) reported measurements of underwater noise associated with military aircraft using a hydrophone deployed near a runway off Naval Air Station (NAS) Whidbey Island, WA. The average of the underwater received levels detected was 134 ± 3dB re 1µPa. The frequency of the sound from these overflights ranged from 20 Hz to 30 kHz, with a peak between 200 Hz and 1 kHz. However, these peak levels are well below the best hearing sensitivity of the whales reported by Branstetter et al. (2017) to be between 20 and 60 kHz. 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), that may impact ability to access prey.

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

Entrapment and Entanglement in Fishing Gear

Drowning from accidental entanglements in nets and longlines is a minor source of fishing related mortality in killer whales, although not all incidents may be reported. One killer whale was reported interacting with a salmon gillnet in British Columbia in 1994, but did not get entangled (Guenther et al. 1995). Two killer whales have been recorded entangled in Dungeness crab commercial trap fishery gear off California (one in 2015 and one in 2016) (NMFS 2016m). 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 (Raverty et al. 2020)). In 1977, a SRKW from L pod (L8) drown in a net and recreational fishing lures and lines were found in the stomach upon necropsy. 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[38]. No entanglements, injuries or mortalities of SRKW have been reported in recent years.

Oil Spills

As described in the Status of the Species section, SRKWs are vulnerable to the risks imposed by an oil spill. 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 in the action area has increased since 2013 and inspections of high-risk vessels have declined since 2009 (WDOE 2017). In 2014, NOAA responded to 16 actual and potential oil spills in Washington and Oregon. Polycyclic aromatic hydrocarbons (PAHs), a component of oil (crude and refined) and motor exhaust, are a group of compounds known to be carcinogenic and mutagenic (Pashin and Bakhitova 1979). Exposure can occur through five known pathways: contact, adhesion, inhalation, dermal contact, direct ingestion, and ingestion through contaminated prey (Jarvela-Rosenberger et al. 2017), all of which could have adverse health effects to killer whales (see discussion in Status 2.2.1.4). In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, if they occur they may reduce prey availability for SRKWs.

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. As 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.

While harvesting of humpback whales no longer occurs within the region, the commercial harvest in the early 1900s effectively removed the population from the Salish Sea and it is only

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

recently beginning to return to historic numbers (Ivashchenko et al. 2016). From 2017 to 2019, the Whale Museum, the Orca Network, and the British Columbia Cetacean Sightings Network (BCCSN) recorded 1,972 opportunistic unique sightings of humpback whales in Washington waters, with some individual whales reflected across multiple sightings (Unpublished data from the Whale Museum and BCCSN)[39]. The largest number of sightings within the U.S. portion of the Salish Sea occurred in the summer and fall months (Figure 24[40]) and research is ongoing to use photo-identification to identify which breeding populations make up the humpback whales seen in inland waters of Washington.

[39] Data obtained from the Whale Museum and the B.C. Cetacean Sightings Network were collected opportunistically with limited knowledge of the temporal or spatial distribution of observer effort. As a result, absence of sightings at any location does not demonstrate absence of cetaceans.

[40] '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 were grouped by date, latitude and longitude, and the number of whales included in the report. The Whale Museum considers sightings within 15 minutes of each other within the same area to be the same sighting and only recorded one sighting. 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 do not include sighting within Canadian waters.

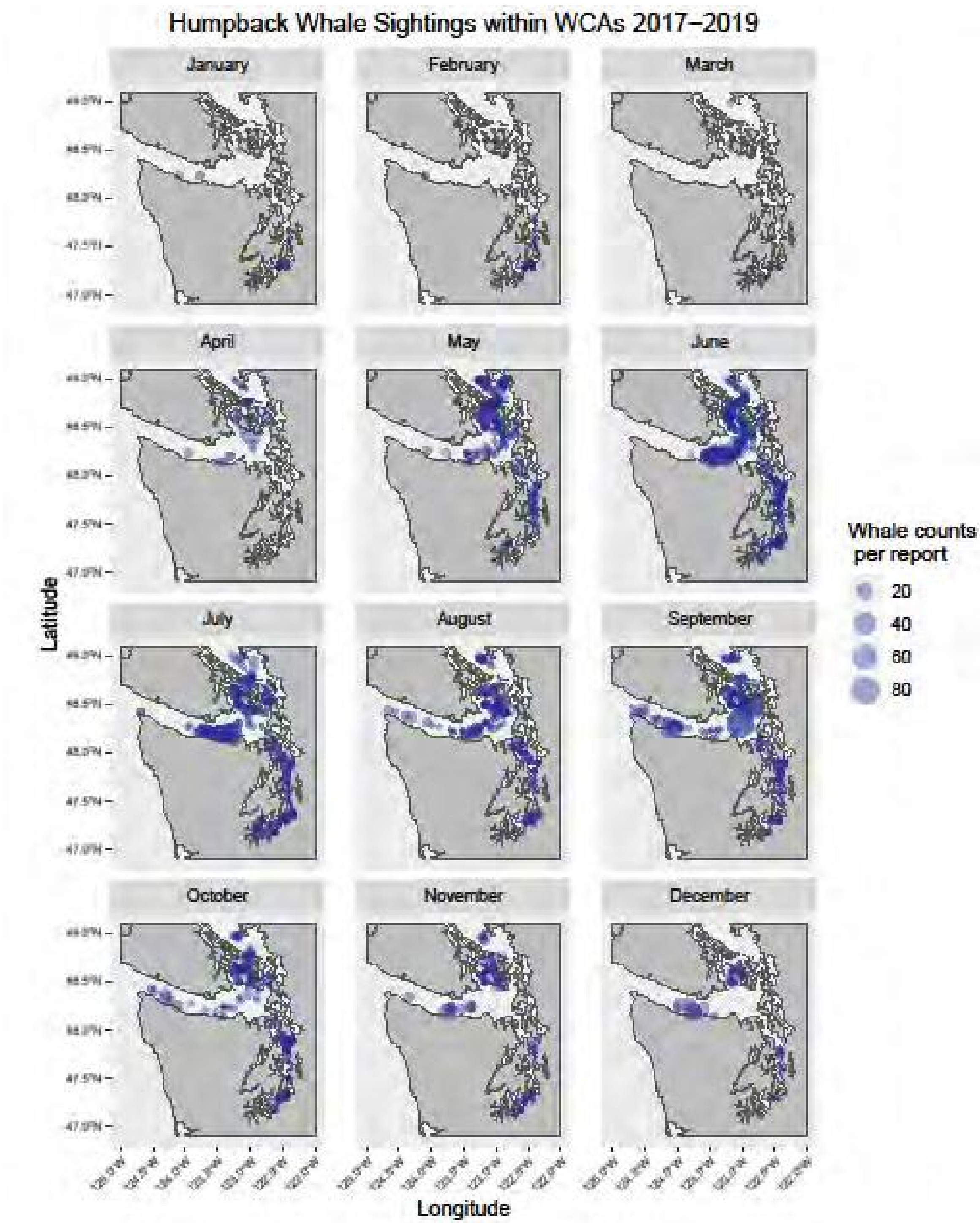

Figure 25. Humpback whale sighting reports from the Whale Museum, BCCSN, and Orca Network. Each dot represents a unique sighting report from 2017-2019. The size of the dot is proportional to the number of whales reported in the sighting. Sightings are opportunistic and not corrected for effort. Only reports within U.S. waters are reflected here.

Fisheries

Worldwide, fisheries interactions have an impact on many marine mammal species. 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 large whales along the West Coast since 2016 (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 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 in 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- 2020.

Year	Total Entanglements	Number of Confirmed Reports in WA (Inland Waters)	Number of WA Inland Waters Confirmed Reports	WA Coastal Dungeness Crab Entanglements**
2017	16	2	1	2
2018	33	7	3	2
2019	17	3	3	1
2020*	10	1	1	0***

*The number of reports in 2020 may have been reduced due to the COVID-19 pandemic and reduced entanglement response network capabilities.
**No entanglements of humpback whales have been reported as entangled in inland Dungeness crab gear.
***No humpback whales were reported as entangled in WA Dungeness crab gear, however one gray whale was entangled in this type of gear.

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[41]. Because the herring fishery in Puget Sound is small and humpback whales have a diverse prey base, it does not pose a concern for humpback whales in the region.

Natural and Anthropogenic Noise

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

Vessel sounds in inland waters are from large ships, passenger and car 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 possibly extend up to 24kHz (Au et al.

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

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 2019 and 2020, NMFS consulted on pier repairs 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[42]. 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.

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. 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 along with decreasing vessel speeds to 7 knots and limiting viewing time to 30 minutes[43]. These guidelines are voluntary and 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 Association also has guidelines to minimize impacts from their commercial whale watching activities. Fraser et al. (2020)found that commercial whale watch vessels in the Salish Sea are more likely to observe voluntary guidelines than recreational boaters with non-compliance rates of 14.4% vs 20% respectively when viewing humpback whales. However, commercial whale watch vessels committed more non-compliant interactions than other vessel types.

[42] NMFS consultation numbers: WCRO-202100066, WCRO-2020-02857, WCRO-2019-00556. Retrieved from https://www.fisheries.noaa.gov/resource/tool-app/environmental-consultation-organizer-eco

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

Ship strikes and other interactions with vessels occur regularly with humpback whales along the West Coast, with a small number in inland waters. Between 1995 and 2020, there were 31 reported ship strikes on humpback whales along the West Coast, 10 of which were within Washington waters (NMFS stranding database 2021). Of the whales struck along the West Coast, approximately 44 percent were reported as dead[44]. Multiple studies have found that the Washington outer coast and the eastern end of the Strait of Juan de Fuca represent areas of high risk of vessel strike for humpback whales (Nichol et al. 2017; Rockwood et al. 2017a; Miller 2020). Large vessels within this area are on average traveling at speeds that are likely to result in a fatal strike if a collision were to occur (Miller 2020). Additionally, there is considerable overlap between public sightings of humpback whales and the shipping lanes in the Salish Sea (Miller 2020). Two humpback whales were struck by vessels off of Clallam County, one in 2008 and one in 2016 (NMFS stranding database 2021). A humpback whale carcass was found near Neah Bay in 2018 and a necropsy confirmed that the whale was struck by a vessel (NMFS stranding database 2021). There is also overlap with humpback whale public sightings and ferry routes within the inland waters (Miller 2020), with a number of sighting reports from individuals on ferries themselves. 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 database 2021). Another humpback was presumed to be fatally struck by a Washington State ferry in July 2020. A different humpback carcass was found at Ocean Shores, WA with injuries consistent with a vessel strike in July 2020[45].

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 circulate within individuals and may cause adverse health effects. Due to their migratory behaviors and limited research, it is not clear at this time the degree to which pollution in the Salish Sea impacts humpback whales from the two listed DPSs.

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[44] Some of the recent vessel strike reports have not been officially reviewed and assigned a serious injury/mortality level. As such, the percent of strikes resulting in mortality will increase once these reports with initial assignments of mortality have been formally reviewed.

[45]https://www.cascadiaresearch.org/washington-state-stranding-response/humpback-whale-washed-near-ocean-shores-was-killed-apparent-ship

2.4.5 Scientific Research

The listed salmon, steelhead, rockfish, SRKW, 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. Additionally, there are stand-alone research and monitoring activities. 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 all 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 (Dishman 2021).

Species	Life Stage	Production/Origin	Total Take	Lethal Take
Puget Sound Chinook	Juvenile	Natural	388,621	8,676
		Listed hatchery intact adipose	86,433	2,966
		Listed hatchery clipped adipose	207,705	11,012
	Adult	Natural	859	34
		Listed hatchery intact adipose	937	10
		Listed hatchery clipped adipose	1,151	60
Puget Sound steelhead	Juvenile	Natural	45,796	1,124
		Listed hatchery intact adipose	2,309	38
		Listed hatchery clipped adipose	5,265	111
	Adult	Natural	1,814	39

Species	Life Stage	Production/Origin	Total Take	Lethal Take
		Listed hatchery intact adipose	22	0
		Listed hatchery clipped adipose	34	7
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 for three reasons. First, most researchers do not handle the full number of individual fish they are allowed. NMFS 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. Therefore it is very likely that fewer fish (in some cases many fewer), especially juveniles, than 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 take would occur in inland waters, with a small portion in the coastal range of SRKW. 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 takes 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 and 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. No lethal take of humpback whales is authorized under any of the existing research permits and is not anticipated.

2.5 Effects of the Action on Species and Designated Critical Habitat

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

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 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 Puget Sound co-managers propose to manage the Puget Sound Chinook fishery based on management units. These units are typically made up of individual river system populations and may also be identified by different life-history groups in the same water shed. Some management units contain one population and others, multiple populations, e.g., the Skagit Summer/Fall Management Unit comprises the Lower Skagit, Lower Sauk and Upper Skagit Chinook populations (Table 21). The co-managers propose to manage each of these units based on exploitation rate limits at the total, Southern U.S. (SUS), or pre-terminal SUS level (Table 21). This biological opinion analyzes the effect on each of the populations within each management unit, as described below, and then considers those effects at the MPG (Region) and ESU level.

NMFS must make a determination as to whether the action(s) will appreciably reduce the survival and recovery of the ESU. The Puget Sound Chinook salmon ESU comprises 22 populations. Therefore, to inform its determination, NMFS considers the distribution of risks to the individual populations across the ESU. The Viable Risk Assessment Procedure (VRAP), detailed in Appendix A provides estimates of the maximum, population-specific exploitation rates (called Rebuilding Exploitation Rates or RERs) that are associated with a high probability of attaining escapement levels which will maximize the natural production for each population (the rebuilding escapement threshold) and a low probability of escapements falling below levels at which the population may become unstable (the critical escapement threshold) due to effects of fisheries. In that way, the RERs are consistent with survival and recovery of that specific population, under current environmental conditions. The RERs are an important reference for NMFS in determining the likely implications of a proposed fishery for the viability/recovery of a population. When the exploitation rate from a proposed fishery is likely to be at or below the RER, that results in reasonable confidence that the likely effects of the fisheries pose a low risk to that population.

Comparison of the RERs to the results of the proposed action establishes an initial map of risk across the populations in the Puget Sound Chinook salmon ESU. However, it is not the only consideration in our overall jeopardy assessment, under the ESA. Our analysis also accounts for many other variables, both at the population and the region and ESU levels. . That information, together with the rest of the information described below informs NMFS' determination as to whether the proposed action would jeopardize the ESU. As detailed in the sections below, the RER analysis together with these additional elements can provide meaningful context for the potential effects to the specific populations. Collectively it informs NMFS' determination as to whether the proposed action would jeopardize the ESU, as well as the recovery of the ESU, as a whole. The jeopardy determination is made on the ESU, not based on effects to an individual population.

After taking into account uncertainty, the critical escapement 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.

For most populations, the rebuilding escapement thresholds are well below the escapement levels associated with recovery, however, under current conditions particularly for freshwater habitat, achieving escapement levels necessary for recovery is not possible. Achieving these rebuilding escapement levels under current conditions is a necessary step to eventual recovery when habitat and other conditions are more favorable. Therefore, in determining the rebuilding escapement thresholds, 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.

In deriving the RERs and escapement thresholds, 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 equivalents (NMFS and NWFSC 2018)(Table 21) for the purposes of assessing proposed harvest actions. FRAM is the analytical tool used by NMFS and the co-managers to assess proposed fishery actions within the action area.

NMFS has identified surrogates, for population-specific RERs, for those populations where data are currently insufficient or where NMFS has not completed population-specific analyses to establish population specific RERs. These "surrogate RERs" are determined based on populations with RERs that are similar in population size, life history, productivity, watershed size, and hatchery contribution. NMFS also considers the results of independent analyses conducted using other methods (e.g., analysis of maximum sustained yield (MSY) for the White River Chinook population provided by the co-managers) in determining the appropriate surrogate RER for a specific population.

Although component populations contribute fundamentally to the structure and diversity of the ESU, it is the ESU, not an individual population, which is the listed species under the ESA. NMFS uses the FRAM-equivalent RERs and the critical and rebuilding escapement thresholds, 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. 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, inclusive of all other fishery impacts to the specific population, 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, as stated above, where the proposed action would result in an exploitation rate that would exceed the RER for a population, NMFS considers other relevant information in assessing the risk to the population. Further, as also stated above, the RERs for individual populations do not constitute a jeopardy standard. Jeopardy is determined at the ESU level and takes into account our overall assessment of the risk from the proposed action to individual populations as well as the role of each population in recovery of the ESU as described in the recovery plan.

Table 21. Rebuilding Exploitation Rates by Puget Sound Chinook population. Surrogate FRAM-based RERs are italicized.

Region	Management Unit	Population	Rebuilding Exploitation Rate	FRAM-based Rebuilding Exploitation Rate
Strait of Georgia	Nooksack Early	N.F. Nooksack S.F. Nooksack	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%

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

While the attainment of total exploitation rates relative to the individual population's RERs (Table 21) is important information, it is not the only element that NMFS considers in assessing the effects of proposed fisheries on listed Puget Sound Chinook salmon populations, as described in this section. The risk to the ESU associated with individual populations not meeting their RERs must be considered within a broader context. Other information such as: NMFS' guidance on the number, distribution, and life-history representation of populations within the regions and across the ESU necessary for recovery; the role of associated hatchery programs; observed population status, and trends; and the effect of further constraints on the proposed actions are all elements NMFS considers in determining the impact of a proposed harvest action. NMFS evaluates the RER assessment in combination with this information to assess the likely effects of the proposed action on the individual population's viability and then to roll up these assessments at the regional and ESU levels to assess the overall effects on the survival and recovery of the ESU.

The objectives of the RERs are to achieve natural-origin 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 for exceeding the population's rebuilding abundance and not falling below the population's critical abundance (Table 5), when compared with the same productivity and survival conditions under a no harvest scenario. The RERs 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 (described in Appendix A). 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, when assessing the effects of a proposed fishery action, 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[46] 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.[47]

Individual populations within the listed ESU are also at increased risk if actual exploitation rates exceed the management objectives that are part of the proposed action. That is, the fisheries are managed to stay below their exploitation rate-based management objectives but in some years fisheries may exceed those rates if the assumptions on which the fisheries were planned preseason changes (e.g., abundance is lower than forecasted).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 used to develop the management objectives as well as the RERs. 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 management objective. 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 assumptions, The most recent estimates of observed exploitation rates, relative to their pre-season planned objectives, 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 any observed overages, and identify remedial actions designed to address any identified problems, to be implemented in future planning years.. 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 (Adicks 2016). The update of the FRAM model base period in late 2016, provided another opportunity for a high-level overview of management performance. This 2016 update of the FRAM model itself was designed in part to address identified problems and improve management by shifting the base period (reference

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

[47] 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; 2014e; 2015c; 2016f; 2017b; 2018c; 2019b; 2020d).

years) that the model utilizes to a more contemporary period accounting for the structure of more recent salmon fisheries. The co-managers conducted another performance review of two specific 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 annual 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%**	7% 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	6%	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%	49%	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 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 version 6.2 base period for FRAM (April 2019). This has resulted in revisions to some of the 2010-2016 actual rates, as compared to prior versions of this table.

*During the co-managers review and update to the FRAM base period (version 6.2, Oct, 2018), they also reviewed some population management objectives. For example, the Nooksack objective was updated to 10.5% SUS from the previous 7% SUS seen here.

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' considers its federal trust responsibilities to treaty Indian tribes. In recognition of treaty right stewardship, NMFS, as a matter of policy, has sought not to entirely eliminate tribal harvest (Secretarial Order 3206). 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 to Puget Sound Chinook analyzed in this section 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, 2021 through May 14, 2022 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. As described in the Environmental Baseline (Section 2.3.1), NMFS has previously consulted on the impacts of U.S. salmon fisheries outside Puget Sound (NMFS 2004a; 2008e; 2019e). 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 2021). Thus, Table 23 describes the sum of fishing-related mortality anticipated under the proposed 2021-2022 Puget Sound fisheries, except for the 2022 early spring Chinook fisheries (described below), as well as, that expected from the PFMC, Canadian, and SEAK fisheries.

Also included in Table 23 are the RERs and critical and rebuilding thresholds discussed above which NMFS considers in evaluating 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%), the Suiattle (32%) and the Upper Cascade (35%) populations. All of the population-specific RERs are shown in Table 21.

NMFS' critical and rebuilding escapement thresholds, described in section 2.5.1.1 (assessment approach), 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 methods and represent a variety of assumptions regarding levels of hatchery contribution based on the available information. NMFS expects the estimation 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.

Table 23. FRAM adult equivalent exploitation rates expected for the 2021 fishing season encompassing ocean and Puget Sound fisheries and escapements expected after these fisheries occur for Puget Sound management units compared with their FRAM RERs and escapement thresholds (surrogates in italics). Outcomes expected to exceed at least one population's FRAM RER within a management unit (top half of table) or fall below a population's critical escapement thresholds (bottom half of table) are bolded. Outcomes expected to exceed a populations rebuilding escapement threshold (bottom half of table) are underlined.

Region	Management Unit	Ocean (AK, CAN, PFMC)	Puget Sound	Ocean + Puget Sound	RER or RER surrogate
Georgia Basin	Nooksack early	25.2%	7.3%	**32.5%**	5%
Whidbey/ Main Basin	Skagit spring	13.3%	9.2%	22.5%	24-35%
	Skagit summer/fall	23.2%	15.7%	**38.9%**	36-49%
	Stillaguamish	11.7%	6.4%	**18.1%**	17-22%
	Snohomish	12.2%	4.5%	16.7%	19-20%
Central/South Sound	Lake Washington	16.1%	18.1%	**34.1%**	*5-24%*
	Duwamish-Green R	16.1%	38.6%	**54.7%**	17%
	White River	6.4%	14.9%	21.3%	*24%*
	Puyallup River	16.1%	31.3%	**47.3%**	*17-35%*
	Nisqually River	13.1%	34.6%	**47.7%**	*35%*

Region	Management Unit	Ocean (AK, CAN, PFMC)	Puget Sound	Ocean + Puget Sound	RER or RER surrogate
Hood Canal	Mid-Hood Canal R.	15.1%	7.5%	**22.6%**	*5%*
	Skokomish River	15.0%	34.2%	**49.2%**	35%
Strait of Juan de Fuca	Dungeness River	12.0%	2.5%	**14.4%**	*5%*
	Elwha River	11.6%	2.7%	**14.3%**	*5%*

Escapement		Natural (HOR+NOR)	NOR	Critical	Rebuilding
Georgia Basin	Nooksack Management Unit		464	400	500
	NF Nooksack (early)		**154**	*200*	-
	SF Nooksack (early)		310	*200*	-
Whidbey/ Main Basin	Upper Skagit River (moderately early)	7,017	6,587	738	5,740
	Lower Sauk River (moderately early)	400	400	*200*	371
	Lower Skagit River (late)	1,420	1,420	281	2,131
	Upper Sauk River (early)	871	871	130	470
	Suiattle River (very early)	431	431	170	223
	Upper Cascade River (moderately early)	141	141	130	148
	Stillaguamish R MU (NF + SF)[1]	906	317	400	502
	NF Stillaguamish R. (early)		**270**	300	550
	SF Stillaguamish R. (moderately early)		**47**	*200*	300
	Skykomish River (late)		1,876	400	1,491
	Snoqualmie River (late)		1,060	400	816
Central/South Sound	Cedar River (late)	778	547	*200*	282
	Sammamish River (late)	831	**73**	*200*	*1,250*
	Duwamish-Green R. (late)[2]	3,741	1,669	400	1,700
	White River (early)	2,281	497	*200*	488
	Puyallup River (late)	2,536	929	*200*	797
	Nisqually River (late)[2]	1,721	605	*200*	1,200
Hood Canal	Mid-Hood Canal Rivers (late)	18	**18**	*200*	*1,250*
	Skokomish River (late)	3,787	**182**	452	1,160
Strait of Juan de Fuca	Dungeness River	674	343	*200*	925
	Elwha River	4,783	215	*200*	*1,250*

Source: Chin3721_BiOpTab.xlsm (J. Carey, NOAA, pers. comm., April, 2021). Model output escapements adjusted to reflect natural-origin (NOR) or natural (hatchery-origin (HOR)+NOR) escapement as closely as possible using FRAM inputs, preseason forecasts or postseason data from previous years.

[1] Co-managers consider the Stillaguamish River to have two populations based on their return timing (early and moderately early) and consideration of genetic information collected after the completion of the Puget Sound Technical Recovery Team assessment. NMFS continues to estimate escapements for the North and South Fork Stillaguamish Rivers separately, consistent with the Puget Sound Recovery Plan and Puget Sound Technical Recovery Team assessment.

[2] 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.

Spring Chinook Fisheries

The Puget Sound annual salmon management period begins in the spring on a given year (May) and runs through the winter and into the next spring (May). The timing of this period is centered around the annual forecasting and pre-season planning processes in the PFMC and PSC forums. This presents a unique temporal situation for the harvest management of the spring-timed runs of Chinook salmon, in that, there are segments of two run-years of these populations presented in the annual period, unlike the summer- and fall-run Chinook where the single, annual runs occur fully within the annual management cycle. Mature spring Chinook salmon, from Puget Sound rivers, can begin their migration into freshwater in the late winter to early spring period each year and continue into the early summer period. This means that for annual salmon fishery management, portions of two, distinct annual runs of returning, mature spring Chinook salmon occur under the timeframe of the annual management plan, as demonstrated in Figure 26.

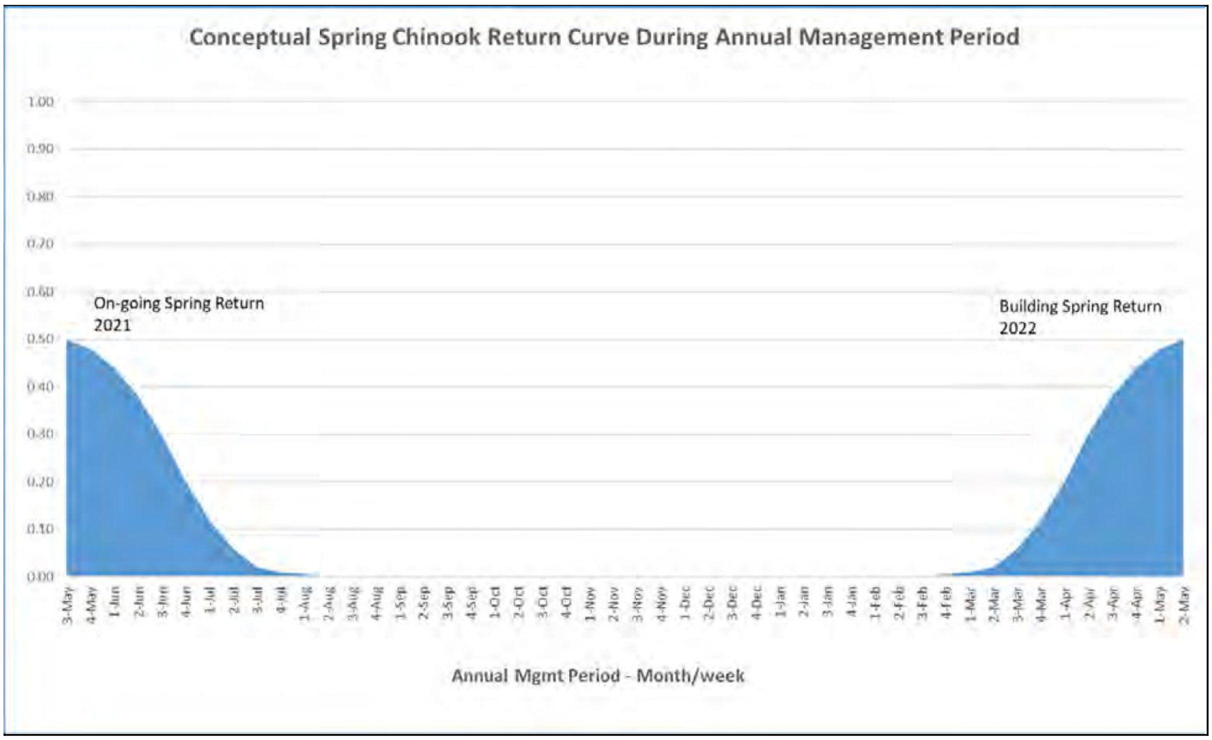

Figure 26. Conceptual representation of the two run-years of spring Chinook salmon encountered during the proposed annual Puget Sound salmon management cycle. Actual proportions of runs over time not accurately represented.

In order to manage the impacts of the spring Chinook fisheries for the full annual management cycle (May, 2021-May, 2022) and apply appropriate management constraints to the two individual run years, the co-managers propose to manage the fisheries targeting spring Chinook stocks consistent with the following conservation-based management objectives as described in Section 1.3 (Table 24).

Table 24. Management objectives and thresholds for early Chinook stocks in Puget Sound proposed for use by the Puget Sound co-managers for the 2021-2022 annual management cycle (Mercier 2021).

Management Unit/Population	Normal Abundance Regime			Minimum Fishing Regime	
	Exploitation Rate Ceiling		Escapement Goal	Low Abundance Threshold	Critical Exploitation Rate
	Total	southernUS			Southern US
Nooksack spring NF Nooksack SF Nooksack	Minimum Fishing Regime applies			 400 200	10.5%/13.5%*
Skagit Spring Suiattle Upper Sauk Cascade	37.5%			**823**** 170 130 170	10.3%
White River		22%	1,000	400	15%
Dungeness		10%		500	6%

(Mercier 2021)
* Expected total SUS exploitation rate will not exceed 10.5% in 4 out of 5 years and 13.5% in 1 out of 5 years
** If either the aggregate goal or any of the individual population goals are not reached, the exploitation rate in Southern US fisheries will not exceed the CERC. Otherwise the total RER ceiling will apply, in accordance with the Skagit MUP.

The assessment of the proposed spring Chinook fisheries for the May 1, 2021 through May 14, 2022 is structured in two parts. First is an evaluation of the proposed fisheries affecting Puget Sound spring Chinook management units in 2021, based on the 2021 FRAM modeling results and the final 2021-22 List of Agreed Fisheries (Mercier 2021). We then assess the likely impacts on the Puget Sound spring Chinook management units for the April-May 14th period in 2022. For the spring 2022 fishery, the co-managers will submit to NMFS a joint supplemental management plan for any proposed spring Chinook-directed fisheries in the spring of 2022, once the forecast and pre-season planning process in 2022 has been completed – usually by mid-April, annually. The supplemental plan would be coordinated between the co-managers and would will include: the forecasted spring Chinook management unit run size for the current year (2022, in this case); the management objectives applicable for that run-year based on the forecast—normal or critical (Table 24); an updated assessment estimate of allowable impacts and those estimated to be taken during the spring Chinook management period, prior to May 15, 2022.; plans for monitoring this period, and a description of how this fishery would operate within any limits in place for other ESA-listed species incidentally encountered during this fishery.

The proposed management objectives for the spring Chinook management units include objectives for normal abundance regimes (above low abundance thresholds) and minimal fishing regimes (at or below low abundance thresholds (Table 21). These low abundance thresholds (LAT) are typically set at or above the population's critical abundance thresholds, as described in section 2.2.2.1., and reduce the likelihood of short-term demographic risks to the populations. The minimum fishing regime objectives substantially limit the allowable harvest of the spring management units in SUS fisheries. Taken together, these help assure that when low abundance runs are forecasted for these spring MUs, that conservative fishing impact limits are in place to maximize the number of natural-origin spring Chinook adults in escapement. The Nooksack Management Unit exploitation rate limit does not change even if abundance is above the LAT (Table 21). This helps ensure that fishery related impacts from the SUS fisheries, including PS, do not add risk to the status of the Nooksack populations. Three out of the four MUs (Nooksack, White, and Dungeness) have conservation hatchery programs associated with the spring population. These fish help assure that total spawning abundances are maintained near or above the re-building abundance threshold and mitigate demographic risks at low population sizes, also described in section 2.2.2.1.

When forecasts for the Skagit, White, and Dungeness Management Units are above the LAT, the proposed management objectives allow additional harvest impacts to occur in the fisheries. For Skagit, the exploitation rate limit moves to a total exploitation rate limit in all fisheries (southern US and Northern US/Canada). For the White River and Dungeness, the limit moves to a less restrictive southern US limit. In the cases of Skagit and White River, the rate limits in the normal abundance regime (Table 21) are based on exploitation rates, which on average, should result in meeting or exceeding the rebuilding escapement levels for these populations. These rates are consistent with exploitation rates in proposed management plans for which NMFS has concluded the action would not pose jeopardy to the listed species.

Except in few years, for individual management units, the Puget Sound spring Chinook fisheries have a have a good history of meeting the annual management objectives for the individual management units and populations. In most years post season observed exploitation rates are substantially lower than the annual objective (Table 22).

Test, research, and in-season run size update fisheries, meant to inform harvest management decisions, are included as part of the total fishery-related mortality reflected in Table 23 and included in the rates discussed in the following paragraphs. Other research and monitoring activities that are not part of the proposed harvest, which have broader applicability to stock assessment, such as understanding the run-timing and spatial differences between populations within a management unit, are not included in Table 23. Mortality from this category of projects will not exceed a level equivalent to one percent of the estimated annual abundance (i.e. 1% ER), for any management unit, as described in the proposed action (See Section 2.5.6). A third category of research activities informing Puget Sound salmon fishery management are permitted under sections 7 and 10 of the ESA, or Limit 7 of the 4(d) Rule and are part of the Environmental Baseline (section 2.4.5).

Georgia Basin Region: 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 of these populations are genetically unique and thought to represent the indigenous profiles of the populations. They are both 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 escapement for the North Fork Nooksack is just below its critical escapement threshold and the South Fork Nooksack population is well below its critical escapement threshold (Table 5), indicating risk to the viability of both populations in this Region. Natural-origin spawners average only 180 for the North Fork Nooksack and only 56 for the South Fork Nooksack since the ESU was listed in 1999.

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[48]. 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). Results for the 2019 return indicate substantial spawners from the supplementation program contributed to the spawning population. This was particularly beneficial since the 4-year old 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.

When hatchery-origin spawners are included, average total spawning escapement for the North Fork and South Fork Nooksack populations is significantly higher. With the conservation program returns included the North Fork average total spawners is 1,532 (Table 5). The South Fork conservation program has brought the post-1999 average total spawning escapement above the critical threshold to 266 spawners and has contributed to total spawning escapements to the South Fork in excess of 600 for the 2016-2018 returns.

Average productivity (recruits/parent spawners) is 0.3 for the North Fork and 1.9 for the South Fork (Table 5). 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 more positive response

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48 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.

from the supplementation program in the South Fork, as described in the above paragraphs. Trends in total escapement (hatchery + natural spawners) are increasing and stable for the North Fork and South Fork Nooksack populations, respectively (Table 6). The growth rates for natural-origin escapement and natural-origin recruitment are stable and negative, respectively, for the North Fork (Table 6). This indicates that the numbers of natural-origin fish that are escaping the fisheries, relative to the parent generation, provide some stabilizing influence for abundance, and reduce demographic risks. However, the slightly negative (0.99; Table 4) growth rate for natural-origin recruitment may indicate a downward trend productivity over the data period. Growth rates for both natural-origin escapement and recruitment are negative for the South Fork population (Table 6) indicating the population is not maintaining itself relative to the parent generation. 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). However, recent-year (2015-18) increasing returns from the South Fork conservation hatchery program and of natural-origin South Fork adults may indicate signs for optimism (Table 6). These currently short-term increases are not yet affecting the long-term growth rate trend, given that long history of low levels of system production since 1990.

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 time as defined by the applicable Puget Sound harvest plan[49] (Table 22). Seventy-eight percent of the harvest occurred in Alaska and Canadian fisheries (Table 13).

The anticipated total exploitation rate resulting from the 2021 PFMC, PST fisheries and proposed actions is 32.5 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 small contributor to the overall rate (Table 24). With the proposed action, the North Fork population is anticipated to be below its critical thresholds (Table 24), 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 rebuilding threshold in 2021 given recent year hatchery-origin contribution rates (see Table 5) for comparison of natural spawning escapement and natural-origin spawning escapement). The South Fork population is expected to exceed its critical threshold for 2021. 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 Chinook annex (NMFS 2019e) specifically to provide greater protections to critical populations of Puget Sound Chinook, including the Nooksack populations.

Fisheries in the Strait of Juan de Fuca, northern Puget Sound, and the Nooksack River have been managed to limit fishery impacts to Nooksack spring Chinook since the late 1980s. Net, troll, and recreational fisheries in Puget Sound are regulated to minimize incidental natural-origin

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[49] The Nooksack management unit was managed for an objective of 7% exploitation rate in southern U.S. fisheries until 2016 when the FRAM model was updated. 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%.

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 of spring Chinook 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-tribal fishermen. Since 1997, there were limited ceremonial and subsistence fisheries in the lower Nooksack 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 tribal ceremonial and subsistence harvest of surplus North Fork hatchery fish. Additionally, in 2020, the State of WA opened a limited mark selective recreational fishery in the North Fork Nooksack River, targeting surplus hatchery-origin returns, which is planned for 2021 as well. Any proposed extension of the in-river C&S fishery in 2021, beyond June 30, would rely on in-season monitoring and an assessment of impacts to the populations to confirm that such fisheries will not result in exceeding the exploitation rate modeled in the pre-season and analyzed in this opinion. (Mercier 2021). The fishing-related mortality from all the fisheries is summarized in Table 24. In 2021, 82 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 Chin3721). If the proposed actions were not to occur in 2021, we estimate that at most an additional 15 and 27 natural-origin spawners would return to the North and South Fork Nooksack early Chinook escapements, respectively. 2022 Nooksack terminal area Spring Chinook fisheries, proposed to begin in April of 2022 and managed under the proposed conservation objectives (Table 21), would be expected to have a similar level of impact to natural-origin escapement, as described above, to the North and South Fork Nooksack populations. The Nooksack spring Chinook management unit objectives are developed to minimize the impact of SUS fisheries on natural-origin escapement. If the fishery were not to occur, we anticipate the number of additional natural-origin spawners that would return would be similar to that of recent years (i.e., 14-15 North Fork Nooksack River Chinook and 3-27 South Fork Chinook) as the management objective, general structure of the fishery and conservation programs are expected to be the same or similar to recent years. Neither the proposed 2021 or spring 2022 fisheries, that are part of the proposed action, will impact the Nooksack populations at a level that would change the status of the populations, relative to their critical or rebuilding abundance thresholds.

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 2021 anticipated exploitation rates are substantially higher than the RERs. However, the vast majority of harvest occurs in fisheries north of the U.S. border for the lower 48 states, including Canadian fisheries which are outside U.S. jurisdiction. Under the proposed actions, the exploitation rate on Nooksack early Chinook, within the action area, is expected to be low (<7.5%). 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 on SUS fisheries 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 2021 Puget Sound fisheries would not likely accrue meaningful benefits for either Nooksack population. The Kendall Creek hatchery program retains the indigenous profile of the North Fork Nooksack early Chinook. The South Fork Nooksack Chinook program is designed to retain and enhance the indigenous profile of that population. Both programs are key components for recovery of the Nooksack early Chinook salmon populations 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 further constraints to fisheries occurring in 2021 would not significantly change the status or trends of either population from what would occur without the fisheries. The populations will continue to rely on the conservation hatchery programs to preserve the genetic profiles and reduce demographic risks to the populations until factors limiting recovery are addressed.

Whidbey/Main Basin Region: The ten Chinook salmon populations in the Whidbey/Main Basin region are genetically unique and thought to represent the indigenous profiles of the Chinook populations in the Skagit, Stillaguamish, and Snohomish Rivers. These areas are managed primarily for natural-origin production. The ten populations comprise four management units (MUs): Skagit Spring MU (Suiattle, Upper Cascade and Upper Sauk), Skagit Summer/Fall MU (Upper Skagit, Lower Skagit and Lower Sauk), Snohomish MU (Skykomish and Snoqualmie) and the Stillaguamish MU (North Fork Stillaguamish and South Fork Stillaguamish)(Table 3). The six Skagit Chinook populations are in PRA Tier 1, the two Stillaguamish populations and the Skykomish population are in PRA Tier 2, and the Snoqualmie population is in PRA Tier 3 (Figure 1). 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). Hatchery contribution to natural escapement is extremely low (<11%) in the Skagit system and moderate (18%-51%) in the Snohomish and Stillaguamish systems (Table 5). 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 critical and rebuilding for the NF Stillaguamish and Lower Skagit populations (Table 5). Observed productivity from 1999-2015 broods is 1.0 or more for all but the North Fork Stillaguamish populations and 2.0 or greater for five of the ten populations (Table 5). Longer term trends (1990-2018) indicate declining growth in recruitment for the seven of the 10 populations (Lower Sauk, Upper Sauk, Suiattle, Upper Cascade, NF and SF Stillaguamish and Skykomish) (Table 6). With the exception of the South Fork Stillaguamish, long term trends in total natural escapement are stable or increasing (Table 6). Growth rates for natural-origin escapements are stable or increasing for seven of the 10 populations and all but the Upper Skagit are equal-to or higher than the growth rate for recruitment (Table 6). 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. Including the proposed action, total exploitation rates for eight of ten populations (Upper Skagit, Suiattle, Lower Sauk, Upper Sauk, Upper Cascade, NF Stillaguamish, Skykomish, Snoqualmie) are expected to be below their RERs in 2021 (Table 21 and Table 22). Exploitation rates on two populations (Lower Skagit and South Fork Stillaguamish) are expected to exceed their RERs in 2021. NMFS considers the proposed actions to present a low risk to the eight populations for which exploitation rates would not exceed their RERs. The exploitation rates in 2021 for the Lower Skagit and South Fork Stillaguamish populations are anticipated to exceed the RERs by a small (2.9 and 1.8 percentage points, respectively) amount. The exploitation rates in 2021 Puget Sound fisheries are expected to be relatively low across the four Whidbey/Main Basin management units (5%-16%) (Table 24). All populations in the region except the North and South Fork Stillaguamish are expected to exceed their critical escapement thresholds. Six of the 10 populations will also exceed their rebuilding escapement thresholds (Table 24) in 2021. For the North and South Fork Stillaguamish, if the proposed actions were not to occur in 2021, we estimate that an additional 2 natural-origin spawners would return to the South Fork Stillaguamish and an additional 11 natural-origin spawners would return to the North Fork Stillaguamish, 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 589 adult fish to augment the North Fork and South Fork spawning populations, reducing any short-term risk for these populations. There are two conservation hatchery programs in the Stillaguamish River for Chinook salmon—a summer-timed program and a fall-timed program. Both of these programs are small in size and incorporate natural-origin adults into the hatchery broodstock to maintain genetic integration in the hatchery fish. The use of natural-origin broodstock and the low abundance of natural-origin fish in these systems currently limits the size of the programs.

Skagit terminal area Spring Chinook fisheries, are proposed to begin in April of 2022 and would be managed under the proposed conservation objectives (Table 21) The Skagit spring Chinook management unit objectives are developed to achieve escapements that meet or exceed the rebuilding escapement threshold (Table 5) at normal run sizes (Table 21) and provide added protection for runs at critical run sizes by restricting the allowable level of southern US harvest to a rate that provides escapement above the populations' critical escapement thresholds (Table 5), on average. Exploitation rates on the Skagit Spring Chinook Management Unit have ranged from 15 to 28 percent over the last seven years, consistently well below the exploitation rate ceiling (Table 22). So it is reasonable to expect the early spring 2022 fisheries would have lower levels of impact to natural-origin escapement for the three Skagit spring populations (Upper Sauk, Suiattle, and Cascade) as the period of fisheries proposed to potentially take place in 2022 (April-May 14, 2022), would only act on a portion of the returns, limiting the scale of overall impact to the Skagit Spring Chinook Management Unit and to the individual populations. The managers could adjust the fishery if needed to ensure that impacts remain below the applicable exploitation rate ceiling once abundance forecasts for 2022 are available.

In summary, the effects of the proposed actions in 2021 and 2022 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 two of the 10 populations in the region indicates some potential, short-term risk to viability of these population, from the proposed fisheries. However, the increasing or stable trends in total escapement (hatchery and wild) and growth rate in natural-origin escapement across most of the populations, the robust status of the populations compared with their thresholds in 2021 for the Upper Skagit, Lower Sauk, Upper Sauk, Suiattle, Skykomish, and Snoqualmie populations should mitigate any increased risk to overall viability in the Whidbey/Main Basin Region. 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 2021. The number of additional spawners that would be gained from further fishery reductions is very low and would not change the status or trends of the Stillaguamish populations.

Central/South Sound Region: 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 (early) 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 (28%-80%) for the populations within this region (Table 5). NMFS determined the Nisqually and White River populations must eventually be at low extinction risk (high viability) to recover the ESU (NMFS 2006b). Management of the Nisqually population will need to transition from hatchery-based management (escapement to the river was a secondary consideration) 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, as well as several dams limiting upper watershed access (Cedar, Duwamish-Green, Puyallup/White, and Nisqually. The indigenous Chinook 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 2021, 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 (PSIT and WDFW 2017a; NMFS and NWFSC 2018). Average natural-origin escapement in the Cedar and White rivers exceeds their rebuilding escapement thresholds (Table 5). Observed productivity is 1.0 or more for four of the six populations (Table 5). Total escapement trends are stable or increasing for all populations within the region except for the Puyallup River, which is declining (Table 6). Growth rates for recruits and escapement are positive for the White River; negative for the Puyallup, and mixed for the Cedar, Sammamish, Duwamish-Green, and Nisqually populations (Table 6). As with most populations in other Puget Sound regions, the growth rates for escapement are generally higher than growth rates for recruitment, with the exception of Sammamish. 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 in escapement (NOR) and recruitment and a declining trend in total escapement suggests that the Puyallup population may be at a higher risk to viability than other populations in the region. However, the population's average natural-origin escapement is well above critical escapement threshold and just below the rebuilding threshold (Table 5), it is a Tier 3 population in terms of its role of recovery for the ESU (Figure 1) and its life history type is common within the region.

Natural-origin spawning escapements in 2021 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 24). The additional contribution of hatchery spawners to natural escapement for most of these populations (Table 24) 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 the 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 annual 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.[50] 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 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 in effect at that time, 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 (Dapp and Dufault 2018) are 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 2021, 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 5). 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 2021 are projected to result in 929 natural-origin fish escaping to the spawning grounds with an additional 1,607 hatchery origin recruits straying to the spawning grounds for a

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[50] 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.

total natural escapement of 2,536. These outcomes will result in natural-origin escapement above the rebuilding threshold.

Exploitation rates in 2021 for all 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, Duwamish-Green, Puyallup, and Nisqually) (Table 24), by substantial amounts. The White River population total exploitation rate in 2021 is expected to be above its RER but by a smaller margin (3.3%) than the other management units. 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 were extirpated, so the risk is not losing unique genetic of life-history diversity from the ESU. The observed increasing trend in total escapement for both the Cedar and Sammamish populations and stable growth rate in natural-origin escapement for the Cedar should mitigate increased risk as a result of exceeding the RER in 2021. In addition, escapement for the Cedar is expected to exceed its rebuilding threshold in 2021 (Table 24). If the Puget Sound salmon fisheries closed in 2021, we estimate that an additional 16 natural-origin spawners would return to the Sammamish population. These additional spawners would not 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 5). The low productivity of the watersheds given the much higher level of overall escapement (Table 5 and Table 24) suggests natural-origin recruitment will not increase much beyond existing levels unless constraints limiting marine, freshwater, and estuary survival for the Cedar and Sammamish 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 2021 Puget Sound salmon fisheries is 38.6 percent for a total exploitation rate of 54.7 percent for the 2021 fishing season (Table 24). This rate substantially exceeds its surrogate RER of 17 percent. Exceeding the RER infers an increased risk to the long-term viability of the population, which is also experiencing strongly declining growth rates in natural recruitment **(**Table 6**)**. However, it is important to consider the degree to which other factors and circumstances mitigate the risk. Growth rate for natural-origin escapement is stable and 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 2021 is just below the rebuilding threshold, well above the critical threshold (Table 24), 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 2021 for the Green River are consistent with the returns from those stronger brood years.

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 to the upper watershed, relative to the years preceding 2014, is hypothesized to be strongly linked to the success of the production provided by the Green River supplementation program in the upper watershed. Since 2017, approximately 30% of redd production has been estimated to come from supplementation returns, much of which can be attributed to redds constructed in the upper watershed (Pers Comm. Jason Schaffler, Muckleshoot Indian Tribe, May 2021).

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 in 2021 (Mercier 2021). The 1,200-escapement target is the average natural-origin escapement over the 10 years 2009-2018 including the much higher escapements observed in 2016 (2,566), 2017 (2,011) and 2018 (2,231). Terminal fisheries, as planned in the pre-season, 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 to meet the 1,200 NOR escapement objective, 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 2021 will ensure that the gains in recent years to natural-origin escapement are preserved, with additional opportunities to strengthen the trend[51].

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 34.6 percent for a total exploitation rate of 47.7 percent. This total exploitation rate is inclusive of an additional 0.7% in-river exploitation to evaluate mark-selective removal gears added to the current 47% objective (Table 24). 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-origin recruitment (Table 6) and a relatively low abundance of natural-origin escapement (Table 5). 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 2016; Thom 2017). The co-managers completed work on a transitional strategy in a December 2017 plan (Nisqually Chinook Work Group 2017; Mercier 2021) The 2017 plan now guides harvest and hatchery actions moving forward, including fisheries in 2021, and includes timelines, performance criteria and performance goals.

The indigenous Chinook population is extirpated and the objective is to recover the populations

[51] 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.

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 total natural escapement and a stable growth rate for natural-origin escapement (Table 6**)**. 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, in spite of the habitat's current low productivity, and thereby reducing demographic risks.

As mentioned above the Nisqually Indian Tribe's Natural Resources staff propose to continue a selective fishery gear study in the lower Nisqually River tribal net fishery in 2021. This will be the third year of this 5-year work, the first year (2019) being a trial year for various gear effectiveness at catching fish. In 2020, the tribe tested their initial preferred experimental gear[52] for short-term mortality. While the testing was limited due to the 2020 COVID-19 pandemic, they were able to fish for one day, during two separate weeks, and capture and hold (24hr period) 10 adult Chinook salmon from each day. The vast majority of the fish were captured and sampled in good condition, with only minor injuries observed on a couple of fish. The fish were transferred into in-river mesh bags to recover and were sampled and released after a 24 hr period. All 20 total fish were released the next day in category 1 condition – no observable injuries or diminished condition. This year's work will continue testing the short-term mortality of fish captured in the gear, with the objective to capture many more fish (100 or more), over a broader period of days and in a variety of conditions, both environmentally (river flow and temp) and fish densities (Chinook and pink salmon). The test fishery for 2021 is proposed to access up to an additional 0.7%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 is part of the longer-term transitional strategy and 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.

Given these circumstances, as discussed earlier, it is important to consider the degree to which, collectively, these actions mitigate the identified risk of exceeding the RER. The indigenous population is extirpated and the strategy for populations like the Nisqually, as described in Section 2.3.1, is to recover the extant populations using the individuals that best approximate the genetic legacy of the original population, reduce the effects of the factors that have limited their

[52] Small mesh gill net, fished in short drifts and pulled immediately, similar to a traditional multi-strand tangle net implementing live capture, selective removal.

production and provide the opportunity for them to readapt to the existing conditions. The reductions in harvest that have occurred in recent years and the fishery regime for 2021 are a part of the longer-term transitional strategy that is being coordinated with corresponding habitat and hatchery actions (Nisqually Chinook Work Group 2011). The strategy is to reduce harvest impacts in the short term while system capacity and productivity is tested and the other components of the strategy that will take longer to realize benefits (habitat protection and restoration, hatchery reform) take effect. 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 2021 is expected to be above its critical threshold, by 300%, lowering short-term demographic risk to the population. Total escapement is expected to exceed the rebuilding threshold, assuring that the available habitat with be fully utilized. Therefore, the additional risks associated with exceeding the RER in the 2021 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 69 percent of the harvest of unmarked Nisqually Chinook in 2021 Puget Sound salmon fisheries.

The Co-managers may propose fisheries in April 2022 to harvest White River spring Chinook. The fisheries, if proposed would be managed under the White River objectives in Table 24. These objectives limit the allowable SUS exploitation rate to 15% at critical run size and 22% at normal abundance run size. The management of these fisheries has been consistent with only two years out of the most recent 7 years available, where the annual objective was exceeded (Table 23). In other years, exploitation rates have ranged from 5 to 15 percent, well below the exploitation rate ceiling of 22%. So it is reasonable to expect the early spring 2022 fishery would have a lower impact on natural-origin escapement as the early 2022 fisheries (April-May 14, 2022), would only act on a portion of the returns, limiting the scale of overall impact to the White River Chinook Management Unit. The managers could adjust the fishery if needed to ensure that impacts remain below the applicable exploitation rate ceiling once abundance forecasts for 2022 are available. The population, which has been managed annually under the proposed objectives, has performed well, relative to its rebuilding escapement threshold, with a long-term average escapement of natural-origin fish above the rebuilding criteria (Table 5). Additionally, the population shows growth in both long-term natural-origin escapement and recruitment, indicating that harvest rates are not impeding the population from growth.

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 2021. Therefore, implementation of the proposed 2021 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 2021 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 Region: 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 Chinook 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 5) (Ruckelshaus et al. 2006). NMFS determined that both populations must be at low extinction risk to recover the ESU, so management of activities affecting both populations will need to transition from management based primarily on returning hatchery adult Chinook 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 fall Chinook salmon 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 Hamma Hamma 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 hatchery fall Chinook stock that is better suited to the historic flow regime, re-align the Chinook hatchery production at the George Adams Hatchery and adjust fisheries off of the later-timed Chinook run. 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 (200-300K release goal [53]) being collected in 2018, 2019, and 2020 (WDFW escapement reports) and the expectation of full program in 2021. 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, from the Skagit River basin, for spawning and subsequent juvenile release. Both the spring and late-fall programs are included as part of the proposed actions in 2021 (Unsworth and Grayum 2016; Speaks 2017; Shaw 2018; Norton 2019a; Mercier 2020). These programs are part of the comanagers' longer-term transitional strategy to recover natural origin Chinook salmon that is

[53] On-site release of 200K is primary objective. If additional broodstock are available, additional eggs will be collected to allow for released of up to 100K juveniles into Skokomish River tributaries. Surplus returning late-timed program adults may also be outplanted into tributaries.

being coordinated with corresponding habitat and hatchery actions (Skokomish Indian Tribe and WDFW 2010; Redhorse 2014; Skokomish Indian Tribe and WDFW 2017). In addition to the hatchery programs, 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 2017b). 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. This transition will likely 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 escapement goal management to management for natural spawning ground escapement, including an exploitation rate limit for unmarked (primarily natural origin) Skokomish Chinook of 50% beginning in 2010. The development of the late-timed fall Chinook hatchery program has been ongoing since brood year 2014. All brood years through 2019 met full program collection objectives, utilizing adults returning and maturing during the late time frame, including the first returning 3 and 4 year old fish from the late programs releases in 2015 and 2016. In 2020, low overall run size reduced the total numbers of fish available in the late collection window and a small portion of the late-program was back filled with eggs from the latest returning normal-time program (Mercier 2021).

Average natural-origin escapements from 1999-2018, for both the Skokomish and Mid-Hood Canal populations, are below their critical thresholds and productivity in the Skokomish is below 1.0 (Table 5). 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 the Skokomish population is stable, while the total escapement trend for the Mid-Hood Canal population is increasing (Table 6). The 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 (2019 forward) are not yet factored into the above trend. 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, up to 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 2018 (4yo returns).

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 22). 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 24). Total exploitation rates for both populations are expected to exceed their RER or RER surrogate (Table 24). For the Mid-Hood Canal population, the exploitation rate in 2021 Puget Sound salmon fisheries under the proposed actions is expected to be low (7.5%; Table 24). The forecasted natural-origin escapement for the Skokomish and Mid-Hood Canal populations is low and very low, respectively, relative to their critical abundance threshold. However, if Puget Sound salmon fisheries were closed in 2021, we estimate that only one additional natural-origin spawners would return to the Mid-Hood Canal population. Approximately 109 additional natural-origin Chinook spawners would return to the Skokomish River in the absence of Puget Sound salmon fisheries. This would not change the status of the Mid-Hood Canal Rivers population in 2021 relative to its critical and rebuilding thresholds and would not change the status of the Skokomish population by increasing spawning escapement above its critical threshold.

For the Skokomish population, the anticipated exploitation rate in 2021 under the proposed actions from Puget Sound salmon fisheries is 34.2 percent with a total exploitation rate in 2021 of 49.2 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 reduce the probability of the current Skokomish population exceeding the re-building escapement threshold by half (-50%), in that timeframe, compared with achieving the RER of 35 percent. The 50 percent exploitation rate would also result in 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 three years for which data are available 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 8.5%) 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 2021 schedule maintains the fishery closures implemented in recent years, resulting 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. These changes were made to protect returns of late-fall Chinook and bring the exploitation rate under the ceiling. 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, 2019, and 2020 (Bowhay and Warren 2016; Speaks 2017; Shaw 2018) and will continue to be closed in 2021 (Mercier 2021).

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 were corrected, adjusting the previous underestimate of fishing mortality by 0.8 percent (James 2018b). With the correction, three of the last four years' estimates of exploitation rates from the most recent FRAM validation runs (version 6.2 April, 2019) were equal to or below the objective (Table 22) (James 2018b; Rose 2018). Additionally, while the total exploitation rates for years since 2016 are not yet finalized, the harvest rates in the Hood Canal terminal area, including the Skokomish River, have continued to drop in recent years, The most recent five-year average terminal harvest rate (2016-2020) is 25% lower than the previous five-year average (2011-2015), and the most recent ten-year average (2011-2020) is 10% lower than the previous period (2001-2021) (Gray and Downen. 2021). These indicate that the performance review completed in 2018, coupled with the changes implemented in the terminal fisheries, as described above, have resulted in reduced harvest rates and more certainty of the annual fisheries meeting the pre-season management objective. 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 2021. 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 2021 Puget Sound fisheries, combined with the fisheries that occur outside of Puget Sound, are forecasted to achieve a 49.2% ER, 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 to the viability of the Skokomish Population from exceeding the RER. The indigenous Chinook population is extirpated and the strategy for populations like the Skokomish, as described in Section 2.3.1, is to recover the population 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 co-managers are undertaking this with the development of both the spring Chinook hatchery program and the late-timed fall Chinook hatchery program.

These programs are focused on enhancing the Chinook life history attributes that will most likely benefit from the ongoing habitat recovery, hydro-power mitigation, and harvest strategies being employed in the watershed (Skokomish Indian Tribe and WDFW 2017). The modification to harvest objectives that have occurred so far, including the 50% ceiling and the closure of terminal area fisheries during the late-returning fall Chinook period, are 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, the longer term transitional strategy, and in response to commitments in the 2010 Puget Sound Chinook Harvest RMP (PSIT and WDFW 2010a), the co-managers are also implementing 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, has been developed further as part of the proposed actions in 2018 (Shaw 2018), 2019 (Norton 2019a), 2020 (Mercier 2020), and proposed for 2021 (Mercier 2021). 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 long-term (1999-2018) total average escapement is above the rebuilding threshold (Table 5), the escapement trend of natural spawners is stable and, growth rates for natural-origin escapement are higher than growth rates for recruitment (Table 6). This indicates that current fisheries management is providing some stabilizing influence to abundance and productivity given current habitat conditions; 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 2021. Therefore, implementation of the proposed 2021 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 given the extremely low forecast for 2021. 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 2021 Puget Sound fisheries would not measurably affect the risks to survival or recovery for the Mid-Hood Canal population.

Strait of Juan de Fuca Region: 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, the benefits of these 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 are key to protecting the populations 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=0.96 growth rate of recruits, Elwha=0.89 growth rate of recruits, Table 6) 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—estimated at 1.0 recruits per spawner for both populations (Table 3). When hatchery-origin spawners are taken into account, average escapement exceeds the critical thresholds for both populations and is very near the rebuilding threshold for the Elwha. The trend for natural escapement (HOR+NOR) is increasing for both populations (Table 6). Trends in long term growth rates of recruitment and in escapement are declining for both populations (Table 6) which is not surprising given the historically poor conditions in these watersheds. However, growth rates for natural-origin escapement (i.e., fish through the fishery) are slightly higher than growth rates for recruitment (i.e., abundance before fishing) for both populations (Table 4). This indicates that current fisheries management is providing some stabilizing influence to abundance, in spite of the habitat's current low productivity, and thereby reducing demographic risks.

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 percent each (SUS) for the Dungeness and Elwha River populations, respectively (Table 13), both above their RERs (Table 21). When all fishing-related mortality is taken into account, including the proposed actions, natural-origin escapement is expected to be above the critical threshold for both the Dungeness and the Elwha salmon populations (Table 24). When hatchery spawners are taken into account, escapements are much higher, with total spawners in the Elwha exceeding its rebuilding threshold (Table 5 and Table 24). Total exploitation rates for both populations are expected to exceed their RER surrogates by a substantial margin. Over 70 percent of the harvest occurs outside the jurisdiction of the co-managers (Table 13) while exploitation rates in 2021 Puget Sound salmon fisheries are expected to be 2.5% and 2.7% for the Dungeness and Elwha populations, respectively % (Table 24). If Puget Sound salmon fisheries closed in 2021, we estimate that one additional natural-origin spawners would escape to each of the Dungeness and Elwha Rivers. Therefore, further constraints on 2021 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 2019, an estimated seven nets became derelict, and five of them were recovered (James 2020). 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 2021/22 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 Effects on Species

In the listing determination for Puget Sound steelhead in 2007, NMFS determined that the harvest management strategy that eliminated the direct harvest of natural origin steelhead that the comanagers implemented beginning in the 1990s, prior to listing, largely addressed the threat of harvest to the listed DPS (72 Fed. Reg. 26722, May 11, 2007). Just prior to listing, the incidental terminal harvest rates in fisheries directed at other salmon species averaged 4.2% from 2001-2007, across the reference populations in Puget Sound (Table 16). Although available information on harvest rates continues to be limited, NMFS concluded in status reviews subsequent to listing that the status of Puget Sound steelhead has not changed significantly since the time of listing (Ford et al. 2011a; NWFSC 2015; NMFS 2017a; NWFSC 2020) and reaffirmed the observation that harvest rates on natural-origin steelhead continue to decline and are unlikely to substantially affect the abundance and productivity 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.

A key consideration in biological opinions addressing the effect of harvest to natural origin steelhead is therefore whether incidental harvest rates continue to remain low since listing in both the marine and terminal areas which would reinforce the conclusion that the threat harvest posed to the DPS continues to be low. To assess this premise for marine areas, NMFS compared the average catch of total steelhead in mixed stock marine area fisheries (Table 14, Environmental Baseline); from the time of listing to catches in more recent years and concluded that average catch had declined by 49% (Table 14)[54]. Comparing more recent average harvest rates on the natural-origin steelhead reference populations in the terminal areas (Table 16) showed that the rates, declined from 4.2% to 0.96% in Puget Sound fisheries during the 2007/2008 to 2019/2020 time period, a 78% reduction in harvest rate since listing (Table 16) supporting the conclusion that harvest rates continue to be low.

We then compare the estimated catch in marine areas described in Section 2.4.1. from the proposed action to the best available information on abundance of the Puget Sound steelhead DPS to determine if marine catch levels continue to be low in 2021 relative to the pre-listing period. 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 based on information for the populations that are available. The annual minimum average abundance of 35,375 steelhead includes listed and unlisted hatchery fish, and listed natural-origin fish based on fisheries data provided by co-managers (WDFW and PSTIT 2021; WDFW et al. 2021). The estimate includes total run size information for five reference populations 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. It also includes escapement estimates for 10 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 17 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 and non-listed Olympic Peninsula steelhead populations that are also part of the composition of steelhead affected by marine area fisheries. Therefore, the estimate of 35,375 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.

We then consider the impact in both marine and terminal areas affect harvest rates under the proposed actions compares 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 27 illustrates the marine and terminal areas where fisheries occur).

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[54] On April of 2018 NMFS approved an individual harvest plan for one of the index populations, the Skagit River population, under the ESA 4(d) rule (NMFS 2018b; discussed in Section 2.4.1). As a result, the reference populations used for calculating specific and average terminal harvest rates for the remainder of the Puget Sound fisheries are now limited to the Puyallup, Nisqually, Snohomish, and Green rivers

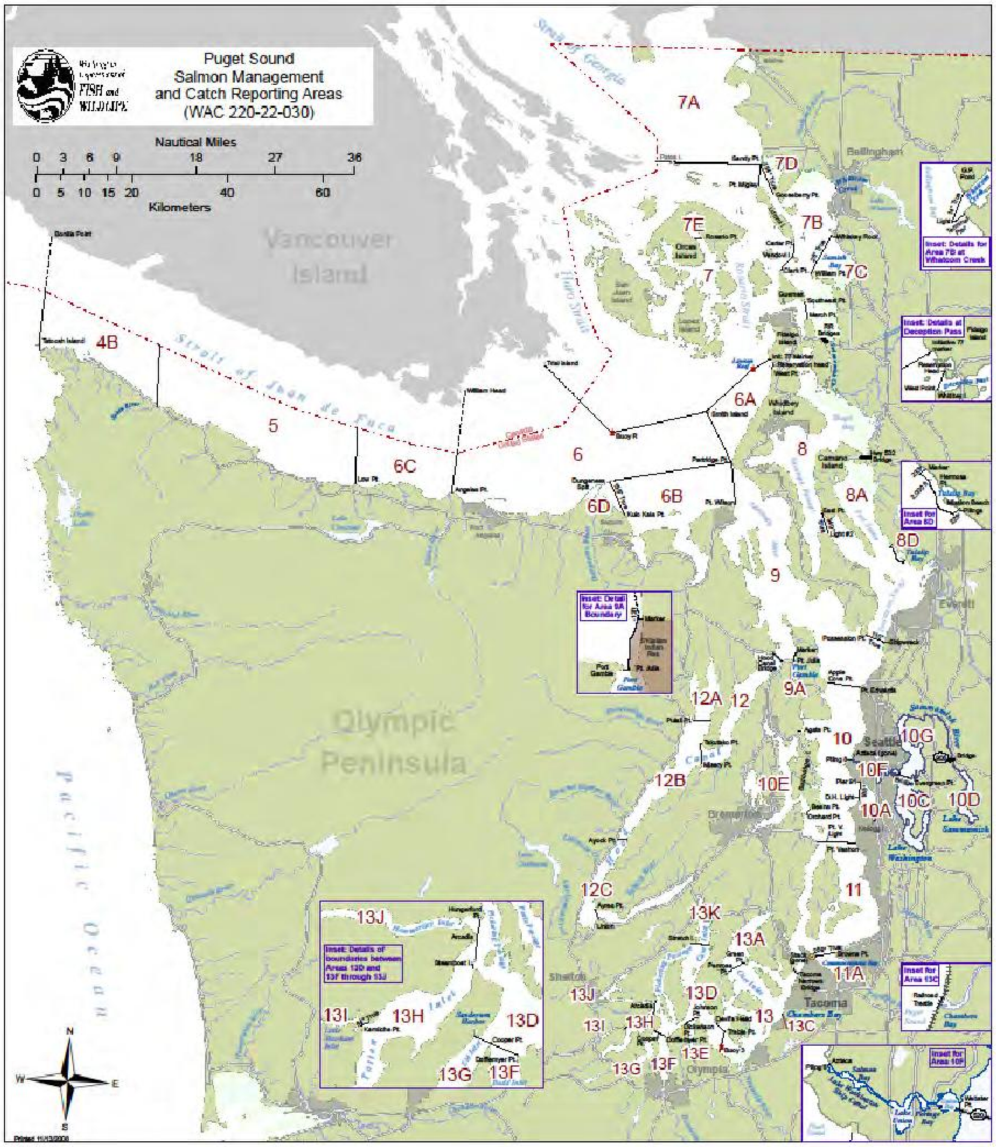


Figure 27. Puget Sound Commercial Salmon Management and Catch Reporting Areas (https://wdfw.wa.gov/sites/default/files/2019-03/wac_220-022-030.pdf).

To assess whether marine fishery impacts on steelhead continue to be low under the proposed action, we first estimate the marine harvest rate from the proposed action. Previous biological opinions have assessed fisheries impacts of up to 324 steelhead in Puget Sound marine waters from 2000/2001 through 2006/2007 as described in Section 2.4.1; Table 14)(NMFS 2011b; 2014b; 2015c; 2016f; 2017b; 2018c; 2019b; 2020d). 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 for 2021, 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 2021-

2022 season (Mercier 2021). Impacts of up to 324 steelhead would represent an estimated overall marine harvest rate on Puget Sound steelhead, as a whole, of 0.92 percent (324/35,375 = 0.92). As described above, because the estimate of overall steelhead abundance is likely 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 reported catch of steelhead in marine area fisheries in recent years averaged 165 from 2007/08 – 2019/20, well below the 324 reported at the time of listing. This catch represents a harvest rate of 0.46 percent (165/35,375 = 0.46). As this rate has remained stable over the post-listing period, it 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 harvest rate in the more recent period (07/08-19/20) also represents a 49% decline from the period prior to listing.

The average harvest rate in terminal area fisheries for the four[55] reference 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 anticipated fishing effort, catch patterns and fishing regulations in each of the four river systems (Mercier 2021). 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 78% reduction in the average terminal harvest rate for the four reference populations since 2008. 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.

2.5.2.2 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

[55] The Skagit terminal rates are assessed separately under the Skagit Steelhead RMP (NMFS 2018)

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 2019, an estimated seven nets became derelict, and five of them were recovered (James 2020). 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.

2.5.2.3 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 to affect Puget Sound Chinook salmon and steelhead. These research projects are described and their impacts on listed Chinook and steelhead 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 in 2021, as a provision of the 2010-2014 Puget Sound Chinook harvest RMP.

PSC Fall Chum Salmon Study

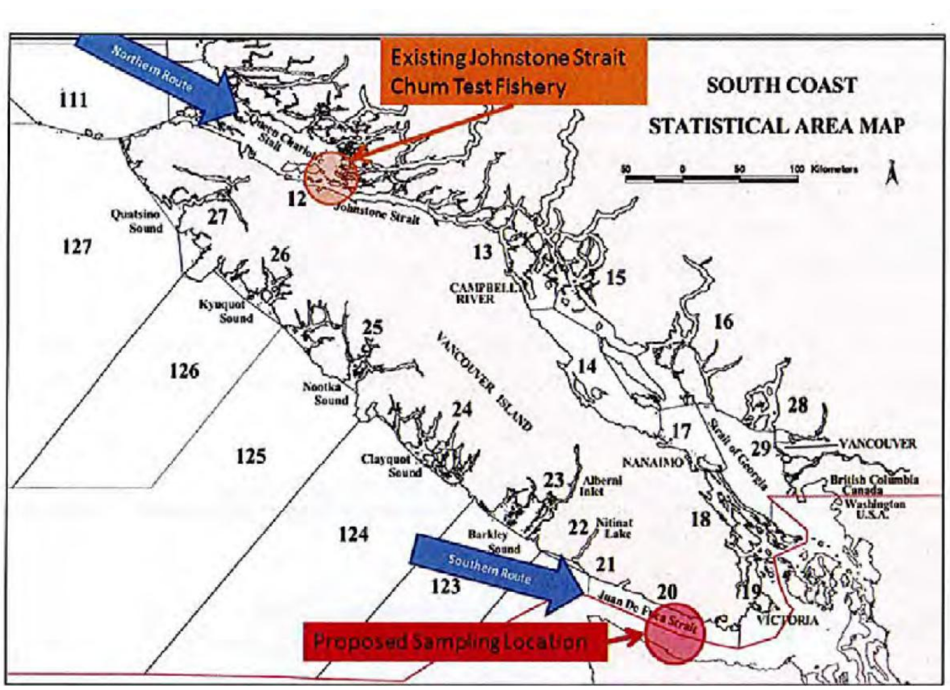


Figure 28. Location of proposed sampling site for PSC chum genetic sampling study.

A PSC Chum Technical Committee has received funding from the PST 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 2021. The fall chum research proposal is included in BIA's proposed action for 2021 and is summarized here (Mercier 2021).

This is the sixth 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 28). 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 2021).

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 2016-2020 resulted in 3 total (one in 2016 and 2 in 2020) encounter with a potentially ESA-listed steelhead (Mercier 2021).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 35,375 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 0.003% of the total Puget Sound steelhead assuming all encountered steelhead were from the Puget Sound DPS.

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 0.02%, based on adult-equivalent mortalities of 4 adult Chinook (Mercier 2021). For most populations, the increase would be 0.01% or less (Mercier 2021). 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 2010-2014 RMP and therefore part of the proposed actions (PSIT and WDFW 2010b; Norton 2019a; Mercier 2020). Based on the results of the 2016-2020 studies in which few Chinook were encountered—24 avg immature Chinook (range 2-69), 3 adult Chinook, only in 2017 (all released).

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 for the 2021-2022 management period. These studies are all designed to remove warm water fish species that prey on salmon and steelhead in the Lake Washington watershed, to further inform the development of warm water fish predator removal fisheries, or to further inform the predation risk posed by the species. These proposals are summarized here and incorporated by reference (Mercier 2021).

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 2021 test fishery will take place from May 1 to June 11th, 2021 and from January 1-April 30, 2022. Over the past three years, the MIT has developed a warm water test fishing study area which is divided into eight zones (Figure 29). 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 2021). The test fisheries proposed for 2021-2022 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. The 2020 spring work was limited to two weeks before being suspended due to COVID-19 restrictions. No Chinook or steelhead were encountered in that period. Over the three prior years of this work there have been zero Chinook adult 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 2021). Only a couple of these have been unmarked (ESA listed) fish (personal com., Jason Schafler, MIT, April 2020).

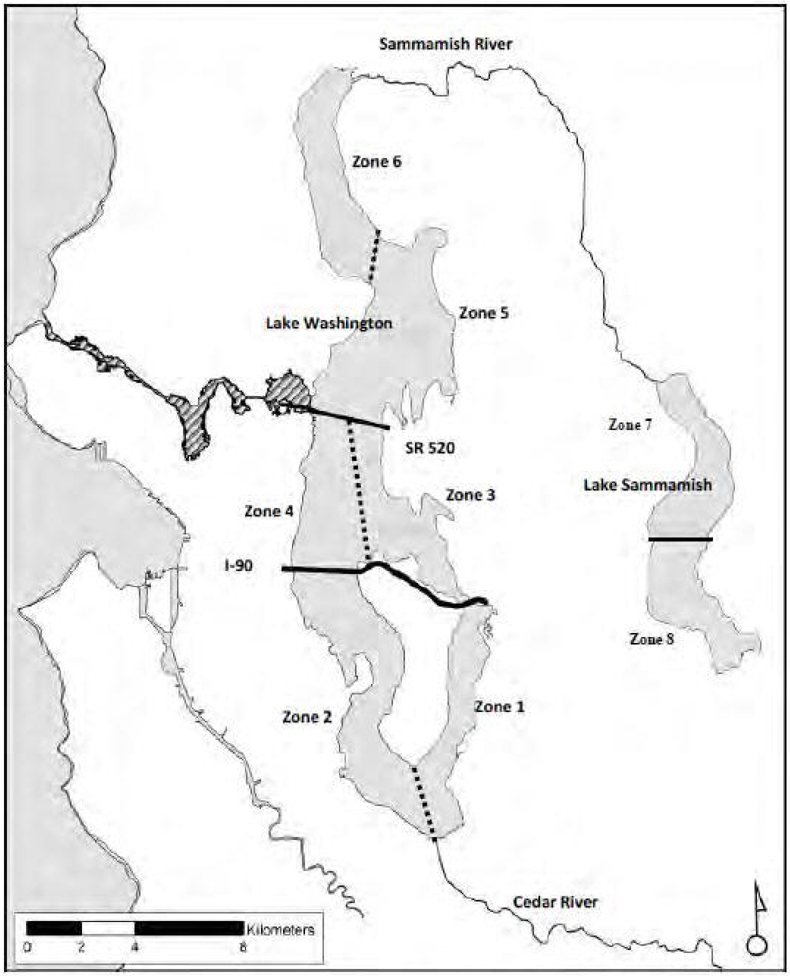


Figure 29. Muckleshoot Indian Tribe proposed warm water test fishery zones (1-8) and exclusion areas (cross-hatched) that will not be fished in order to minimize the potential for adult steelhead encounters (Mercier 2021).

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, 2022 and would occur in warm water test fishery zones 5 and 6 (Figure 29) 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 26). Additionally, the proposal limits the gear used in the fishery to the gears used in previous years' test fisheries (3.5-6" stretchmesh gillnet) and limits the number of nets per fishery (4 net limit per fisher) (Mercier 2021).

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 2021. 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 2021). The spring 2022 Sammamish electrofishing work is proposed for the March 1-June 30 period (personal com., Jason Schafler, MIT, April 2021). 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 2021).

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 involved with the test and pilot commercial efforts, the electrofishing gear affect 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 2021), 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 25.

Table 25. Expected maximum levels of incidental mortality of ESA-listed Lake WA Chinook and steelhead, by life stage, associated with the 2021-2022 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>6</td><td rowspan="2">5</td><td>0</td><td rowspan="2">3</td></tr>
<tr><td>Lake WA Pilot Net fishery</td><td>0</td><td>8</td><td>0</td></tr>
<tr><td>Lake 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>14</td><td>5</td><td>3</td><td>3</td></tr>
</table>

(Mercier 2021)

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 in the Lake Washington (WA) watershed. The objectives of the proposed study are to: (1) describe the relative abundance and size structure of piscivorous fishes in different sectors of the Lake Washington ship canal (LWSC) during the salmon smolt out-migration period; and (2) assess the stomach contents of piscivorous fishes inhabiting different sectors of the LWSC and Lake WA.Identify sectors of the LWSC and Lake WA where predation on juvenile salmonids is greatest during the out-migration period; and (3) Assess effectiveness of Merwin Traps as a tool for capturing and removing non-native piscivorous fishes (perch) in Lake Sammamish, Lake WA, and the LWSC (Mercier 2021).

Gill netting would occur over multiple sampling days between early-May to late-June 2021. Variable-mesh monofilament gill nets will be set during the salmon smolt out-migration period within the study area (Figure 1). Netting effort will be concentrated within the LWSC, but may also occur in selected areas of Lake Washington and Lake Sammamish. Nets will be deployed at night with 12-16 hour set times. A range of mesh sizes (2-inch stretch to 5-inch stretch) will be used in an effort to capture a broad range of fish species and sizes. However, much of the netting effort will utilize smaller mesh sizes (2.5-inch to 3-inch stretch mesh) to target yellow perch, a non-native piscivore known to prey on Chinook smolts during the out-migration period. All species captured will be measured to the nearest millimeter. Stomach contents of some piscivorous fishes caught at selected locations will be assessed for evidence of predation on juvenile salmonids.

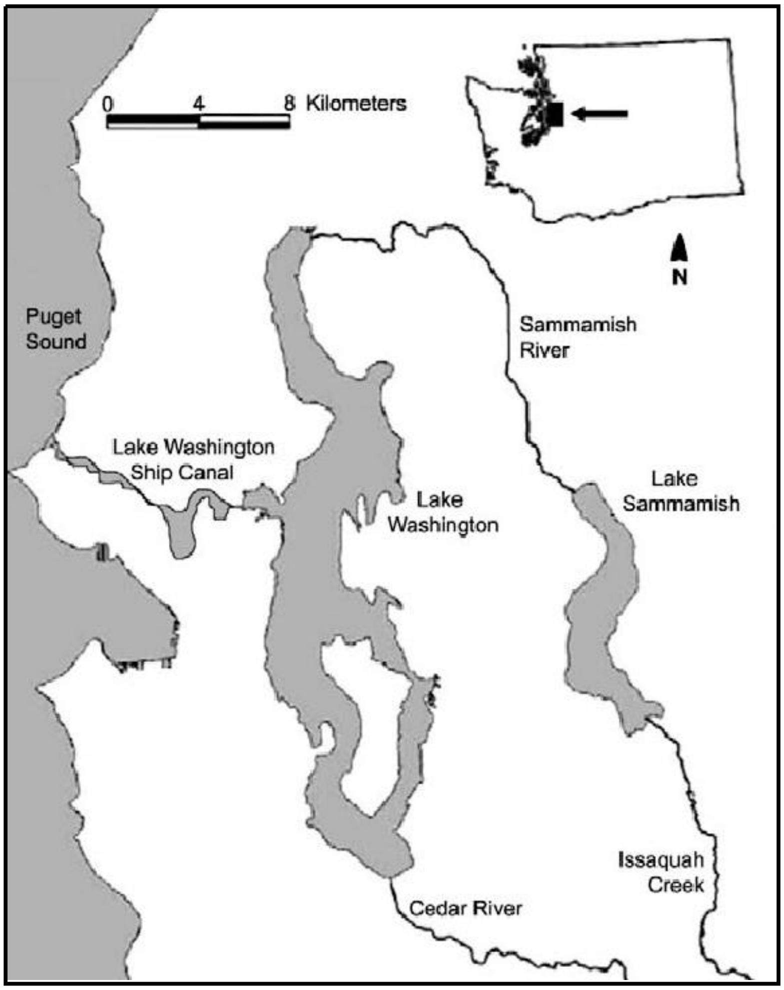


Figure 30. Proposed WDFW study area—LWSC, Lake WA, and Lake Sammamish (Mercier 2021).

Merwin Traps (1 to 2 traps total) may be deployed in Lake Sammamish or Lake Washington between early-March and late June of 2022. It is likely that only one trap will be deployed in Lake Sammamish near the outlet of Issaquah Creek, however a second trap may be deployed in the same general area or in Lake Washington. Traps will be fished continuously and will be checked daily with all species caught being recorded. Any Chinook or steelhead that are captured will be released unharmed (Mercier 2021).

Adult steelhead were not encountered during previous sampling efforts (conducted in 2016, 2017, 2018, or 2019) in the LWSC (Mercier 2021). Spawning ground surveys indicate that few (if any) steelhead spawn in the Lake Washington watershed, and steelhead adults are not expected to be migrating through the LWSC during the proposed sampling period. WDFW estimates that zero adult steelhead will be caught. The probability of encountering a juvenile steelhead is low. Juvenile steelhead were not encountered during previous sampling efforts (conducted 2016-2019) in the LWSC ((Mercier 2021). Spawning ground surveys indicate that few (if any) steelhead spawn in the Lake Washington watershed (Table 33), and the number of steelhead smolts migrating through the Lake WA watershed is expected to be low. Any steelhead smolt migrants that may be present will not be affected by the sampling gear as the proposed gillnet mesh size is too large to entangle juveniles (2 to 4 inch stretch mesh). WDFW estimates that zero juvenile steelhead will be caught (Mercier 2021).

Chinook adults typically begin migrating through the Lake WA watershed in mid-June with the peak migration period occurring in mid to late August. Relatively small numbers of adult Chinook would be migrating through the Lake WA watershed while the proposed sampling would occur (May and June), however some adult Chinook may encounter the sampling gear as they migrate through the action area (Mercier 2021). Chinook adults migrating through the Lake WA watershed are likely to use deep-water offshore habitats where sampling gear is less likely to be deployed. Most sampling effort will occur in near-shore or off-channel, weedy habitats where adult Chinook are less likely to migrate. Adult Chinook were not encountered during the past four years of previous sampling efforts (2016 through 2019) in the LWSC (Mercier 2021). Due to the early timing of the proposed sampling and the off-channel areas where sampling will occur, the number of adult Chinook encountering sampling gear will likely be small. A combined A combined gear mortality of 5 Chinook adults (NOR and/or HOR) is estimated. Juvenile Chinook will actively be migrating through the Lake WA watershed during the proposed sampling period (March - June). 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 (2016-2019) in the LWSC (Mercier 2021). WDFW estimates the sampling will affect zero juvenile Chinook.

Summary

As outlined above the proposed fishery-related research activities in the Lake Washington system, from MIT and WDFW, would not expect the impact to Chinook to exceed a level equivalent to 1% of the estimated annual abundance (i.e. 1% ER). The total expected maximum mortality 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 0.23% of the Lake WA terminal run size based on the 2020 pre-season forecast for terminal run size of 4,410. Potential, additional impacts to sub-adult and juvenile Chinook of up to 14 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).

Table 26. 5-year geometric mean of raw natural steelhead spawner counts for the Lake Washington/Lake Sammamish watershed, where available (NWFSC 2020).

MPG	DIP	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2020	% Change
Central and South Puget Sound	North Lake WA/ Lake Sammamish winter	60	4	-	-	-	-	-
	Cedar River winter	241	295	37	12	4	6	50

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 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.

2.5.3 Puget Sound/Georgia Basin Rockfish

To evaluate the effects of proposed fisheries on individual yelloweye rockfish and bocaccio NMFS first assessed the general effects of the action, followed by the population-level effects. NMFS analyzed direct effects on listed rockfish in two steps. First, NMFS estimated the number of listed rockfish likely to be caught in the salmon fishery and assessed both the sublethal and lethal effects on individuals. Second, NMFS considered the consequences of those sublethal and lethal effects at the population/DPS level. NMFS analyzed indirect effects by considering the potential effects of fishing activities on benthic habitats. Throughout, NMFS identified data gaps and uncertainties, and explained how the assumptions in the analysis are based on the best available science.

Hook and Line Fishing

Recreational 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). Other injuries in addition to barotrauma can include harm from 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 the consultations on the WDFW Incidental Take Permit for the recreational bottom fish fishery and on the halibut fishery in Puget Sound NMFS used depth and mortality information to estimate the proportion of listed rockfish killed as a result of fisheries with the state regulation limiting gear deeper than 120 feet deep (consultation number F/NWR/2012/1984/ and WCR-2017-8426). This allowed NMFS 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 27).

Table 27. 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 NMFS makes the conservative assumption that for the 2021/22 fishing season listed rockfish caught in salmon fisheries would not be recompressed, but rather released at the surface. As such NMFS use the "current surface release mortality" estimates in (PFMC 2014a) as described in Table 27 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 NMFS used 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 NMFS used the release mortality rates estimates from the 120 to 180 feet depth range. NMFS chose 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, NMFS presumes 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 any derelict nets still 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, NMFS does 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 NMFS is 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, NMFS used WDFW bycatch estimates from the 2003 through 2009 time period[56] 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 NMFS used the highest available catch estimates for bocaccio and yelloweye rockfish from anglers targeting salmon to form a precautionary analysis. NMFS considers bycatch estimates from previous years useful because NMFS anticipates that recreational salmon fisheries proposed for 2021/22 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 NMFS used 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) NMFS used the lower confidence interval population estimates available for yelloweye

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

rockfish, and (2) NMFS used the WDFW population estimate of bocaccio for the San Juan Island and Eastern Strait of Juan de Fuca area and note that it is generated within only 46 percent of the estimated habitat of bocaccio within the U.S. portion of the DPS. The rest of the area, including the Main Basin, South Sound and Hood Canal, were likely the most historically common area used by bocaccio (Drake et al. 2010). The structure of these assessments likely underestimates the total abundance of each DPS, 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

NMFS used annual estimated bycatch of yelloweye rockfish from salmon anglers of 4 (WDFW 2014b) to 117 fish (WDFW 2011) (Table 28). These fish would be released, and using the PFMC methodology NMFS estimate that 56% would likely perish from barotrauma and related hooking injuries and/or predation induced by injury.

Table 28. 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

NMFS used annual estimated bycatch of bocaccio from salmon anglers from 2 (WDFW 2014b) to 145 (WDFW 2015) fish (Table 29). These fish would be released, and using the PFMC methodology NMFS estimate that 53% would likely perish from barotrauma and related hooking injuries and/or predation induced by injury.

Table 29. 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	1.67

In addition to fishery mortality, rockfish are killed by derelict fishing gear (Good et al. 2010), though NMFS was 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 2021/22 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, NMFS 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 an assessment of the risk of this occurring. 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. There is no single, reliable historical or contemporary abundance estimate for the yelloweye rockfish or bocaccio DPSs in the Puget Sound/Georgia Basin (Drake et al. 2010).

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. There is no single, reliable historical or contemporary abundance estimate for the yelloweye rockfish or bocaccio DPSs in the Puget Sound/Georgia Basin (Drake et al. 2010).

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. NMFS does not have spatial information at a fine enough scale to determine the proportion of the fishery occurring inside or outside of critical habitat. NMFS 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 NMFS designated deepwater habitats for sites deeper than 98 feet (30 m) that possess or are adjacent to areas of complex bathymetry consisting of rocky 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 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).

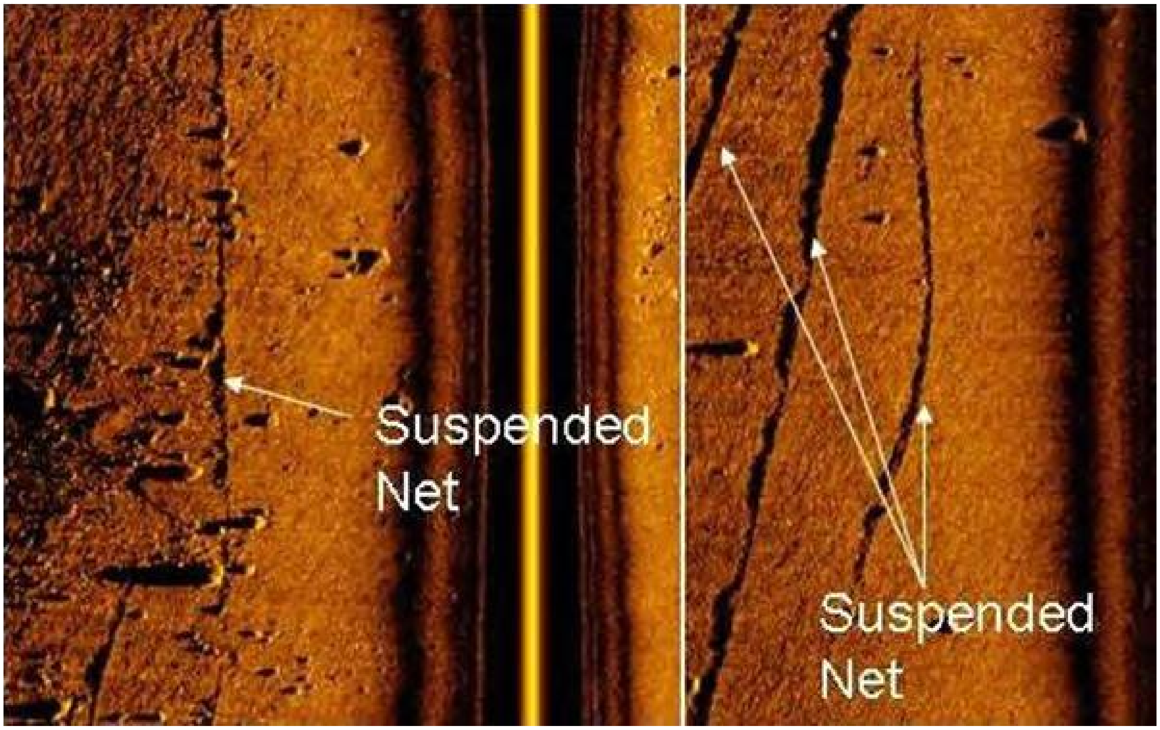


Figure 31. Sidescan sonar images of derelict nets located on Point Roberts Reef of the San Juan basin. Suspended nets have a larger acoustic shadow than nets flush with the bottom. Image used by permission of Natural Resource Consultants (NRC).

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 NMFS cannot estimate the number of yelloweye rockfish or bocaccio killed on an annual basis from newly lost nets, NMFS 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 NMFS considers 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 2021/22 fishing season compared to several years and decades ago (previous estimates of derelict nets were 16 to 42 annually (NRC 2010)). In 2019, an estimated seven nets became derelict, and five of them were recovered (James 2020). 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). NMFS does not have estimates of the number of nets lost in the 2020/21 salmon fisheries. Based on reported derelict nets NMFS estimates that a range of six to 20 gill nets may be lost in the 2021/22 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 total area and not degrade the overall condition of critical habitat for listed rockfish.

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 first the overlap of the proposed fisheries and SRKWs which is relevant to both the direct and indirect effects of the proposed action. There is also information on the number of vessels participating in fishing in the area near the whales compared to vessels engaging in other activities to provide context for potential effects. Next we discuss the direct effects on killer whales from vessel activities and potential for gear interactions and finally the indirect effects of fisheries reducing the prey available to the whales. NMFS has incorporated analyses from the PFMC Salmon Fishery Management Plan Impacts to Southern Resident Killer Whales Risk Assessment May 2020 (PFMC 2020a) into this biological opinion where appropriate. NMFS has also incorporated analyses from WDFW (Cunningham 2021)and the NWIFC (Loomis 2021) regarding the 2021-2022 fisheries and SRKWs to assess the direct and indirect effects of the Puget Sound salmon fisheries on SRKWs.

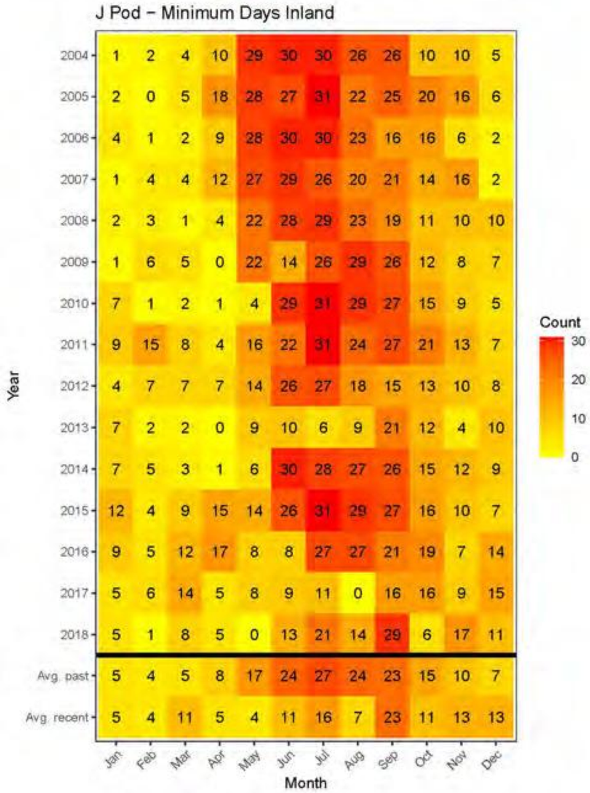
Overlap of Puget Sound Salmon Fisheries and SRKWs

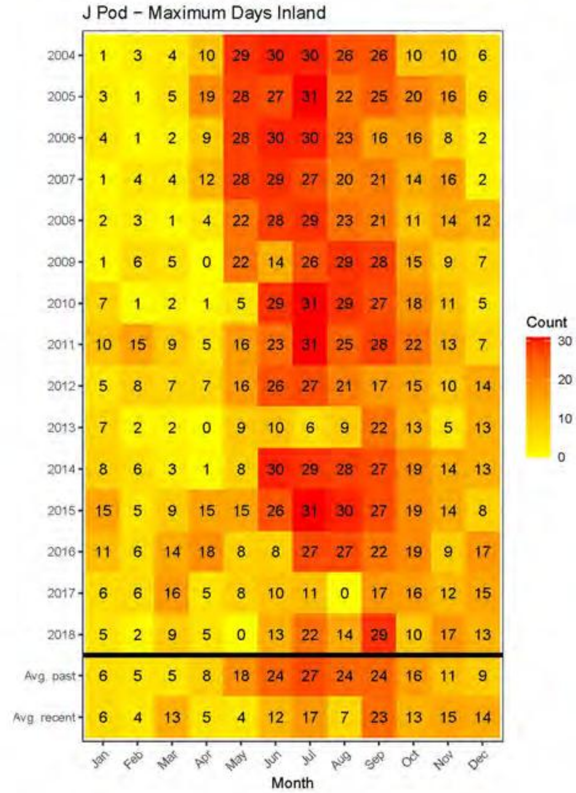
This analysis of the overlap of Puget Sound salmon fisheries and SRKWs relies on several sources of data about the distribution, movement patterns, and foraging areas of the whales and information provided by the co-managers on the presence of fishing vessels and/or effort of fishing in marine fishing areas in Puget Sound. First, we describe SRKW occurrence and location in inland waters. Data on SRKWs covers average occurrence of SRKW in inland waters of the Salish Sea by month and year across the different pods based on sightings, distribution of sightings of killer whales, and known foraging areas or "hot spots" for SRKWs. The whale data is compared to data from the co-managers about the operations of the fisheries including the location of marine fishing areas, the average number of tribal fishing vessels per day in each marine fishing area (fishing effort), overlap of tribal fishing effort with SRKW sighting frequency, and location and timing of state-managed fishery area closures (i.e., relative effort) and additional fishing management measures (non-retention, mark selective, etc) in SRKW foraging hot spots. Additionally, the Soundwatch program provides data on the occurrence of fishing vessels operating near the whales. Overlap between SRKW occurrence and fishing effort inform both the analysis of potential direct effects of vessels and gear on SRKW and indirect effects of prey removal in foraging areas.

As described in the Status section, Southern Residents occur in inland waters throughout the year and have typically spent a 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 34) (Hanson et al. 2010; Shedd 2019) and when SRKWs are in inland waters, they are commonly sighted in this area in summer months (May-September, 2017-2019) (Figure 35). On average, the three pods have been observed in inland waters more often starting in May and June through September (Olson et al. 2018) than at other times of year. 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. Late arrivals and fewer days present in inland waters have been observed in recent years (Hanson and Emmons (2010); The Whale Museum unpubl. Data, Figure 32). Ettinger et al. (In Review) modeled probability of occurrence of SRKW in inland waters over the years 2001-2017 and found that peak occurrence during each year is variable but also that the peak probability of whale occurrence in the Salish Sea has shifted to slightly later over time (about 1-5 days later per year). For example, K pod has had variable occurrence in June ranging from 0 days of occurrence in inland waters to over 25 days (Figure 16, Figure 33). In 2019, there were no observed sightings of SRKWs in the inland waters between April and July. More specifically, in 2019 some members of L pod were not encountered by the Center for Whale Research in the inland waters between January and August 11 and then not again until September (spending only a few days in inland waters in the summer months). Some K pod members were encountered for a couple of days in July and then again in September (Center for Whale Research unpublished data). J pod appeared briefly in the Salish Sea in 2019 during February, March and April and the Center for Whale Research did not encounter them again until July. In 2020, J pod appeared briefly in in the Salish Sea during February and March (once with members of K pod accompanying) and the Center for Whale Research did not encounter them again until July. K and L pods were briefly encountered in late July (Center for Whale Research, unpublished data).

This recent pattern of observations of SRKWs in the Salish Sea is substantially different from patterns observed in previous years. We used the most recent available 15 years of data (2004 – 2018) from The Whale Museum as a reliable indicator of whale presence to estimate the number of days that members of specific pods spent in the Salish Sea (Figure 32). Figure 32 includes the minimum and maximum counts of days spent in the Salish Sea from 2004 – 2018 (The Whale Museum data for 2019 are not complete and data for 2020 are not yet available) to reflect the uncertainty of identification by pod for certain sighting reports in The Whale Museum data set. Occurrence of whales in recent years, particularly 2017-2018, has diverged from patterns in most years prior. Before 2017, the average number of days K pod spent in the Salish Sea in the summer months (July – September) was 21-22 depending on the month (using maximum counts); the average number of days L pod spent in the Salish Sea in the summer months was 22-24 days each month (depending on month, using maximum counts) (Figure 32). For 2017-2018, K and L pod were both sighted <10 days in July and August on average, and K pod was sighted <10 days on average in September as well. Prior to 2017, J pod was observed in inland waters on average 23-27 days in the months of June-September, but in 2017 was only observed around 10 days a month in June and July and 0 days in August. In 2018, J pod was observed more frequently in summer but still less than in most of the previous years (before 2017), except in September. In 2013 K pod, and J pod as well, also spent fewer days in the Salish Sea in early summer months (10 or less days in July and August), but not to the extreme of more recent years (for K pod). Altogether, this illustrates the variability in occurrence in the Salish Sea, especially in recent years. Overall, on average, encounters with J pod in inland waters occur more often than encounters with K and L pods, but all pods are still mainly encountered more frequently in the Salish Sea in summer months than in late fall to spring months(November-May; but see November-December 2017) (Figure 32).


J Pod – Minimum Days Inland
2004 1 2 4 10 29 30 30 26 26 10 10 5
2005 2 0 5 18 28 27 31 22 25 20 16 6
2006 4 1 2 9 28 30 30 23 16 16 6 2
2007 1 4 4 12 27 29 26 20 21 14 16 2
2008 2 3 1 4 22 28 29 23 19 11 10 10
2009 1 6 5 0 22 14 26 29 26 12 8 7
2010 7 1 2 1 4 29 31 29 27 15 9 5
2011 9 15 8 4 16 22 31 24 27 21 13 7
2012 4 7 7 7 14 26 27 18 15 13 10 8
2013 7 2 2 0 9 10 6 9 21 12 4 10
2014 7 5 3 1 6 30 28 27 26 15 12 9
2015 12 4 9 15 14 26 31 29 27 16 10 7
2016 9 5 12 17 8 8 27 27 21 19 7 14
2017 5 6 14 5 8 9 11 0 16 16 9 15
2018 5 1 8 5 0 13 21 14 29 6 17 11
Avg. past 5 4 5 8 17 24 27 24 23 15 10 7
Avg. recent 5 4 11 5 4 11 16 7 23 11 13 13
Year
Month
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Count
30
20
10
0


J Pod – Maximum Days Inland
2004 1 3 4 10 29 30 30 26 26 10 10 6
2005 3 1 5 19 28 27 31 22 25 20 16 6
2006 4 1 2 9 28 30 30 23 16 16 8 2
2007 1 4 4 12 28 29 27 20 21 14 16 2
2008 2 3 1 4 22 28 29 23 21 11 14 12
2009 1 6 5 0 22 14 26 29 28 15 9 7
2010 7 1 2 1 5 29 31 29 27 18 11 5
2011 10 15 9 5 16 23 31 25 28 22 13 7
2012 5 8 7 7 16 26 27 21 17 15 10 14
2013 7 2 2 0 9 10 6 9 22 13 5 13
2014 8 6 3 1 8 30 29 28 27 19 14 13
2015 15 5 9 15 15 26 31 30 27 19 14 8
2016 11 6 14 18 8 8 27 27 22 19 9 17
2017 6 6 16 5 8 10 11 0 17 16 12 15
2018 5 2 9 5 0 13 22 14 29 10 17 13
Avg. past 6 5 5 8 18 24 27 24 24 16 11 9
Avg. recent 6 4 13 5 4 12 17 7 23 13 15 14
Month
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Count
30
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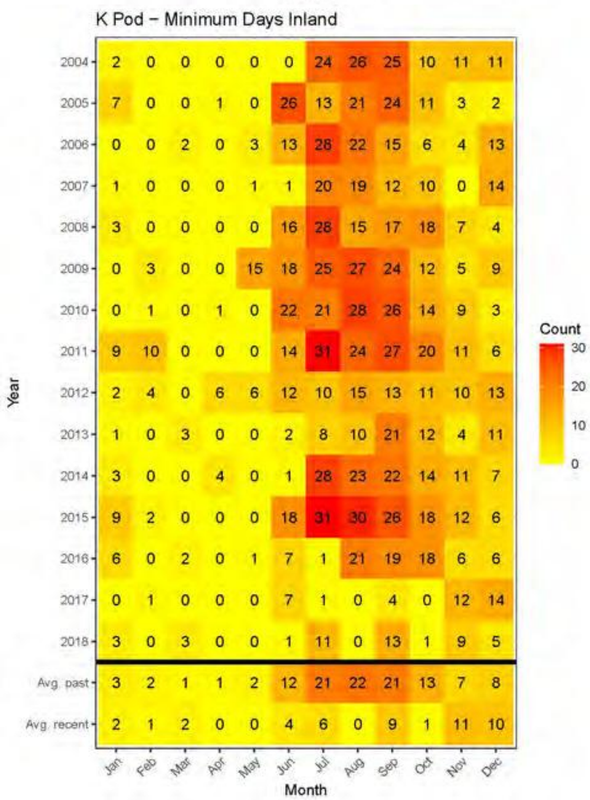
10
0


K Pod – Minimum Days Inland
2004 2 0 0 0 0 0 24 26 25 10 11 11
2005 7 0 0 1 0 26 13 21 24 11 3 2
2006 0 0 2 0 3 13 28 22 15 6 4 13
2007 1 0 0 0 1 1 20 19 12 10 0 14
2008 3 0 0 0 0 16 28 15 17 18 7 4
2009 0 3 0 0 15 18 25 27 24 12 5 9
2010 0 1 0 1 0 22 21 28 26 14 9 3
2011 9 10 0 0 0 14 31 24 27 20 11 6
2012 2 4 0 6 6 12 10 15 13 11 10 13
2013 1 0 3 0 0 2 8 10 21 12 4 11
2014 3 0 0 4 0 1 28 23 22 14 11 7
2015 9 2 0 0 0 18 31 30 26 18 12 6
2016 6 0 2 0 1 7 1 21 19 18 6 6
2017 0 1 0 0 0 7 1 0 4 0 12 14
2018 3 0 3 0 0 1 11 0 13 1 9 5
Avg. past 3 2 1 1 2 12 21 22 21 13 7 8
Avg. recent 2 1 2 0 0 4 6 0 9 1 11 10
Year
Month
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Count
30
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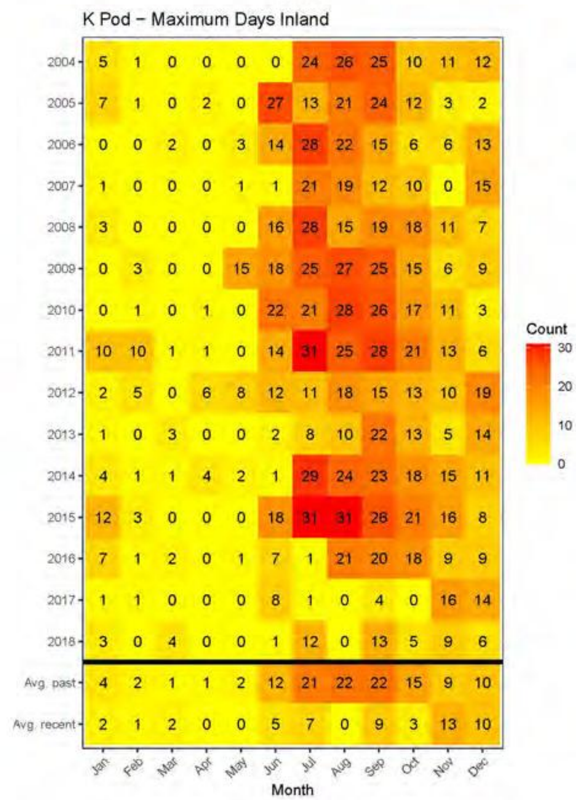
K Pod – Maximum Days Inland
2004 5 1 0 0 0 0 24 26 25 10 11 12
2005 7 1 0 2 0 27 13 21 24 12 3 2
2006 0 0 2 0 3 14 28 22 15 6 6 13
2007 1 0 0 0 1 1 21 19 12 10 0 15
2008 3 0 0 0 0 16 28 15 19 18 11 7
2009 0 3 0 0 15 18 25 27 25 15 6 9
2010 0 1 0 1 0 22 21 28 26 17 11 3
2011 10 10 1 1 0 14 31 25 28 21 13 6
2012 2 5 0 6 8 12 11 18 15 13 10 19
2013 1 0 3 0 0 2 8 10 22 13 5 14
2014 4 1 1 4 2 1 29 24 23 18 15 11
2015 12 3 0 0 0 18 31 31 26 21 16 8
2016 7 1 2 0 1 7 1 21 20 18 9 9
2017 1 1 0 0 0 8 1 0 4 0 16 14
2018 3 0 4 0 0 1 12 0 13 5 9 6
Avg. past 4 2 1 1 2 12 21 22 22 15 9 10
Avg. recent 2 1 2 0 0 5 7 0 9 3 13 10
Month
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Count
30
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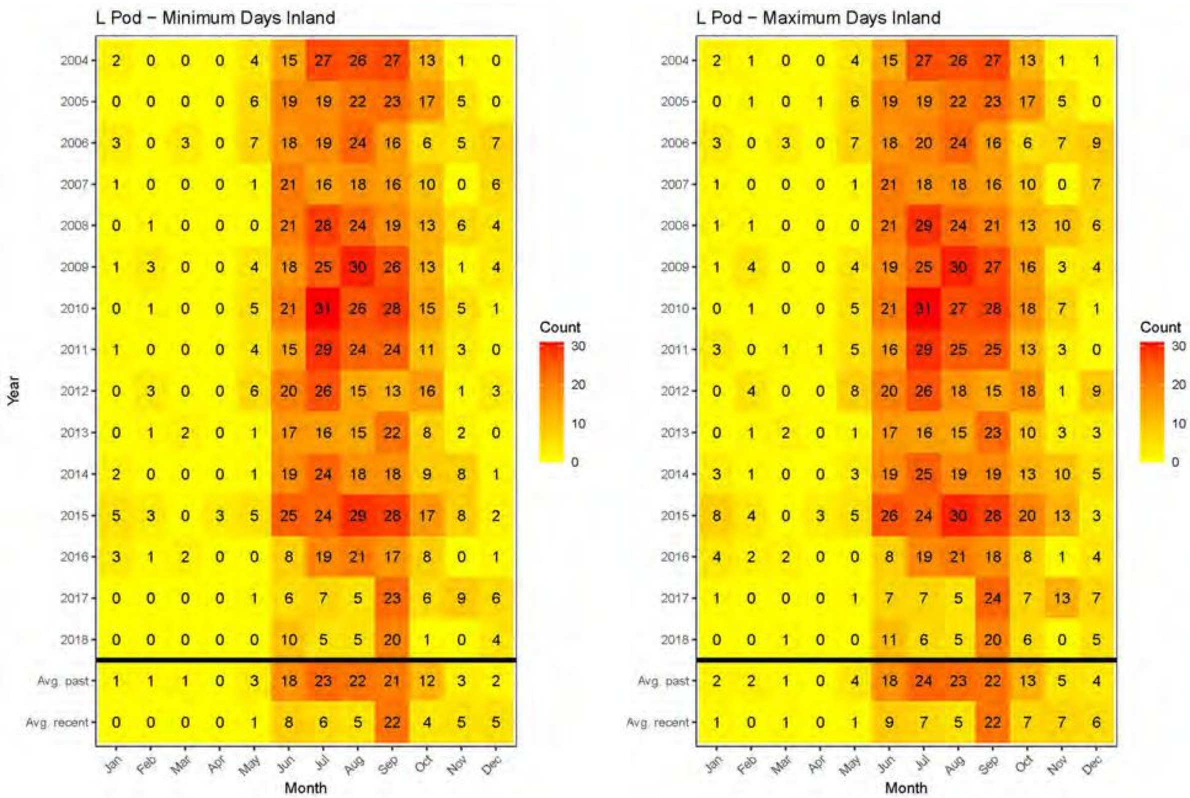


Figure 32. Minimum and maximum number of days that each SRKW pod (J, K, or L) was present in inland waters of the Salish Sea by year and month based on opportunistic observation data (Whale Museum, unpub data). "Avg past" is average before 2017 and "Avg recent" is average in 2017-2018. Minimum days inland includes only sightings in inland waters where pod was specified and known with certainty. Maximum days inland include sightings where pod was specified, including when there was uncertainty, and also includes counts of sightings of Southern Residents (without pod specified) if no specific pod was listed as sighted any time that day. The area of the Salish Sea included in this summary encompasses both U.S. and Canadian waters and includes the area encompassed by the quadrants defined by The Whale Museum (see Figure 1 in (Olson et al. 2018)) and extending further West into the Strait of Juan de Fuca to the edge of SRKW critical habitat at Cape Flattery (see 71 FR 69054). Includes few sightings (<0.2%) in Canadian marine fishing areas (17,18,28,29, see https://www.pac.dfo-mpo.gc.ca/fm-gp/maps-cartes/areas-secteurs/index-eng.html) that overlap but extend past defined quadrants when no other location (quadrant, latitude or longitude) were included.

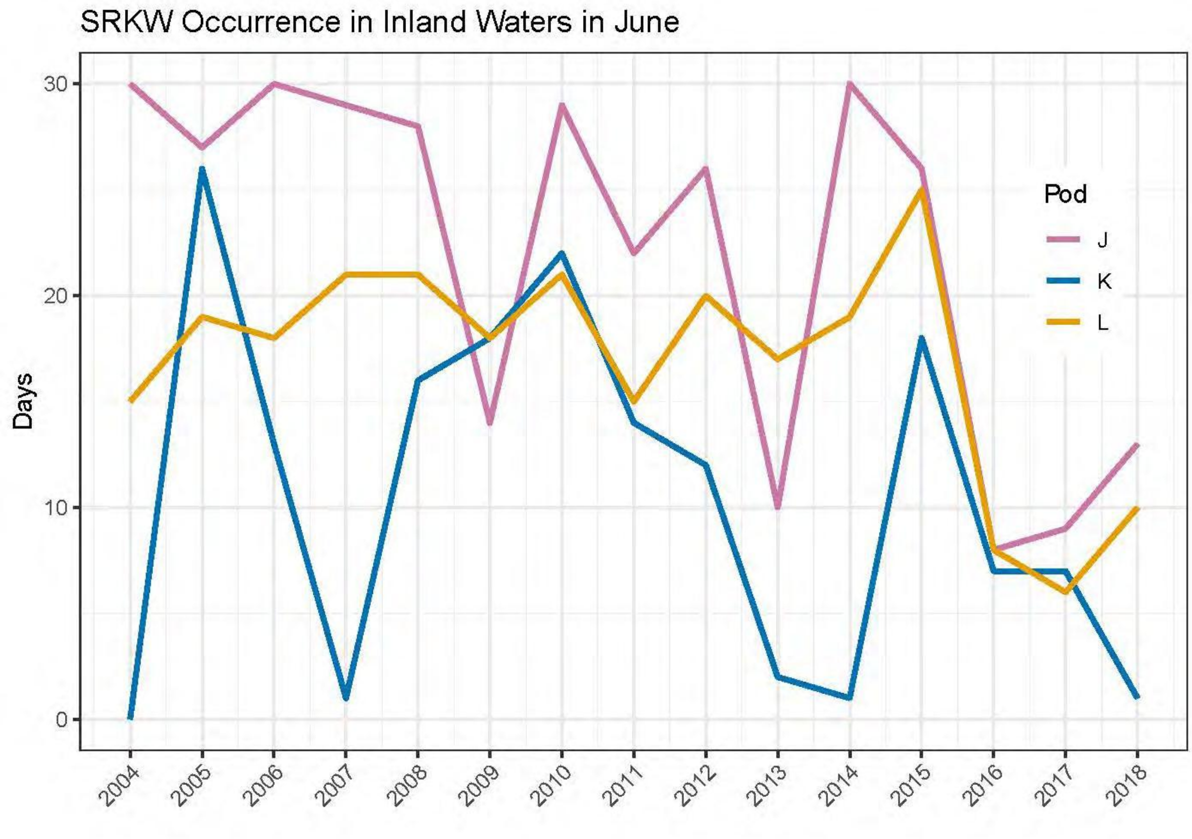


Figure 33. Number of days of SRKW occurrence in inland waters number in June for each year from 2004 to 2018 (data from The Whale Museum).

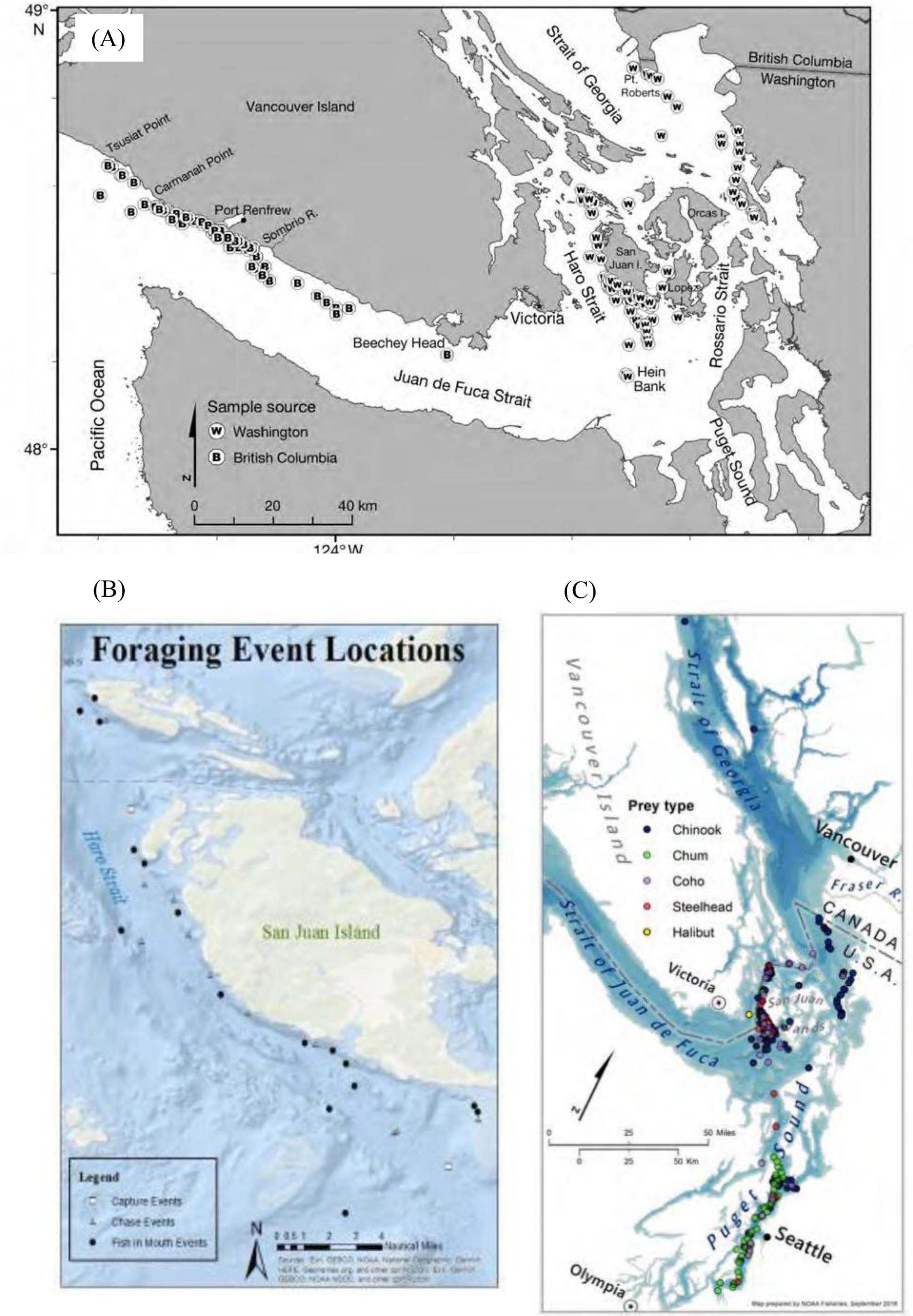
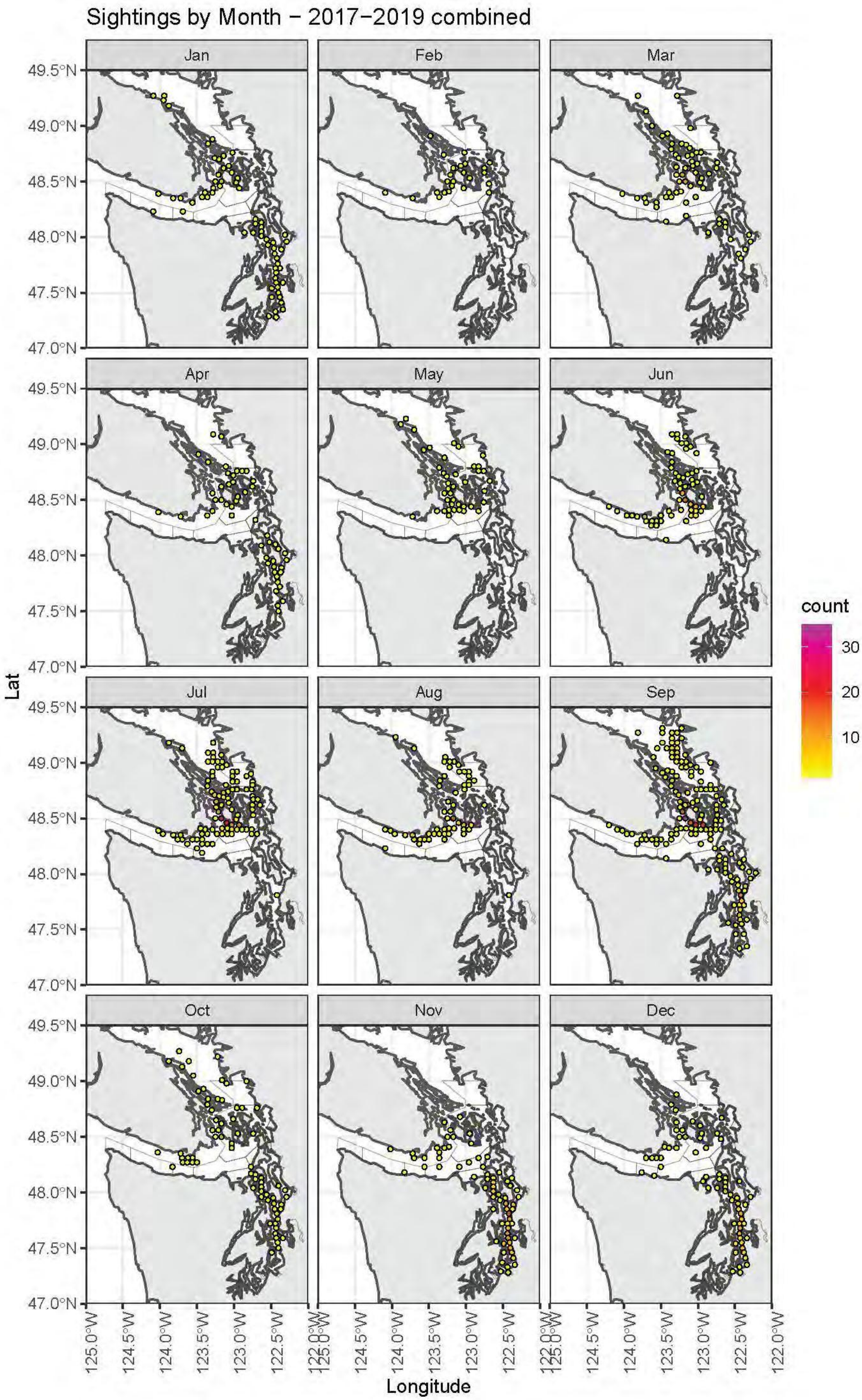


Figure 34. Multiple data sources showing important foraging areas in Salish Sea for SRKW over the last

15+ years. (A) Foraging events observed in the Salish Sea from May to September 2004 to 2008 (Hanson et al. 2010). (B) Foraging events observed in the Salish Sea in September 2017 (Shedd 2019). (C)Location and species of Southern Resident killer whale prey from scale/tissue samples collected in the Puget Sound, Strait of Juan de Fuca/San Juan Islands, and northern Georgia Strait in 2004-2017 ((Hanson et al. 2010), NMFS unpubl. data).

We used the most recent available years of data (2017-2019) from The Whale Museum to show the use of different areas of the Salish Sea by SRKW in each month of the year (Figure 29). Figure 29 includes the frequency of sightings of SRKW by Whale Museum quadrant (see (Olson et al. 2018)) by month for 2017-2019 combined where only one sighting per quadrant per day was counted, so frequency represents the number of days in that month (summed across the three years) SRKWs were sighted in a quadrant. The most recent data, for 2017-2019, show that SRKW continued to be frequently sighted along the West side of San Juan Island, especially in summer months, as well as throughout inland waters, including frequently in Admiralty Inlet and the Central Basin of Puget Sound in September-December (Figure 35, though note data are not complete for 2019 so more sightings may have occurred). This is consistent with spatial patterns in past years (prior to 2017) (see (Olson et al. 2018)). Recent prey samples were collected in these areas following observed foraging events (Hanson et al. 2021, Figure 34C), showing that these areas are used for foraging. There are also sightings North in summer months, near the U.S.-Canadian border, that extend into Canada near the Fraser River mouth. In 2020, SRKWs were also most often observed off the west side of San Juan Island by the Soundwatch program compared to other core Summer critical habitat areas. SRKWs were not observed in June or August by Soundwatch (Frayne 2021), but were observed in July and again in September. To align SRKW sightings with different fishing area, all Puget Sound commercial and recreational marine fishing areas are shown in Figure 30 (A and B, respectively) and the primary Puget Sound fishing zones associated with areas of occurrence for SRKWs (based on sightings) include area 7 (including 7A for commercial fisheries), 9, 10, and 11 (Figure 35, Figure 36). In this section, we refer to recreational fishing marine areas as R-MA and commercial fishing as C-MA and note that R-MA 7 encompasses the area of C-MA 7 and 7A-E (see Figure 36).

We note certain important caveats for the SRKW sightings data. First, comprehensive sightings data from The Whale Museum are only fully available up through 2018; sightings for 2019 are also included but likely do not contain all sightings for 2019 since not all have been entered in the database. Sightings data are managed by The Whale Museum and while the data are predominately opportunistic sightings from a variety of sources (public reports, commercial whale watching, Soundwatch, Lime Kiln State Park land-based observations, and independent research reports), the SRKWs are highly visible in inland waters, and widely followed by the interested public and research community, so are likely complete. The dataset does not account for level of observation effort by season, location or time of day; however, it is the most comprehensive long-term dataset available to evaluate broad-scale habitat use by SRKWs in inland waters. For these reasons, NMFS relies on the number of past sightings to assess the likelihood of SRKW presence in the action area when fishing would occur. Effort corrected data shows similar spatial patterns (see Olson et al. 2018). Previous analysis of this sightings data indicates that while SRKWs may be detected and reported at least one time within a given day they spend in the inland waters (The Whale Museum unpubl. data), not all of their movements and locations throughout the day are documented. In addition, SRKWs are highly mobile and can travel up to 86 nmi (160 km) in a single day (Erickson 1978; Baird 2000).

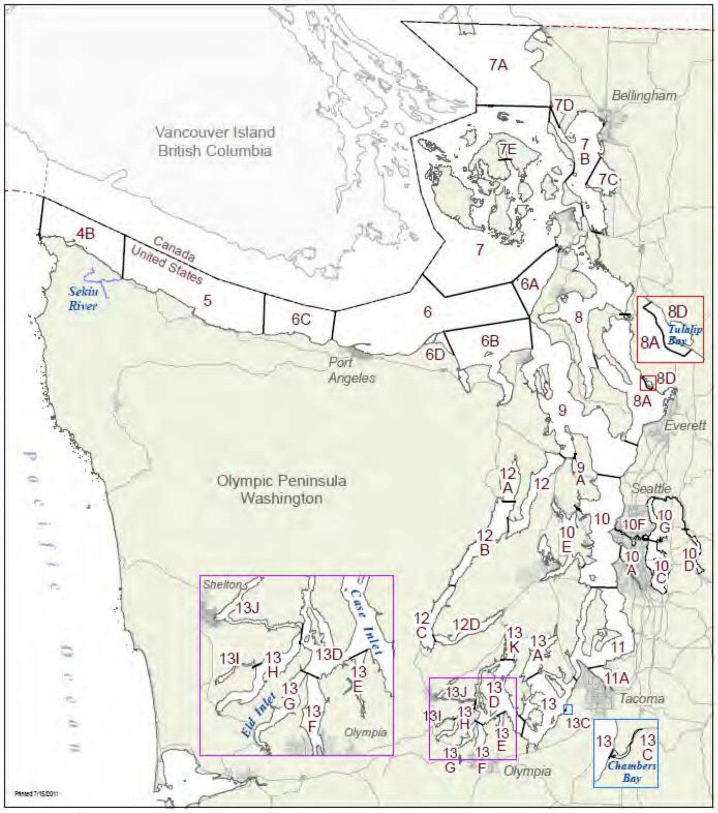


Sightings by Month − 2017−2019 combined
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Lat
Longitude
count
30
20
10
49.5°N
49.0°N
48.5°N
48.0°N
47.5°N
47.0°N
125.0°W
124.5°W
124.0°W
123.5°W
123.0°W
122.5°W
122.0°W

Figure 35. Opportunistic sightings of SRKW in inland waters by month for each Whale Museum quadrant (see Olson et al. 2018 (Olson et al. 2018)) for 2017-2019 combined (Whale Museum unpublished data), overlaid with commercial fishing areas (grey outlined areas, see Figure 30). Duplicate sightings per day were removed so counts of sightings represent unique sightings by day per month (total across 2017-2019). All sightings for 2019 have not yet been included in Whale Museum database to date but we include the sightings that have been entered (no current 2019 sightings in November, December).

The vessels associated with the Puget Sound salmon fisheries overlap with the whales, particularly in the San Juan Island area, or recreational marine area 7 (R-MA 7) (Figure 35, Figure 36) in July through September (shown here and as described in previous Puget Sound fishery biological opinions, e.g. NMFS (2019b)) based on occurrence/frequency of SRKWs and fishery area management. SRKWs also forage near the US-Canadian border, which is also part of R-MA 7, and is part of C-MA 7a (Figure 34). In 2021, the recreational Chinook salmon mark-selective fishery (MSF) in R-MA 7 will occur from July 1, 2021 through July 31 and August 16-31 (Table 30, (Cunningham 2021)). Anglers will be allowed to catch two fish including 1 hatchery Chinook salmon and must release chum, wild coho, and wild Chinook salmon. The R-MA 7 recreational fishery will be non-retention fishery August 1-15 and September 1-30 (including release of all Chinook). This area is a key foraging area for the whales during summer months, especially in recent years in September for all pods, and the non-retention requirements in the recreational fishery are anticipated to 1) potentially reduce impacts from vessels (we anticipate lower fishing effort, and less vessel traffic, in non-retention fisheries) and 2) reduce impacts to prey available (as discussed below) to SRKWs in the times and areas of high importance. There are no Chinook directed fisheries in the Strait of Juan de Fuca in May-June and September-February, and only fishing in R-MA 5 in March and April (Cunningham 2021). Puget Sound recreational fishery closures in 2021-2022 occur in the winter time period (Oct.-Apr.) and include the complete winter closure to Chinook fishing in recreational Marine Areas 6, 7, 8, 9, and 12 (Figure 36); also no Chinook salmon directed fisheries in May-June in areas 6-9 (SRKWs have been observed in these areas in these months in past years, The Whale Museum, unpublished data). In addition, all winter sport fisheries in 2021-2022 are closed in R-MA 6,7,8,9, and 12 (except non-retention in 12 in October/November) (Cunningham 2021). In addition, fishing in area 10, where SRKW are sighted in Fall months and foraging (Figure 35, Figure 36), though likely not primarily consuming Chinook salmon in this area (Figure 34), is non-retention in October, and has no fishing November and December (Cunningham 2021). Though fishing in area 11 is non-retention in October and mark-selective in November/December compared to last year when it was completely closed, 2021 closures are comparable to 2020 and are substantial compared to previous fishing seasons (prior to 2020). Overall, the 2021-2022 recreational Chinook season in R-MA 7 is reduced by 1.5 months relative to 2019 (and is the same as the 2020 season) (Cunningham 2021).

(A)


7A
7D
Bellingham
Vancouver Island
British Columbia
7E
7
B
7C
4B
Canada
United States
Sekiu
River
5
6C
7
6A
6
6D
6B
8
8D
8A
Tulalip
Bay
Port
Angeles
9
Everett
Olympic Peninsula
Washington
12
A
12
9
A
Seattle
10
10F
10
G
12
B
10
E
10
A
10
C
10
D
Shelton
13J
Case Inlet
12
C
12D
13
K
13
A
11
13I
13
H
13D
13
E
13
G
Eld Inlet
13
F
Olympia
11A
Tacoma
13C
Chambers
Bay

(B)

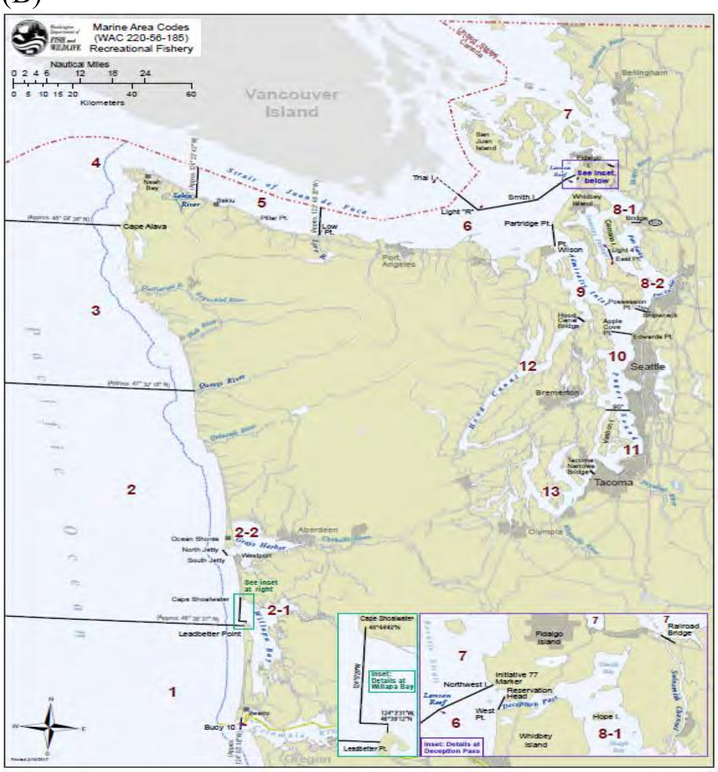

Marine Area Codes
(WAC 220-56-185)
Recreational Fishery
Nautical Miles
Kilometers
Vancouver
Island
Bellingham
7
4
5
6
Strait of Juan de Fuca
Trial I.
Light "R"
Smith I.
Partridge Pt.
See inset
below
Cape Alava
Sekiu
Pillar Pt.
Low
Pt.
Port
Angeles
Pt
Wilson
8-1
8-2
3
9
10
Seattle
12
Bremerton
11
Tacoma
13
2
2-2
Aberdeen
Ocean Shores
North Jetty
Westport
South Jetty
Olympia
See inset
at right
Cape Shoalwater
2-1
Leadbetter Point
1
Buoy 10
Cape Shoalwater
Inset:
Details at
Willapa Bay
Leadbetter Pt.
7
Fidalgo
Island
Northwest I.
Initiative 77
Marker
Reservation
Head
West
Pt.
6
Inset: Details at
Deception Pass
Whidbey
Island
Hope I.
8-1
Railroad
Bridge

Figure 36. (A) Puget Sound Commercial Salmon Management and Catch Reporting Areas and (B) Puget Sound Recreational Salmon Management and Catch Reporting Areas (reprinted from (Cunningham 2021)).

Table 30. Puget Sound Marine Pre-Season Recreational Chinook Seasons in Marine Area 7 (MA7) (2017 – 2021). 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							
2021			MSF	NR/MSF	NR							

Commercial salmon fishing vessels licensed by WDFW also operate in C-MA 7 in the vicinity of San Juan Island (Cunningham 2021). 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 2021, these vessels will target sockeye and pink salmon returning to the Fraser River. During the Fraser fishery, Chinook salmon are required to be released by purse seines for non-tribal commercial fishing. The number of days fished in WDFW-managed commercial purse seine and gillnet fisheries in C-MA 7 and 7A (San Juan Islands and Point Roberts areas, respectively, see Figure 36 A) during 2009, 2013, and 2017 averaged 11 days in August and early September, with the majority of days in August (Cunningham 2021). For 2021, these commercial fisheries (with the gear types outlined above) in these areas targeting Fraser River sockeye are predicted to be zero or dramatically reduced compared to these earlier years –(2009, 2013, 2017)(Cunningham 2021) based on the low Fraser River sockeye forecast with no harvestable surplus. Fraser pink salmon in 2021 is at 3.0M, which is a relatively small run size and would only allow a limited 1-2 day commercial fishery opening in 7/7A. However, Fraser Panel area fisheries are managed in-season with real time run size updates and the fisheries planned for implementation in the pre-season can be modified, in-season, in response to these updated estimates.

For tribal fishing in pre-terminal areas within Puget Sound, Chinook salmon harvest predominately occurs in fisheries directed at other salmon species with Chinook salmon catch being incidental and/or in times and areas where SRKWs encounters are not expected or rare (Loomis 2021). The temporal and seasonal effort observed in recent years for tribal fisheries is not expected to change substantially over the duration of 2021-2022 (Loomis 2021). Therefore, to assess the potential spatial/temporal overlap of tribal vessels with SRKWs within the inland waters in 2021-2022, 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 2021). The recent 5-year average tribal fleet size in the Salish Sea (as defined by unique fish tickets) is 755 vessels. Assessing the potential for interaction utilizing the SRKW sightings (including in SRKW "hot spots" – high use areas) and unique fish ticket data indicates that there is minimal overlap between SRKWs and tribal salmon fisheries (Figure 37). 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 (including around San Juan Islands, in July-September with >1 to 2.5 boats). There is also overlap North of this area in July-September with an average of >2.5-5 vessels per time step day but with somewhat less occurrence of SRKWs. In October-April and May-June, there are fewer tribal vessels per time step day (<2.5), on average, in the areas with the greatest SRKW observations (>30 SRKW observations, including in the Central basin of Puget Sound, Loomis 2021). Most harvest occurs in times and areas when/where SRKWs are more rare and/or directed at species other than Chinook. Furthermore, the majority of tribal fisheries impact on Chinook is terminal (77/23 terminal vs. pre-terminal) therefore, it occurs in areas outside the reach of killer whales.

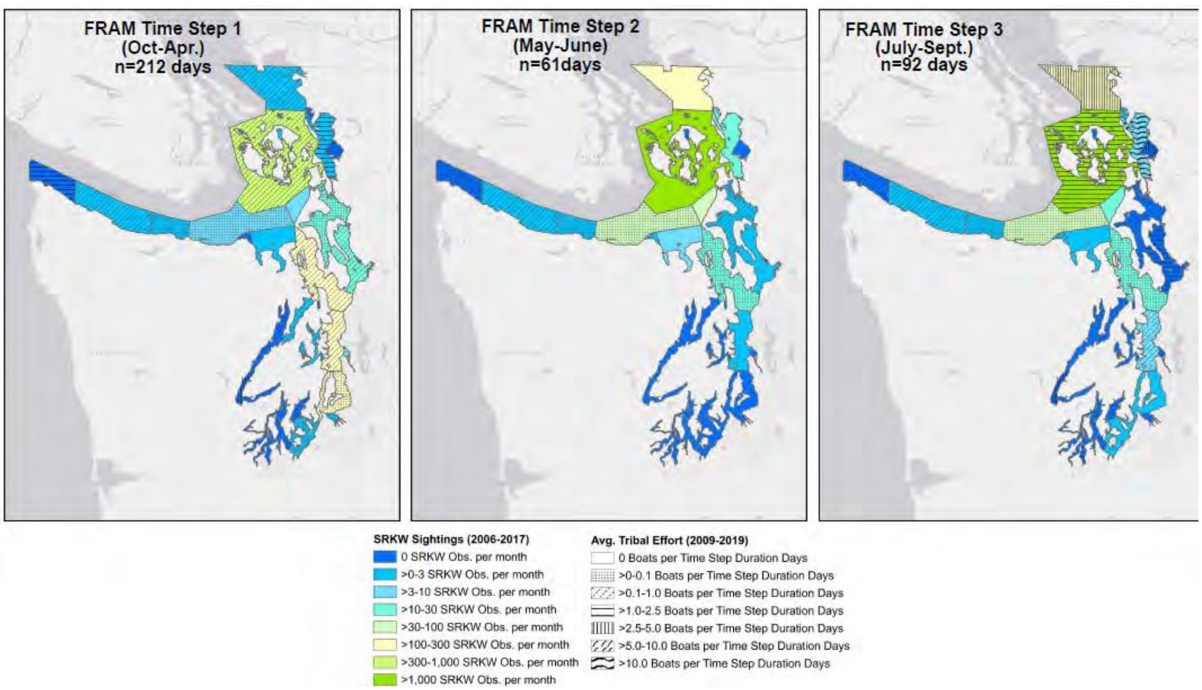


Figure 37. Average overlap of tribal fishing vessels (measured by unique fish tickets) and Southern Resident killer whale sightings in all FRAM timesteps (Timestep 1 Oct-Apr.; Timestep 2 May-June; and Timestep 3, July – September) (reprinted from (Loomis 2021)).

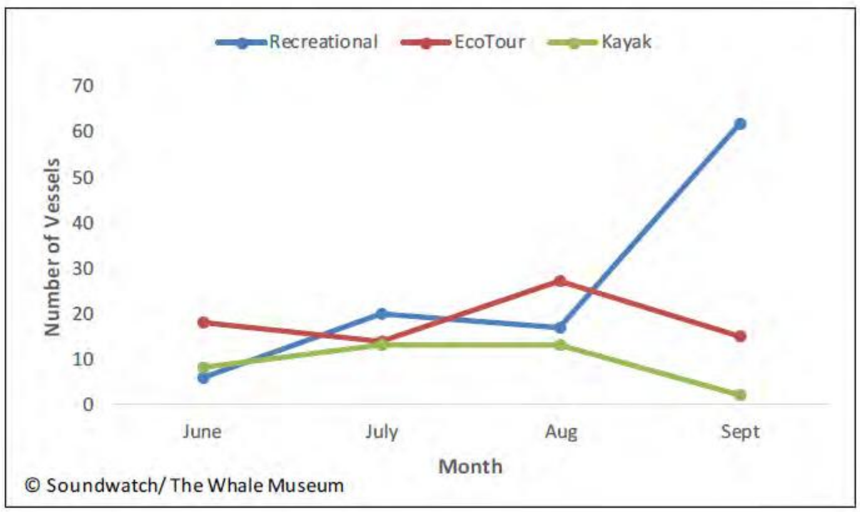
To put the number of Puget Sound salmon fishing vessels in R-MA7 in the summer months in context, we use the Soundwatch Boater Education Program's long-term data set because it provides insight into annual trends of vessel activity near the whales. The Soundwatch Boater

Education Program collects data on the number and types of vessels (including fishing vessels) and vessel activity within ½ mile of the whales during the summer months in inland waters. Vessel activity categories include transiting, whale-oriented, fishing (defined as moving or stationary with poles or nets in the water), research, enforcement, acoustic (not in a ½ a mile range but within acoustic or visual range), and other. Therefore, this data provides information on the number of vessels engaged in fishing near the whales versus other activities. Given the 2021-2022 recreational, commercial and tribal fisheries seasons are similar to 2020 or reduced compared to past years (prior to 2020), 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, fishing activities do significantly influence trends in vessel presence near the whales. Although Soundwatch does not further categorize the fishing vessels into commercial, tribal, and recreational, given the limited number of pre-terminal tribal fishing vessels (2.5 vessels per day on average), and the relatively small number of days on average the commercial fishing vessels have occurred in past years during the fishing season (averaged 11 days in August and early September), we assume the majority of fishing vessels present off the west coast of San Juan Island observed by Soundwatch are recreational. 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 37) (Seely 2017). The annual variations in the maximum number of fishing 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 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. Of the total incidents recorded in 2018, 11% were for vessels fishing within 200 yards of the whales (Shedd 2019).

In 2020, the maximum number of total vessels observed in a ½ mile radius of the whales was 39 (with an average of 10.5), and reflects a continued general downward trend compared to previous years (Frayne 2021). The majority of vessel counts occurred in northern Haro Strait on the west side of San Juan Island (Frayne 2021), where SRKWs are known to forage. Vessel activity around SRKWs in most months was primarily whale-oriented activity, except in the month of September when vessels within ½ a mile of SRKWs were mainly engaged in fishing (Figure 38), which may be because of the opening for salmon fishing (Frayne 2021) similar to previous years. In September, 2.4 boats on average daily near the whales were engaged in fishing activity (compared to 2.3 participating in whale-oriented activity) and September was also the month where the maximum count of vessels near the whales (39) occurred. Therefore, vessels in the presence of SRKWs mainly occur off the west side of San Juan island, particularly in September when the majority of boats near whales are participated in fishing, though on average there is <3 vessels fishing near the whales.

In summary, from the information presented above, fishing vessels mainly overlap with SRKW occurrence in marine area 7 off the west coast of San Juan island because SRKW typically spend the majority of their time foraging in this area in summer months and fishing vessels are active in the area particularly in Summer (with additional overlap in other areas and times of year outlined above). But recreational fishing management measures in Summer (non-retention requirements) will likely limit effort in the area, tribal effort in the area is low in Summer months (few boats on average) compared to other areas, and commercial fishing presence off the west side of San Juan Island is likely very limited due to no harvestable surplus of sockeye. Information about the overlap of fishing vessels/effort and occurrence of SRKWs is used in the effects analyses below: potential direct effects of fishing vessels and gear on SRKW and indirect effects of fishing through prey removal in foraging areas. For direct effects, the analysis includes discussion of potential vessel and acoustic disturbance, gear interaction, and ship strike impacts of SRKW, based on the spatial, temporal overlap between vessels and SRKWs illustrated in this section. Within indirect effects, overlap between SRKW and fishing vessel presence informs discussions on the potential for vessels to deplete prey availability in SRKW foraging hot spots and management measures that likely reduce any impacts.



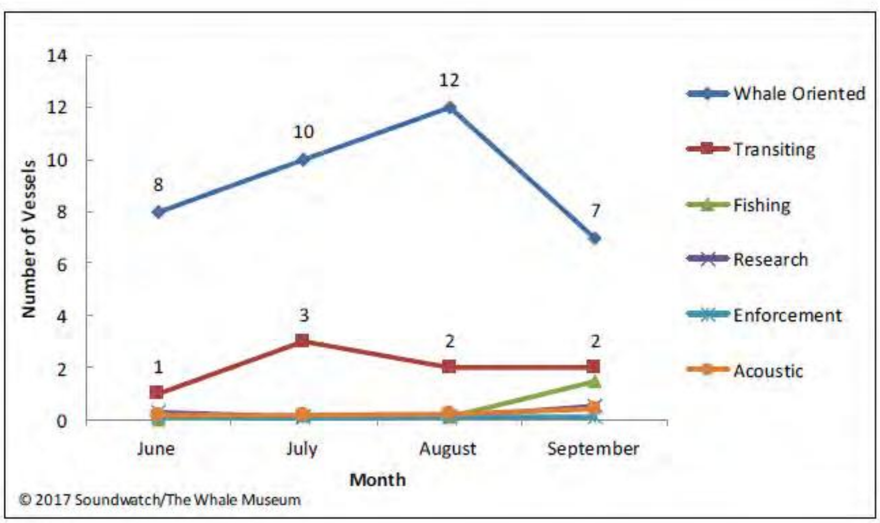


Figure 38. Monthly maximum (top) and average numbers (bottom) of vessels near Southern Resident

killer whales by vessel type and activity in 2017 (Figures from Seely (2017)).

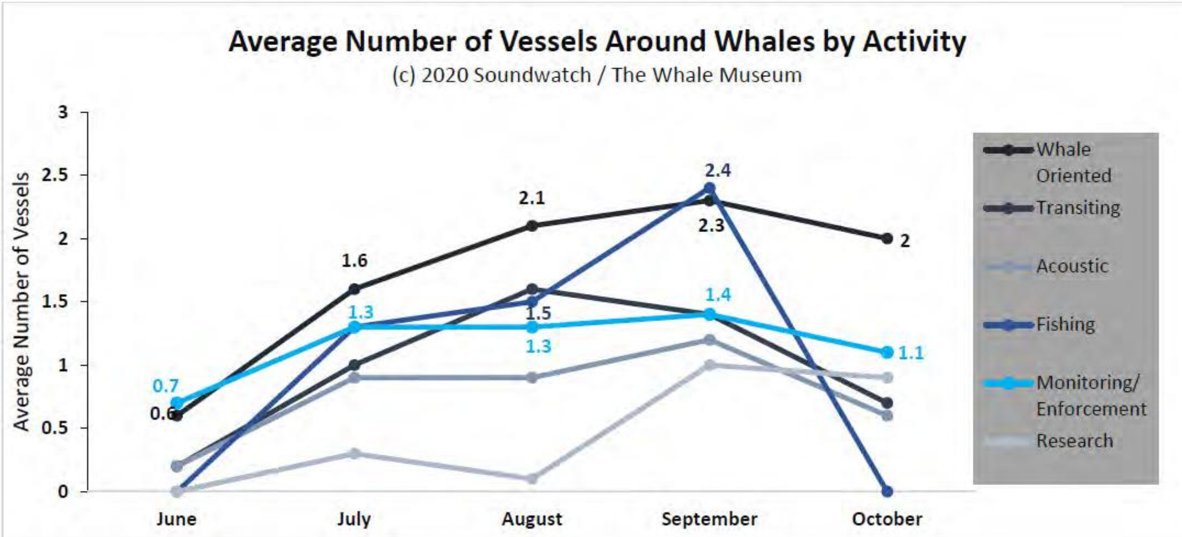


Figure 39. Average number of vessels within one half-mile radius of killer whales by vessel activity and month in Soundwatch 2020 vessel counts, reprinted from (Frayne 2021).

Direct Effects: Vessel activities and gear interactions

There is potential for direct interaction between SRKW 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 and timing of the proposed fisheries. This analysis considers how direct effects from vessel activities and gear interactions associated with the proposed fishery may impact the fitness of Southern Resident killer whales. Above we describe the general predicted overlap of the whales and the 2021-2022 fisheries using recent seasonal SRKW sightings and considering fishery management measures in place for the upcoming season that may reduce overlap, and here we describe the potential for direct interactions (e.g., vessel strike, gear interaction, vessel or acoustic disturbance), potential responses by the whales (e.g., mortality, serious injury, behavioral changes), and also the additional education and outreach actions by WDFW that likely limit interactions. Our conclusion based on the available information is that interactions with vessels or fishing gear associated with the proposed action are not likely to have more than minor, insignificant effects on SRKWs.

Potential Interactions and Responses

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 or instances of gear interaction with marine mammals are rare, though a recent paper did determine vessel strike as the cause of death for three stranded killer whales (one Southern Resident, one Northern Resident, and one transient, for 22 whales where a definitive cause of death could be determined from 2004 to 2013) (Raverty et al. 2020). One Southern Resident that had a confirmed death from vessel strike was habituated to humans (L98) while another Southern Resident included in the data set for body condition analysis (J34) had trauma consistent with a vessel strike. Several other killer whales, including one Southern Resident (L112), had blunt force trauma of unknown origin (see Status section). Interactions of killer whales and fishing gear in general have been observed (as described in the Environmental Baseline), however, entanglements are rare. Fatal fisheries interactions are infrequent for all killer whales (see (Raverty et al. 2020)), and no such interaction has ever been observed in association with Puget Sound salmon fisheries.

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)[57]. 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 kill or seriously injure marine mammals. Commercial fishers in all categories participating in U.S. fisheries are required to report incidental marine mammal injuries and mortalities (with the exception of tribal treaty fisheries, but tribes voluntarily report such interactions). The current LOF classified the "WA Puget Sound Region salmon drift gillnet" fisheries (Treaty Indian fishing excluded) as Category II fisheries (i.e., occasional interactions that result in M/SI) due to incidental takes of harbor porpoise, Dall's porpoise, and harbor seals (85 FR 21079, April 16, 2020). 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 SRKWs are reported (in accordance with provisions of the MMPA, 50 CFR 229.7).

There is substantial vessel traffic within the action area, particularly into and out of major ports. Private vessels commonly come within ½ mile of the whales in inland waters (Frayne 2021), and some private vessel operators are likely to be recreational and commercial fishers associated with the proposed action. The majority of vessels within ½ mile of the whales in September of 2020 were participating in fishing activity; specifically, 2.4 vessels on average daily near the whales were fishing (Frayne 2021). 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 based on the information presented previously, we expect that the proposed action may result in some additional exposure of SRKWs to the physical presence or sound generated by vessels participating in salmon fisheries if SRKWs were present nearby. There is a potential for SRKW/fishery vessel interaction during all months the fishery is occurring, with the highest likelihood for interaction occurring in R-MA 7 in the summer months (especially in September) where the potential for overlap of the whales and fisheries are the greatest (all pods in the area and highest number of vessels engaged in fishing).

For fishing vessels, if interactions were to occur, vessel and acoustic disturbances may cause behavioral changes, avoidance, or a decrease in foraging. As discussed in the Status of the Species and Environmental Baseline sections, 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 (e.g., (Williams et al. 2006; Noren et

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

al. 2013; Holt et al. 2015)). Even more of a concern for SRKWs 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). As mentioned above, Southern Residents spent 17 to 21% less time foraging in the Salish Sea in the presence of vessels depending on the distance of vessels (see (Ferrara et al. 2017)). Most recently, Holt et al. (2021) demonstrated that SRKW subsurface behavior changes significantly when vessels are close (< 400 yd), with fewer foraging dives and less time spent in this state compared to when vessels were at a distance > 400 yd. In particular, females were more impacted than males, being more likely than males to switch to a non-foraging state when vessels were close. Reduced foraging opportunities may be especially detrimental for females as they were more likely to switch to non-foraging behavior in vessel presence (Holt et al. 2021), and have high energetic needs for reproduction. Increases in energetic costs because of behavioral disturbance and reduced foraging can both decrease individual whales' fitness and health (Dierauf and Gulland 2001; Lusseau and Bejder 2007). Currently, the degree of impact from repeated vessel-caused disruptions of foraging and energy intake is unknown. However, decreasing the number of repeated disruptions from vessels would likely reduce the impact on foraging and, in turn, reduce the potential for nutritional stress.

Some of the disturbances from vessels participating in fishing 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 MA 7 in the summer months where the potential for overlap of the whales and fisheries are the greatest. Additionally, with winter fishery closures discussed above, 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, there may be reduced impacts from these closures to J pod given their occurrence in inland waters throughout the year (Cunningham 2020; 2021). 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 2021). Commercial gillnet and purse seine also do not use these for fishing specifically (used for navigation). 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 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. Continued implementation and enforcement of the 2019 restrictions on speed and buffer distance around SRKW for all vessels.
2. Increased effort dedicated to outreach and education programs. This includes 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. Outreach content was created in the form of video, online (including social media), and print advertising

targeting recreational boaters. On-site efforts include materials distributed at pumpout and re-fueling stations along Puget Sound, during Enforcement orca patrols, and signage at WA State Parks and WDFW water access sites. Additionally, State Parks integrated materials on whale watching regulations and guidelines in their boating safety education program to ensure all boaters are aware of current vessel regulations around SRKW.

3. Continued promotion of the voluntary "No-Go" Whale Protection Zone along the western side of San Juan Island in R-MA and C-MA7 for all recreational and commercial fishing vessels (with the exception of the Fraser Panel sockeye and pink fisheries[58]) (Figure 40). 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[59] extended in 2018 and the full protected area recognized by the Pacific Whale Watch Association[60] 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.

[58] Non-treaty Fraser River Panel commercial fisheries utilize purse seine gear within ¼ mile of San Juan Island and are required to release non-target species (Chinook and coho ;(Cunningham 2021)).

[59] https://www.sjcmrc.org/projects/southern-resident-killer-whales/

[60] https://www.pacificwhalewatchassociation.com/guidelines/

Figure 40. An approximation of the Voluntary "No-Go" Whale Protection Zone, from Mitchell Bay to Cattle Point (Shaw 2018). See https://wdfw.wa.gov/fishing/locations/marine-areas/san-juan-islands

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, which has less impact on SRKWs. When in transit, vessels would likely travel at faster speeds with greater 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, and would likely result in very minor or short-term changes to the whales' behavior or avoidance.

Fishing vessels are subject to state regulations when transiting state waters that protect SRKWs, which includes vessel viewing distances of 300 yards to the side of the whales (400 yards in the path of whales) and vessel speed within ½ nautical mile of the whales of 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 near San Juan Island in summer months), 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 and likely limited pink commercial fishing, reducing vessel presence in important SRKW foraging areas. Lastly, SRKWs forage primarily off the west side of San Juan island (in R-MA 7) in summer months and presence of vessels engaged in fishing around SRKW was highest in September in 2020 ((Frayne 2021), though only 2.4 vessels on average). But, the non-retention requirement in September and part of August in Area 7 near San Juan Island is expected to slightly reduce recreational fishing vessels, and a complete closure of the winter fisheries in R-MAs 6, 7, 8, 9, and 12 (except non-retention in 12 for 2 months) are expected to minimize vessel impacts to SRKWs, primarily J pod. Overall, the direct impacts from fishing vessels are expected to be relatively low in 2021-2022 and similar to previous years (comparable to 2020), based on the reduced presence of fishing vessels in the key foraging areas (e.g. the reduced vessel impacts likely to occur in foraging hot spots along the west side of San Juan Island). Also, there will be increased outreach and education efforts to the fishing community (including educational material on adjusting or silencing sonar in the presence of SRKWs), and continued promotion of the no-go zone off the West Coast of San Juan Island. As a result, we expect that any transitory, small amount of disturbance caused directly by the fishing vessels' presence and sound is not likely to disrupt normal 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. We anticipate any interactions from vessels or gear attributed to the proposed action are not expected to result in take of SRKWs.

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. The Workgroup presented a final risk assessment at the June 2020 PFMC meeting. We relied on the PFMC SRKW Ad Hoc Workgroup report (PFMC 2020b) and methods where appropriate (analyses that included Salish Sea) as well as the analyses described in Cunningham (2021) and Loomis (2021) 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; 2019e; 2020d) 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 section 2.2.1.4 Status of Southern Resident Killer Whales) 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.

To date, the available data and analyses have not supported an analytical approach that statistically quantifies effects of changes in Chinook salmon abundance to killer whale survival and recovery (i.e., mortality and reproduction). In the absence of a predictive analytical tool to evaluate this relationship, we use a weight-of-evidence approach to consider all of the information we have--identifying a variety of metrics or indicators with varying degrees of confidence (or weight)--in order to assess the impacts of the proposed action. First, we discuss and summarize what is known about the relationship between SRKWs and their primary prey, Chinook salmon, and methods used to explore these relationships, and why we do not rely more extensively on correlations in our analysis of impacts of fisheries on prey availability and instead rely on a weight-of-evidence approach. We then discuss our evaluation on the potential indirect effects of changes in prey availability from the Puget Sound salmon fisheries in 2021-2022 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 Chinook Salmon Abundance and SRKW Demographics

Several studies in the past have found correlations between Chinook salmon abundance indices and SRKW demographic rates (e.g. fecundity and mortality) (Ford et al. 2005; Ford et al. 2009; Ward et al. 2009; Ward et al. 2013). Although these studies examined different demographic responses related to different Chinook salmon abundance indices, they all found significant positive relationships (high Chinook salmon abundance coupled with high SRKW fecundity or survival). However, the assumption that these correlations represent causation was previously criticized by a panel of experts (Hilborn et al. 2012). The panel cautioned against overreliance on correlative studies.

There are several challenges to quantitatively characterizing the relationship between SRKWs and Chinook salmon and the impacts of reduced prey availability on SRKW's behavior and health. Attempts to compare the relative importance of any specific Chinook salmon stock or stock groups using the strength of statistical relationships have not produced clear distinctions as to which stocks 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 have previously appeared 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 (see (Hilborn et al. 2012; Ward et al. 2013). For example, low coastwide Chinook salmon abundance in the late 1990s corresponded to an approximate 20% decline in the SRKW population, constrained body growth, and low social cohesion as described in the Status of the Species (also see Agenda Item B.2, May 23, 2019).

To explore potential demographic projections, Lacy et al. (2017) developed a population viability assessment (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 of SRKW demographic rates with Chinook salmon abundance using a prey index for 1979 – 2008, and models SRKW demographic trajectories assuming that the relationship is constant over time. Over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate. Furthermore, they suggested in order for the population to reach the recovery target of 2.3% growth rate, the acoustic disturbance would need to be reduced in half and the Chinook abundance would need to be increased by 15% (Lacy et al. 2017)

Although they found higher concentrations of PCBs could also potentially push the population from slow positive growth into decline, although to a lesser degree than prey availability, the authors took the position that eliminating or reducing this pathway of effects was not a practical action to the whales given the long timescale and costs involved in this type of recovery action. Murray et al. (2019)(and also in (Murray et al. 2021)) updated the PVA model by incorporating new data and information on all threats and interaction of threats (Chinook abundance, vessel noise, vessel strikes, and contaminants), assumed SEAK resident killer whale vital rates as baseline reference rates for SRKW in the absence of threats (as the SEAK population has been increasing in size and is considered not subjected to the same threats), and then attempted to explain patterns in historical SRKW data based on the multiple threats. They found that a single threat alone could not replicate the observed patterns in SRKW population trends from 2000-2017 and only when the threats are considered together did the PVA model output most closely replicate observed trajectories in SRKWs. Another study found a significant inverse 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 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.

More recent research has found SRKW body condition can be collected for multiple individuals over multiple years (Fearnbach et al. 2018) and may be assessed against the salmon abundance. Stewart et al. (In Press) used 473 measurements of body condition from 99 SRKWs from 2008-2019 to assess relationships between Chinook salmon abundance (from various runs) and SRKW body condition transition (changes from one body condition state to another) through Bayesian model selection. For J pod, the model that included Fraser River Chinook abundance was the best model for predicting a change in SRKW body condition compared to models with other Chinook or no Chinook covariates (though Salish Sea Chinook abundance was similarly a good predictor possibly because Fraser River runs make up the a large proportion of Salish Sea abundance). They found there was a higher probability of a decline in body condition in J pod when Fraser River abundance was low. For L pod, the best fit model showed a relationship with the probability of a change in body condition and Puget Sound Chinook, but this relationship was weaker than the relationship between J pod and Fraser River Chinook and all other models between L pod condition and salmon abundance indicators showed unintuitive relationships (higher probability of a decline in body condition with higher salmon abundance). For K pod, the best model did not include any covariates of salmon abundance. Model results also suggested that whales in poorest body condition have higher probability of mortality. Additional efforts to relate sample sizes, for SRKWs and other populations, and relate body condition and demographic rates, including reproduction, are ongoing.

Recently, the PFMC's Workgroup attempted to quantify the relationship between Chinook abundance and SRKW demographics (PFMC 2020b). Here, we briefly describe their analysis and results applicable to our discussion of the relationship between Chinook abundance and SRKW status, but more detailed information is provided in (PFMC 2020b) and (NMFS 2021a). The Workgroup used a regression analysis to relate past SRKW demographic performance metrics with estimates of the starting abundance of Chinook salmon for the same seasons

(October – April, May – June, and July – September) and areas North of Falcon (NOF)[61], Salish Sea, SWVCI, Oregon coast, and California coast) for the years 1992 – 2016 (PFMC 2020b). For survival, abundance at a lag of one year was also considered; for fecundity, lags of both one and two years were considered. The Workgroup considered one and two year temporal lags because of physiological mechanisms linking food supply to future performance, such as the 17-18 month gestation period of SRKWs (Duffield et al. 1995; Robeck 2016), and effects of prolonged nutritional stress on body condition, and also because exact birth and death dates are sometimes uncertain (see (PFMC 2020b; NMFS 2021a)).

Similar to past efforts, the Workgroup found predicting the relationship between SRKWs and Chinook salmon abundance to be challenging. The relationships between modeled Chinook salmon abundance and SRKW demographics examined by the Workgroup in this most recent analysis appear weaker than those from prior analyses. For example, although the average coastwide Chinook salmon abundance in this last decade is higher than the average over the entire time series (1992 – 2016), the SRKW population has experienced a decline in their population. One of the Workgroup's fitted regressions, however, met the criterion of statistical significance ($p \leq 0.05$) (winter Chinook abundance NOF and SRKW survival with one year time lag, $p = 0.0494$) and several regressions had $p \leq 0.10$ in times and areas with likely whale presence. Furthermore, while not statistically significant, in the majority of cases (71 percent) the general patterns in the relationship were as expected, i.e., the survival and fecundity increased with increasing Chinook salmon abundance while occurrence of peanut-head decreased with increasing Chinook salmon abundance (PFMC 2020b). Although the Workgroup emphasized that caution is warranted when interpreting the regression results given the limitations of the data, they concluded that these results, coupled with the potential occurrence of SRKWs in the NOF area in all seasons, suggest that Chinook salmon abundance in NOF 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 2020b).

The Workgroup also attempted to predict the effects of the reduction in Chinook abundance due to PFMC ocean salmon fisheries on SRKW performance metrics, and results suggested that any effects of the fisheries on SRKW demographics were relatively small. They compared model predictions of SRKW performance metrics corresponding to the estimated Chinook abundance left in the ocean after fishing each year ("postseason abundance") to model predictions of vital rates corresponding to the estimated Chinook abundance that would have been left in the ocean that same year, if removals in PFMC fisheries did not occur ("zero PFMC"). In general, in any given year, the model-estimated changes in fecundity and survival were small when scenarios with the PFMC-driven reductions in Chinook abundance in the NOF area were compared to scenarios without the reductions ($\leq 0.2\%$ change in both mean estimates in survival and fecundity, see Table 5.5a in (PFMC 2020b)). The Workgroup concluded that SRKWs are likely impacted by reduced prey availability in the NOF area to some unknown degree, and there is potential for overlap with salmon fisheries in this area every year, but overall, the PFMC salmon

[61] 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). Also see the SRKW Environmental Baseline (section 2.4.3).

fishery impacts on NOF abundance are small relative to both annual variation in abundance and the total abundance in a given year (PFMC 2020b).

One factor confounding our ability to quantitatively describe the relationship between SRKW demographic performance and the effects of the fisheries on Chinook salmon abundance, is the likely very low statistical power to detect a significant relationship because of the limits of the relevant data. Statistical power is the probability of detecting a significant effect (defined here in the common sense of $p \leq 0.05$ for a two-sided test), for different assumed values of the true effect. For models such as regression analyses that have been used to quantify relationships between SRKW demographic parameters (such as fecundity, survival) and changes in Chinook salmon abundance, existing data may be too limited to produce enough statistical power to detect a statistically significant relationship, even if a biologically significant difference exists. In most years, SRKWs experience fewer than five births or deaths; these already small sample sizes are exacerbated by the small (and declining) population, as well as the life history of the species (i.e., long lived individuals but low number of offspring per reproductive female), and the confounding effects on Chinook salmon abundance. Based on simulations and power analysis (Ward and Satterthwaite 2020) and described in NMFS (2021a), results indicate that the SRKW demographic data alone would not be expected to help provide anything more than weak evidence for or against a significant change related to prey abundance (or any other perturbation). In NMFS (2021a), we concluded that analyses that are attempting to detect a significant change ($p \leq 0.05$) in SRKW demographic rates given a change in prey abundance (from management change or other source), may be unlikely to detect a significant effect even if a biologically significant effect is present. The PFMC's Scientific and Statistical Committee (SSC) reviewed the Workgroup's risk assessment methods and "agrees that further analyses are unlikely to yield more informative results, as the regressions, generalized linear models, and cluster analyses had similar results to each other and to previous analyses. Given the large amount of data usually required to detect small differences in survival of long-lived species, further work is unlikely to resolve these relationships." (Agenda E.4.a, Supplemental SSC Report 1, November 2019).

Additional limitations and key uncertainties the Workgroup highlighted in their report (PFMC 2020b) include (1) the statistical model assumptions (i.e. assume stationarity), (2) uncertainty in Chinook salmon stock abundances, (3) limited range of observed Chinook salmon stock abundances, (4) uncertainty in Chinook salmon stock distributions, (5) lack of information on Chinook salmon distributions during winter, (6) limited information on distribution for most spring-run Chinook salmon stocks, (7) effects of changes in Chinook salmon size and age structure, uncertainty in the distribution of SRKWs, (8) differential responses to changes in Chinook salmon among pods, (9) uncertainty in the factors driving changes in the distribution of SRKWs, uncertainty in the ability of SRKWs to switch to alternate prey sources, (10) patterns of temporal variation in competing threats, and (11) Chinook salmon stocks whose abundances are not included in the modeling.

Though it is difficult to find quantitatively statistically significant relationships between prey abundance and SRKW demographics, nutritional stress as a chronic condition can lead to reduced body size and condition of individuals (e.g., Trites and Donnelly 2003) and whales in poor body condition have a higher likelihood of mortality, while accounting for age and sex (Stewart et al. in press). Although there is currently no robust quantitative model that identifies a low abundance threshold that is predicted to cause adverse effects to SRKWs, there is evidence SRKWs and other killer whale populations that are also known to consume Chinook salmon may have experienced adverse effects from low Chinook prey availability in the late 1990s likely due to common factors affecting changes in the populations (NMFS 2008g; Towers et al. 2015).

Effects of reductions in Chinook salmon abundance could be more significant to SRKWs at relatively low levels of Chinook abundance and this likely also depends on the status of SRKWs at the time. Populations with healthy individuals may be less affected by changes to prey abundance than populations with less healthy individuals (i.e., there may be a spectrum of risk based on the status of the whale population). Impacts on prey availability attributed to fisheries are expected to reduce prey availability at all abundance levels, but removals present more risk at lower abundance levels and when the whales have a poor status. Because SRKWs are already stressed due to the cumulative effects of multiple stressors, and the stressors can interact additively or synergistically, any additional stress such as reduced Chinook salmon abundance likely have a greater physiological effect than they would for a healthy population, which may have negative implications for SRKW vital rates and population viability (e.g., (NAS 2017b). Intuitively, at some low Chinook abundance level, the prey available to the whales may 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. 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 searching for prey during periods of reduced prey availability may decrease the time spent socializing; potentially reducing reproductive opportunities. Also, low abundance across multiple years may have even greater effect because SRKWs likely require more food consumption during certain life stages, female body condition and energy reserves potentially affect reproduction and/or result in reproductive failure at multiple stages of reproduction (e.g. failure to ovulate, failure to conceive, or miscarriage, successfully nurse calves, etc), and effects of prey availability on reproduction should be combined across consecutive years. Good fitness and body condition coupled with stable group cohesion and reproductive opportunities are important for reproductive success.

For coastal salmon fisheries the PFMC recently adopted a proposed amendment to the salmon FMP that includes an identified 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) (Amendment 21 to the FMP, NMFS 2021, and see killer whale environmental baseline, section 2.4.3). Amendment 21 to the FMP is designed to minimize the effects of PFMC fisheries on prey availability and address the concerns for disproportionately high percent prey reductions in years of particularly low Chinook abundance in times and areas where/when the fisheries and whales overlap and potential for localized depletion by fisheries in SRKW foraging locations. The measures include restrictions on non-tribal quotas in the NOF area when abundance falls below the low abundance threshold that would ensure that fisheries in years of low abundance could not result in disproportionately high removals of Chinook salmon. Other measures would reduce overlap between the whales and fisheries, including in hot spots and other high use areas, reducing the potential for competition for prey. The threshold is specifically focused on abundance in the NOF area since the Workgroup concluded that Chinook abundance NOF may consistently be more important to SRKWs than other ocean areas. The threshold used is based on years included in the Workgroup's analysis when Chinook abundance was relatively low and there was a general mix of SRKW status (i.e., consisting of a spectrum of risk), with two relatively good status years (1994 and 2007) and five years of fair or poor SRKW status. As suggested above, removals of prey likely present more risk at lower abundance levels and when the whales have a poor status. Thus, including a threshold based on years a mix of SRKW status was observed, relatively good and relatively poor status, to address concerns of low Chinook abundance and the spectrum of risk based on the whale status is considered a more conservative approach than an abundance threshold that only factors in abundance levels when the whale status was poor. The low abundance threshold the Council developed for Amendment 21 was also based on a range of years including two periods when there were multiple and consecutive years of low Chinook abundance (1995 – 1996, 1998 – 2000). If prey availability is low on the coast (particularly below the threshold), and abundance is low or depletion occurs in foraging hot spots, SRKWs may increase searching efforts in other areas within their geographic range, including in the Salish Sea (though management actions associated with Amendment 21 may help reduce depletion in hot spots).

In summary, given the multiple caveats in interpreting the results discussed above, we apply a relatively low weight to regression analyses in general and continue to rely on a more qualitative weight-of-evidence approach. Again, to date, the available data and analyses have not supported an analytical approach that statistically quantifies effects of changes in Chinook salmon abundance to killer whale survival and recovery (i.e., mortality and reproduction). Therefore, we use a weight-of-evidence approach to consider all of the information we have--identifying a variety of metrics or indicators with varying degrees of confidence --in order to assess the indirect impacts from the proposed action on SRKWs through possible changes in prey availability. Though statistically significant relationships continue to be difficult to identify, the recent adoption of Council-area fisheries management based on low abundance thresholds recognize the higher risk to SRKW demography in low Chinook abundance years.

Effects of Prey Reduction Caused by the Proposed Action

We analyzed the effects of prey reduction in two steps. First, we consider the pre-season forecast of Chinook salmon abundance for 2021-2022 in comparison to previous years, and also compare the magnitude of reductions in prey available to the whales expected from the proposed fisheries based on the pre-season abundance and expected Chinook catch by the Puget Sound salmon fisheries, e.g., percent reduction in overall abundances from the fisheries (for marine fisheries only, freshwater fisheries were not considered in the analysis). Second, we considered information to help put the reduction in context because of the likely higher risk to SRKWs if Chinook abundance is low (see discussion above). We haven't identified a low abundance threshold specifically for Puget Sound and assessing availability of prey compared to the needs of the whales is another way to evaluate risk (though there are data gaps that limit interpretation). This includes: 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 Chinook prey available compared to the whales' Chinook needs, based on diet studies of Southern Residents and their predominant consumption of large Chinook, and finally 3) considering additional aspects of the action that could have negative consequences, specifically the potential for localized prey depletion, but also specific management measures (area closures, limits, etc.) that may reduce negative consequences. 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 and adapted for Puget Sound fisheries as described in Cunningham (2021) and Loomis (2021). The analysis of the effects of Puget Sound fishing on salmon availability for 2021-2022 is similar to 2020-2021 (NMFS 2020d), however, we use a different methodology to calculate percent reduction by the fishery and overall Chinook abundance compared to previous Puget Sound fisheries biological opinions prior to last year (e.g. (NMFS 2019b)); therefore we caution that percent reductions and abundance in this biological opinion are not comparable to all previous Puget Sound fisheries opinions. It should be noted that NOAA, the Puget Sound treaty tribes, and WDFW are exploring specific application of outcomes from the PFMC Workgroup to Puget Sound and potential improvements to the analysis approach for impacts of future fisheries in the Salish Sea. In addition, the uncertainties and limitations of the PFMC Workgroup methods that are briefly discussed above (in the previous section on the relationship between SRKWs and Chinook abundance) and discussed more extensively in PFMC (2020b) and NMFS (2021a) are also applicable to our analysis here to the extent we are relying on the Workgroup's methods.

To assess pre-fishing abundance and 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) (for more method specifics see (PFMC 2020b), (NMFS 2021a), and Environmental Baseline section 2.4.3). Estimated reductions in abundance attributable to Puget Sound fisheries removals were determined by taking the post-fishery abundances in the Salish Sea, with all fisheries removals (validation runs), and comparing these to the post-fishery abundances calculated with no Puget Sound fisheries in the year (all other fisheries that reduce Salish Sea abundance were still included). The annual effect of Puget Sound fisheries on the abundance of Chinook in the Salish Sea was calculated as the difference between the post-fishing July-September Salish Sea abundance in the "No Puget Sound fishery" model run and the corresponding model run with all fisheries occurring. Table 31 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 2021 in the "SALISH" region in October is approximately 605,100 Chinook salmon. This is slightly lower but similar to the recent 10-year post-season validated, starting abundance average of approximately 612,400 total abundance (2007 through 2016[62]; Table 31). This retrospective time period was chosen because the analysis is anchored to data from FRAM model runs, and 1992-2016 is the time period for which FRAM model runs were available at the time of the analysis, but percent reduction has been reduced in recent years so we focus on the most recent 10 years of the retrospective time period. A portion of that abundance is made up of Puget Sound Chinook (41% in 2021 compared to 1992-2016 average of 35%).

[62] The 2007-2016 estimates are from post-season FRAM runs (validation round 6.2) and 2021 represents the final pre-season FRAM run estimate.

Reductions to Salish Sea Chinook abundances caused by pre-terminal fisheries have decreased over time (see Table 31, Figure 41), even with starting abundance remaining relatively similar over time (see (PFMC 2020b) Appendix E Table 3; (NMFS 2021a)). Annual pre-terminal fisheries are estimated to reduce the overall abundance of Chinook by an average of approximately 3% in the Salish Sea relative to starting abundance (from 2007-2016) (Cunningham 2021). The largest proportion of these reductions by Puget Sound salmon fisheries is highest in inland waters in July-September compared to other seasons (Jonathan Carey pers. Comm.). The abundance of the 2021 predicted return of adult Puget Sound Chinook salmon that will escape pre-terminal fisheries is forecasted to be a decrease from the most recent ten-year average pre-terminal escapement, but similar to the average pre-terminal escapement for the full available data series 1975-2019[63] (Cunningham 2021) and is within the observed range of variation seen from year to year. The near-average starting abundance of Chinook salmon in 2021, coupled with pre-terminal escapement within the observed range and similar fishing effort as that from recent years (described above) suggests similar conditions of prey availability for SRKWs in the action area in 2021 compared to the average conditions over this last decade. NMFS expects the level of Puget Sound fisheries in 2021 to be similar to or lower than in recent years, given the critical status of several Chinook populations and the more restrictive harvest limits under the PS Harvest plan and obligations under the PST. Additionally, the low Fraser River sockeye and pink returns will further limit the non-Chinook commercial fishery effort in 2021 as well. Therefore, (Cunningham 2021) estimates an approximate 3% reduction in prey availability attributed to the Puget Sound salmon fisheries in 2021.

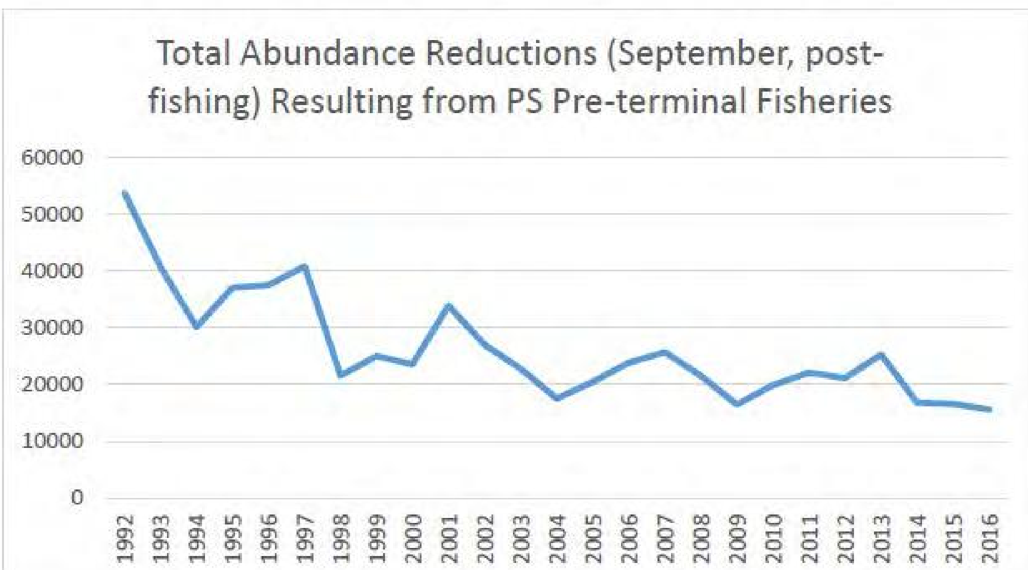

Figure 41. Reduction to post-fishing September abundance caused by Puget Sound pre-terminal fisheries from 1992 to 2016. This analysis used the PFMC SRKW ad hoc workgroup framework and was conducted jointly by WDFW and NWIFC. However, it should be noted that NOAA, NWIFC, and WDFW are exploring potential improvements to this framework and its specific application to Puget Sound. Reprinted from Cunningham (2021).

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

We note that the spatial model used to estimate percent reductions (used by the Workgroup and adapted for Puget Sound fisheries) 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. For the Salish Sea, this leads to uncertainty in percent reduction estimates because most salmon are returning to natal rivers and possibly not re-distributing to other regions. This along with other modeling limitations adds a level of uncertainty to these percent reduction estimates. Other uncertainties in Workgroup methods and Chinook modeling methodology are outlined above in the discussion on quantifying the relationship between SRKWs and Chinook abundance and in the ad-hoc Workgroup report (PFMC 2020b). Different limitations and model assumptions may bias percent reduction estimates, but Workgroup methods are currently the best available methodology. Finally, there is a low probability that all the Chinook salmon caught by the fishery would instead be intercepted and consumed by SRKWs if there was no fishery; this adds additional uncertainty to the estimate of reduction of prey available to SRKWs by the fishery in that the reduction in Chinook abundance from the fishery does not directly translate to a 3% loss to SRKWs.

Table 31. Estimated starting abundance (beginning of FRAM timestep 1; October) of age 3-5 Chinook in the "SALISH" area (Shelton et al. 2019). Estimates are from the post-season FRAM runs (validation round 6.2) for years 2007-2016. 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 using analysis from the ad-hoc Workgroup (Cunningham 2021). 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.	**612,411**	**20,098**	**3.33%**

The refined approach to Chinook salmon management under the PST Agreements of 2008 and 2018 to address conservation concerns for several Chinook stocks was designed to result 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 2021). It is also anticipated that the proposed Puget Sound Chinook Harvest Plan and the current PST Chinook salmon agreement will lead to a fishing pattern similar to the last 10 years (Loomis 2021). 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 (Loomis 2021).

The timing of fisheries is also important in evaluating effects to prey availability for SRKWs. First, reductions in prey availability by Puget Sound fisheries in inland waters is highest in summer months. Evidence suggests that there is a higher likelihood of SRKWs having reduced body condition in winter months. In addition, Chinook biology suggests fish are more concentrated in the summer than the winter, possibly making it more difficult to find prey in winter if salmon density in an area is low. Also SRKW dietary studies suggest greater diet diversification during the winter and 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 2021-2022 focus on the winter time period (Oct.-Apr.) and include the complete winter closure to recreational Chinook fishing in multiple Marine Areas 6, 7, 8, 9, and 12 (Table 30, except non-retention in 12 in two months) and also further non-retention restrictions and other closures in other areas (area 10 in November/December for example), likely limiting impacts to prey availability during winter months. 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, these closures/management measures may additionally limit fishery impacts on prey availability for J pod in winter months.

It is helpful to consider the magnitude of prey reductions in the context of the timing 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 metabolic needs. As described above, the analysis in this year's opinion uses a similar approach to last year, updated from previous years. Under this approach we 1) compare the NWIFC (Loomis 2021)estimates of SRKW daily prey energy requirements to our estimates of daily prey requirements based on demographics of the SRKW population similar to methods in previous biological opinions (e.g. NMFS 2019), and 2) use the Shelton et al. model and FRAM to estimate Chinook abundance to provide a comparison of Chinook food energy available compared to SRKW metabolic needs.

The NWIFC (Loomis 2021) 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 2021) estimated available kilocalories available to the whales using the following method. Salmon 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). Loomis (2021) assumed adult Chinook have on average between 3,944 kcal/fish and 10,944 kcal/fish depending on the area (O'Neill et al. 2014). Based on NWIFC's analysis, the daily energy requirements for adult males is approximately 15 to 16 Chinook required a day; adult females are estimated to eat 9 to 13 adult Chinook each day. Estimates of the amount of prey needed for SRKW vary considerably based on assumptions of the overlap in time/space of Chinook and SRKW, cohort size of the fish, selectivity of capture, and the fraction of energy that comes from Chinook (Loomis 2021).

We compare the NWIFC approach to estimating the amount of Chinook per day required by the whales with the approach we have used in previous consultations (specifically (NMFS 2019b)) which includes some different information compared to the NWIFC analysis described above. We found the daily prey energy requirements (DPER) for the current population of SRKWs based on methods (outlined in (NMFS 2019b)) and using body mass equations (from (Noren 2011)) for upper (maximum) and lower (minimum) bounds on energy requirements and based on specific energy requirements by age and sex. Prey energy requirement calculations do not include increased energetic cost of body growth for juveniles or increased energy cost from lactation for females, as these are currently unknown. We combined the sex and age specific maximum daily prey energy requirement information with the population census data to estimate daily energetic requirements for all members of the Southern Resident population, based on the population size as of summer 2020 (72 whales) and using ages for this upcoming year (2021). We multiplied the daily energy requirements of each pod by the average number of days that the pod was in inland waters for each FRAM time period (Oct-April; May-June; July-Sept), using both the average inland waters occurrence from 2004-2016 (see Figure 32, using maximum likely occurrence) and using average inland water occurrence from 2017-2018 to represent a minimum occurrence scenario as the whales occurred less frequently in the action area in recent years (Figure 32). Next, we summed the energy requirements across pods by time periods and multiplied by the percent of Chinook in the diet for each time period (55% for October – April; 97% for May – June; 71% for July to September; diet proportions (used in(NMFS 2019b)), and then summed across time periods for a yearly need. These estimates are presented in Table 32. With this approach, we are assuming that the whales' diet and needs in the past are representative of what they need in the future (i.e., does not account for potential differences in population abundance and sex / age structure over time, potential differences in time spent in inland vs. coastal waters, changes in diet composition, etc.).

Table 32. Minimum and Maximum DPER for the Southern Resident killer whale population of 72 individuals using the average number of days in inland waters for 2004-2016 (maximum occurrence) and the average number of days inland for 2017-2018 (recent years with lower occurrence) for the three FRAM time periods.

FRAM Time period	Average inland (2004-2016)		Min. inland - average 2017-2018	
	Min DPER	Max DPER	Min DPER	Max DPER
Oct-April	501,495,097	601,866,937	474,198,474	569,107,026
May-June	318,318,255	382,028,128	129,144,232	154,991,831
July-Sept	862,433,838	1,035,045,839	409,207,570	491,108,504
Annual total	1,682,247,190	2,018,940,904	1,012,550,275	1,215,207,361

Annual total for Chinook based on diet proportion	1,196,919,036	1,436,476,645	676,616,440	812,037,978

Based on our analysis, the overall yearly energetic needs of SRKWs while in inland waters ranged from 6.77 million kcal to 1.44 billion kcal (for Chinook prey). SRKWs prefer larger fish and we used the kcal/fish estimate of 16,386 kcal/fish for an "average" adult Chinook salmon (from (Noren 2011)) used in previous consultations to estimate the likely availability of Chinook to Chinook needed to provide the food energy required by the whales in 2021, we multiplied the per fish kcal value (from (Noren 2011) ;16,386 kcal/fish) by this year's forecasted abundance (605,082), to produce an estimate of 9.9 billion Chinook kcal available to the whales. Comparing this estimates to the needs of the whales in Table 30 (up to 1.44 billion kcal), we expect there will be more Chinook kcals available than what is required by the whales. We note that even using the lower per fish kcal estimate used in Loomis (2021) (either 3,944 kcal/fish and 10,944 kcal/fish) we would still expect the available energy to exceed the whales' metabolic needs. The whales have spent fewer days in the Salish Sea in recent years and if that trend continues even after reductions in prey from the fishery, we would expect there would still be more energy available to the whales compared to the estimates of their metabolic needs (see Table 32). However, we are very limited in our interpretation these values given our lack of knowledge on foraging efficiency of the whales.

The NWIFC (Loomis 2021) 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) for a retrospective scenario that applies a reduction in Fraser River early Chinook salmon to simulate predicted effects of the Big Bar slide[64]. The stocks of Fraser River early Chinook affected by the slide primarily return as 5 year olds and the Big Bar slide occurred in 2019, therefore next year is the first year that progeny of Chinook impacted by the slide would be included in age 3-5 ocean abundance and the majority of those progeny are expected to return to freshwater in 2024. The NWIFC analyses did not show any years with prey below the needs of the killer whales in the other two time steps (May-June and July-September), only winter in some years accounting for the Big Bar slide scenario. 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, particularly in fall and/or winter, that add to the available calories for SRKW. Also, NWIFC concluded that the result that some years have winter Chinook availability is less than the estimated caloric needs of the whales (in the simulated Big Bar slide scenario) is virtually the same with or without fishing. During years or seasons when the ratio of Chinook prey available to meet the whales' needs is relatively low (similar to that seen in the analysis by NWIFC in winter in certain years, for a reduced Fraser scenario) any additional measurable reduction would be a concern. Given the 2021-2022 pre-fisheries Chinook abundance in October is estimated to be average (compared to the recent 10 years, 2007-2016), we anticipate the prey available in

[64] In 2019, the Big Bar landslide, located on a remote section of the Fraser River, 64 kilometers north of Lillooet, British Columbia, created a barrier to the seasonal northward Fraser salmon migration (https://www.pac.dfo-mpo.gc.ca/pacific-smon-pacifique/big-bar-landslide-eboulement/index-eng.html) The NWIFC analysis on Chinook abundance in the U.S. portion of the Salish Sea with and without pre-terminal fisheries included a scenario where the analysis was completed after removing 85% of the Fraser River early Chinook stock to simulate the predicted effects of the Big Bar rock slide, and NWIFC cites Chuck Parken, Department of Fisheries and Oceans Canada, personal communication.

2021-2022 will be relatively average in winter (i.e. not relatively low and does not yet include effects of the Big Bar slide). Furthermore, with closures of recreational fishing in winter months in multiple areas for 2021-2022, and low tribal effort throughout Puget Sound (less than 10 boats per day per marine area and even less in areas with the most overlap with SRKWs; (Loomis 2021) we would expect only a minor effect from the Puget Sound fisheries in the time period NWIFC found to have the lowest ratios.

As discussed in the Status of the Species section, SRKW body condition is more likely to be reduced when Chinook salmon may be less available, such as in winter months. However, as described above, winter Chinook abundance for 2021 in the Salish Sea is expected to be relatively average and Chinook salmon reduction attributed to the Puget Sound salmon fisheries is relatively low during winter. In contrast, the greatest reduction in the available prey attributed to the proposed action primarily occurs in the summer months; however, we are unable to quantify how a small change in prey availability from fishing in the summer months for 2021-2022 (approximately 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 ratio of available kcals to needs on 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. (2017a)).

Also, 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. Prey studies have indicated that SRKWs switch from Chinook to other salmon in fall months (particularly coho and chum salmon; (Ford et al. 2016; Hanson et al. 2021)). 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.

Another context to consider for prey reductions from fisheries is the potential for localized depletions. SRKWs have been observed foraging in certain areas (hot spots, especially the West side of San Juan Island) more than others (see above section on overlap), and to the extent the fisheries remove Chinook that might otherwise be available in these areas, they may limit SRKW access to those fish. It is noted that localized depletion can possibly occur if a species is managed at a spatial scale that is larger than the scale of ecological processes and fisheries (Ames 2004; Walters and Martell 2004; McGilliard et al. 2011), such as concentrated fishing on spawning aggregations (see (de Mitcheson 2016) and sources therein). On their return to their natal rivers as adults, salmon may congregate in marine areas adjacent to the rivers. 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, it is possible that the overall reduction in prey resulting from the proposed action would not be evenly distributed across Puget Sound/Salish Sea, especially if fisheries are concentrated in certain areas. Concentrated fisheries and reductions could cause local depletions of prey. 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. Localized depletions caused by direct overlap between foraging whales and the fisheries, would increase competition for fish, and in some conditions, the whales may not be able to always meet their energetic needs (i.e., the prey available to the whales may not be sufficient to allow for successful foraging). For example, if there are localized prey depletions in foraging hot spots in R-MA 7, the whales may increase their searching effort and move to other potential foraging areas within their geographic range. 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 recent years when the whales have 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 hot spots. For example, an approximate 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 proposed fisheries measures in 2021-2022 compared to previous years that may help limit the potential for localized depletion. As described above, the 2021-2022 fishery includes some changes in recreational fishing to reduce impacts to Chinook salmon including reduced impacts in R-MA 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. 2019-2021) 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. Again, tribal fisheries are mainly terminal (77/23 split terminal vs. pre-terminal) and therefore occurring in areas where the salmon would no longer be available to the whales, and pre-terminal fisheries seem to be highest in times/areas where SRKWs are less common (Loomis (2021) and Figure 41). Even at their highest levels tribal fisheries have a limited number of vessels (2.5 boats on average per day) in area 7 during summer. Finally, winter closures of recreational fisheries in areas 6,7,8,9, and 12 should limit prey removal from these areas which may limit impacts to J-pod (more common in inland waters in Fall/Winter than K and L pods). Although difficult to quantify, these actions should limit 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 when fisheries in area 7 were non-selective in summer months and there were fewer winter closures).

In summary, the proposed actions are expected to cause an approximate 3% reduction in abundance of age 3-5 Chinook salmon in inland waters in 2021-2022 which is relatively low compared to previous decades, and similar to the average for the last decade. The starting Chinook abundance in 2021-2022 (i.e. October TS1 abundance) is also estimated to be similar to the recent 10-year average and at levels where prey energy available is greater than that required by the whales. This suggests the winter Chinook availability is not likely to be below the estimated caloric needs of the whales (such as that predicted in the Big Bar slide scenario). The estimated reduction is highest in inland waters during July through September compared to the other seasons, but not all of the fish caught in the fishery would have been intercepted and consumed by the whales. Although some of the prey reduction occurs in an area known for its high use and is considered a foraging hot spot (e.g. R-MA 7), recreational fishery restrictions in the summer (especially September; mark selective and non-retention) and winter (closure), likely very limited commercial fishing due to no harvestable surplus in Fraser River sockeye, and minimal tribal fishing (approximately 2.5 boats per day), will likely limit the impacts in this hot spot. 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 would expect increased energy expenditure or reduced foraging to have more significant impacts on the health and reproduction of the whales in times of low Chinook salmon abundance (see discussion above), but 2021 is expected to be at an average level. Though fishing will reduce prey compared to no fishing in the area, we anticipate limited reductions in prey in 2021-2022 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 (area closures, non-retention, etc.) proposed to further reduce impacts from vessels that may also reduce impacts to prey availability. We do not expect these effects from fishing to persist or be so large that they result in more than a minor change to the overall health of any individual whale. Efforts to reduce fishing in the primary foraging area along the west side of San Juan Island (especially in August and September) will reduce the potential for prey reductions to result in significant localized depletions or prey depletions at levels that would cause injury or impair reproduction.

2.5.4.2 Effects on Critical Habitat

In addition to the direct and indirect effects to SRKWs discussed above, the proposed action affects critical habitat designated for Southern Resident killer whales in inland waters of Washington. 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. As indicated in Section 2.4.1, Puget Sound salmon fisheries are managed consistent with the recovery of Chinook salmon, therefore, we expect limited impacts to future production of salmon from Puget Sound, based on the proposed fisheries. Consequently, we would not expect impacts to salmon (i.e, prey feature) in proposed coastal killer whale critical habitat along the coast, where young salmon originating from the action area could move to and be available to the whales in future years, or any other feature of proposed coastal critical habitat. Therefore, we focus this analysis on designated inland critical habitat that overlaps with the proposed action.

The proposed actions have the potential to affect the quantity, quality, and availability of prey and passage conditions in critical habitat. Although Southern Resident killer whale critical habitat remains at risk from serious oil 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 critical habitat feature related to prey includes prey quantity, quality, and availability and this analysis draws on the analysis of the effects on prey to the whales themselves. The proposed action has the potential to affect quantity and therefore availability of prey, but likely little effect on prey quality. We would not expect any impacts from the proposed action on the quality of prey with respect to levels of harmful contaminants. However, as described in section the Environmental Baseline for SRKWs (section 2.4.3), size and age structure in Chinook salmon has substantially changed across the Northeast Pacific Ocean since the 1970s. Across most of the region, adult Chinook salmon (ocean ages 4 and 5) are becoming smaller, the size of age 2 fish is generally increasing, and most of the Chinook salmon populations from Oregon to Alaska have shown declines in the proportions of age 4 and 5 year olds and an increase in the proportion of 2 year olds (mean age in populations has declined over time) (Ohlberger et al. 2018). Strength of trends varied by region (see above). The declining trend in the proportion of older ages in Washington stocks was observed but slightly weaker than that in Alaska. In a follow-up paper, authors found that reasons for this shift may be largely due to direct effects from size-selective removal by marine mammals and fisheries (Ohlberger et al. 2019a). As noted above, SRKW mainly consume larger (age 3 and older) salmon, and larger fish typically have higher energy content. Ohlberger et al. (2019a) through simulation modeling did find that harvest, in comparison to predation, had a “weaker effect” on the observed changes in Chinook mean body size, and that in the simulations, harvesting alone could not explain changes in size (without predation also) in the past 50 years. The simulations suggested that harvest impacts on size were likely stronger in the earlier period of the simulation and less so in more recent periods as harvest rates have declined while predation has increased, and that size composition may have at least partly recovered with the decline in harvest over the last decades if predation pressure had not increased. Therefore, we would not expect the current level of harvest would appreciably decrease Chinook size (i.e., quality) thereby reducing the conservation value of the prey feature.

Effects of the proposed action reduce prey quantity and availability in critical habitat resulting from the harvest of adult Chinook salmon. The extent of reductions in adult Chinook salmon in the action area due to Puget Sound salmon fisheries is described in detail in the Effects analysis for the whales. 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 605,100 which is similar to the recent 10-year average of approximately 612,400 (2007 through 2016) and the proposed action is likely to result in reductions in prey quantity and availability by approximately 3% (similar to average impacts in this last decade).

As described above, our analyses and analyses by the NWIFC (Loomis 2021) 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 anticipate the prey available in 2021-2022 will be relatively average (i.e. not relatively low) and at levels where prey energy available is greater than that required by the whales (based on our analysis and NWIFC analysis of energy requirements of the current SRKW population). NWIFC estimated in some past years, retrospectively, Chinook availability in the Salish Sea would have been less than the estimated caloric needs of SRKW in the winter (for a scenario with reduced Fraser Chinook). However, Chinook salmon reduction attributed to the Puget Sound salmon fisheries is relatively low during winter and in contrast, the greatest reduction in the available prey attributed to the proposed action primarily occurs in the summer months. Given the 2021-2022 pre-fisheries Chinook abundance in October is estimated to be average (compared to the recent 10 years, 2007-2016), we anticipate the prey available in 2021-2022 will be relatively average in winter. Overall, the Puget Sound fisheries (compared to no fishery) 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 we are limited in our interpretation of these values and apply a low weight to analysis on energetic requirements of the whales and calorie availability of prey when assessing the effects of the action.

As described in the Effects section above, the proposed action is expected to cause an approximate 3% reduction in abundance of age 3-5 Chinook salmon in designated critical habitat in 2021-2022 which is a relatively small reduction, and similar to the average of this last decade. The starting Chinook abundance in 2021-2022 is also estimated to be near the recent 10-year average. 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 areas of critical habitat. Reductions in local abundance of prey from salmon fishing may result in the whales leaving critical habitat areas in search of more abundant prey. Prey reduction throughout critical habitat may not accurately predict reductions in prey available in their "Core Summer" area of designated critical habitat, including off the west side of San Juan Island in MA 7, a known foraging hot spot especially in summer but where whales are sighted in other months as well. The estimated reduction by fisheries is highest in inland waters during summer months, July through September, compared to the other seasons. Although some of the reduction occurs in the core ("Core Summer") area known for its high use and is considered a foraging hot spot (e.g. R-MA 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 minimal tribal fishing in summer (approximately 2.5 boats per day), will likely reduce the impacts in this hot spot. Winter closures of recreational fisheries in areas 6,7,8,9, and 12 should limit prey removal from these areas which may limit impacts to J-pod (more common in inland waters in Fall/Winter than K and L pods). We anticipate limited reductions in prey in 2021-2022 in critical habitat 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 for SRKWs.

Effects of the proposed fishing include the potential for 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 for SRKWs. As described above, the vessels associated with the fishing activities overlap with the whales, particularly in July through September in R-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 (compared to if there was no fishing), 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 and summarized here, if interactions between SRKW and fishing vessels were to occur the amount of disturbance caused by the fishing vessels may affect whale behavior including causing them to spend more time traveling and performing surface active behaviors and less time foraging and resting in their critical habitat. The fishing vessels may also reduce the whales' 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 (prior to 2020) based on the reduction in overlap of fisheries and whales in the summer core area due to for example: (1) reduced commercial fisheries due to no harvestable surplus of Fraser Sockeye and likely limited Pink fisheries, (2) non-retention and mark selective recreational fisheries in August and non-retention in September, and (3) small tribal fisheries (2.5 boats in the summer months, in MA 7 as well as winter closures in recreational fisheries in multiple areas as described above. In addition, WDFW will continue to promote the adherence to a voluntary "No-Go" Whale Protection Zone along the western side of San Juan Island in area 7, extending from Mitchell Point to Cattle Point, offshore for ¼ mile (or ½ mile at Lime Kiln lighthouse), for all recreational boats—fishing and non-fishing—and commercial fishing vessels (with the exception of the Fraser Panel sockeye and pink fisheries). Finally, 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 within the hearing range of killer whales,(Branstetter et al. 2017)). Therefore, we anticipate adverse effects to passage conditions from fishing vessels, but these are expected to be small and mitigated by several conservation efforts. It is unlikely that any direct effect from small transitory disturbance that might occur would have more than a very minor effect on passage in the proposed critical habitat.

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, not primary prey species, and an extremely small percent of the total prey available to the whales in the action area and therefore impacts on the species would be insignificant. . No impacts to humpback whale critical habitat is anticipated. This is discussed further in Section 2.12.

Vessel traffic and fishing effort associated with the proposed fisheries are anticipated to be similar to past levels in inland waters of Washington. Between 2004 and 2020, there were 10 reports of a vessel strike of a humpback within Washington waters, six of which occurred since 2016 (NMFS Stranding Network database, 2021). There have been five recorded vessel strikes to humpback whales that occurred off of Clallam County, WA, two in King County, and one in each of Jefferson, Thurston, and Grays Harbor Counties (NMFS WCR Stranding database, 2021). In 2019 and 2020 a Washington State ferry struck a humpback whale and while the reports have not been formally reviewed and assigned an injury status, both were assumed to be fatal given the observations at the time of the incidences. The proposed action includes a treaty troll fishery that operates from May to October in C-MAs 5, 6, and 6C. Because the trolls operate at low speeds (generally 1-4 knots) they pose very limited risk to humpback whales from vessel strikes. There are no recorded cases 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 a strike from a fishing vessel to be extremely unlikely and therefore the potential for effects relating to vessel strikes are expected to be discountable and the low level of potential 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[65] 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

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

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 2021 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) (86 FR 3028, January 14, 202120). 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 and/or of the limited risk of entanglement these specific nets and gear provide to humpback whales, making interactions extremely unlikely. Therefore, we consider the potential for effects relating to these gear types to be discountable.

For 2007 to 2018, gillnet entanglements represent 6 percent of all reported humpback whale entanglements along the West Coast of the U.S., with the most gillnet entanglements occurring in 2018 (Carretta et al. 2013; Carretta et al. 2015; Carretta et al. 2020a). The location of the entanglement reports is evenly split with six in each California and Washington. Because the location of an entanglement report is not necessarily the same as the entanglement origin, it is possible that whales reported as entangled in gillnets in California were entangled in Washington and vice versa. However, three of the Washington reports were identified to tribal gillnet fisheries in Washington, all of which occurred in 2018.

The Puget Sound region salmon drift gillnet fishery (defined in LOF 2021 as that which includes all inland waters south of US-Canada border and eastward of the Bonilla-Tatoosh line- Treaty Indian fishing is excluded) is listed as a Category II fishery, meaning it has an occasional likelihood of marine mammal interactions that can result in M/SI. However, humpback whales are not one of the species that led to this classification[66]. 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 are available in the marine mammal SARs (Carretta et al. 2019; Muto et al. 2019) and a Serious Injury and Mortality Report published annually (Carretta et al. 2020a). 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

[66] Harbor porpoise inland WA is driving the current classification. Dall's porpoise CA/OR/WA and harbor seal, WA inland stocks are also included in the categorization.

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. 2020a). 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 as entangled in tribal gillnet gear that was part of the Puget Sound salmon fishery in the inland Washington waters, in the Strait of Juan de Fuca (Carretta et al. 2020a). 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 is unknown. While there have been occurrences of entanglements of humpback whales in Washington gillnet fisheries, these have been infrequent (Carretta et al. 2020a). There were three reports of humpback whale entanglements in inland waters of WA in 2019 with unidentified gear (Fisheries 2019). There was one humpback whale reported as entangled in the inland waters in 2020 also in unidentified gear (NOAA Fisheries 2021).

Likelihood of Interactions in 2021

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 reports of interactions with reef net gear 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 2021 that are part of this action, we assessed the overlap of humpback whale sightings in recent years and active pre-terminal gillnet fisheries. We assume that the areas with greater overlap will also have a greater likelihood for potential interactions. In our analysis of the 2020-2021 fisheries (NMFS 2020d) we used a single set of sighting data and this year we have expanded the data set and refined our methodology for including sightings in the analysis. Specifically, we examined opportunistic public sighting reports of humpback whales to the Whale Museum on Friday Harbor, the Orca Network, a non-profit organization dedicated to raising awareness of whales of the Pacific Northwest, and the BCCSN, a non-profit organization based in British Columbia, during each year within C-MA(Figure 30) that were open in 2017, 2018, and 2019[67]. A total of 1,552 unique

[67] Sighting reports from the Whale Museum and Orca Network were not available for 2020 and were not complete for the end of 2019. Only sightings in June through November were included. Additionally, only sightings within U.S. waters were analyzed, excluding all sightings within Canadian waters.

sightings[68] were reported over the three year period[69]. 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 public sighting reports. The location of the sightings were then compared with the LOAF[70] for the 2017-2018, 2018-2019, and 2019-2020 seasons. In Table 33, we provide the number of humpback whale sightings in 2017, 2018, and 2019 in each C-MA where net fisheries occurred. The LOAFs group some C-MAs together (i.e. 4B, 5, 6C). To be consistent with these groupings, 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 (i.e. C-MAs 13-13K). Humpback whale sightings within Canadian waters that run the length of the international boundary between Washington State and British Columbia were not included in the estimates of humpback whale sightings.

[68] 'Unique sightings' in this context mean a sighting of a humpback whale(s) in a specific area of the Salish Sea at a specific time. To remove duplicate sightings, the sighting reports were grouped by date, coordinates rounded to two decimal degrees, and the number of whales reported per sighting. Each of these groupings was treated as a unique sighting. A best estimate on the number of whales for each sighting was included based on the comments included, with sightings that didn't include a comment assigned as 1 whale. These sightings likely still include duplicate reports and represent rough estimates. We did not consider movement of whales between the Marine Areas. They do not provide a total number of humpback whales within the Salish Sea at a given time.

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

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

Table 33. Tables a-c show the number of humpback whale sightings and overlap with active fisheries, including test fisheries. For each month the number of "unique" whale sightings are listed as "reports" and include reports to the Whale Museum, Orca Network, and the BCCSN. The estimate of "whale count" is a total of the number of whales included in eache report. Cells are shaded if the sightings overlapped with an open gillnet fishery for all or a portion of the month. C-MAs open for a short portion of a month were considered open for the full month. C-MAs were grouped consistent with the LOAFs. Areas 10, 10A, and 10E were grouped, and 13 A-H were grouped to better reflect the movement through these areas. Fraser River Panel Control was assumed to allow gillnet fishing.

(a)

2017												
C-MA	June		July		August		September		October		November	
	Reports	Whale Count	Reports	Whale Count	Reports	Whale Count	Reports	Whale Count	Reports	Whale Count	Reports	Whale Count
4B,5,6C	3	4	5	11	1	1	4	56	2	10	0	0
6, 7, 7A	98	167	54	64	64	71	36	212	29	45	19	24
9	39	45	2	2	20	20	20	27	18	19	0	0
10,10A, 10E	27	32	4	4	4	5	4	4	2	2	0	0
11, 11A	12	15	13	14	18	22	19	21	0	0	0	0
13A-H	6	6	33	36	1	1	2	2	0	0	0	0

(b)

2018												
C-MA	June		July		August		September		October		November	
	Reports	Whale Count	Reports	Whale Count	Reports	Whale Count	Reports	Whale Count	Reports	Whale Count	Reports	Whale Count
4B,5,6C	6	10	3	6	3	6	7	21	4	15	5	39
6, 7, 7A	84	114	48	93	31	48	23	35	19	26	33	55
9	10	13	11	15	7	7	12	15	19	32	8	9
10,10A,10E	5	5	2	2	1	1	7	7	4	4	8	8
11, 11A	7	10	4	4	0	0	1	1	43	47	23	23
13A-H	7	9	15	16	0	0	0	0	6	7	16	16

(c)

2019												
C-MA	June		July		August		September		October		November	
	Reports	Whale Count	Reports	Whale Count	Reports	Whale Count	Reports	Whale Count	Reports	Whale Count	Reports	Whale Count
4B,5,6C	0	0	13	67	7	13	17	30	2	3	1	3
6, 7, 7A	77	167	87	185	50	70	52	73	39	54	10	14
9	11	11	29	35	19	21	39	46	14	17	0	0
10,10A,10E	5	5	14	15	4	4	5	6	0	0	0	0
11, 11A	2	2	10	12	1	1	0	0	0	0	0	0
13A-H	0	0	0	0	1	3	2	4	0	0	0	0

The Puget Sound salmon gillnet fisheries are generally open for a period of time between June and December, depending on the C-MA. While many of the C-MAs showed overlap, the largest degree of overlap between open gillnet fisheries and the number of humpback whale unique sightings and counts occurred near the San Juan Islands (WCAs 6, 7, 7A) followed by the Strait of Juan de Fuca pre-terminal areas (WCAs 4B, 5, and 6C). This is likely partially due to a sightings bias with large numbers of people whale watching from the San Juan Islands. Other studies have shown the largest congregations of humpback whale sightings and counts in the Strait of Juan de Fuca, including within Canadian waters (NMFS 2019i; Miller 2020). The western portion of the Strait of Juan de Fuca is further away from population centers and humpback whale occurrence in this area is likely underrepresented by public sightings. Because the overlaps focused only on humpback whales within U.S. waters, the larger number of sightings in the Canadian portion of the Strait is not reflected, likely underrepresenting the number of whales in the waters of the Strait. The Strait of Juan de Fuca was also the location of the three humpback whale entanglements in gillnet gear that occurred in 2018. The pre-season estimate of Fraser River sockeye forecasted run size for 2021 is low and contains no foreseeable harvestable surplus. Because of this, the 2021 sockeye test fishery in this area will be much smaller than the same test fishery in 2018. The 2021 season will include some pink salmon harvest, increasing the overlap and risk compared to last year. However, fishers mostly use purse seine gear to fish for pink salmon, which has a very low likelihood of entangling a humpback whale. Therefore we expect limited fishing effort in these northern C-MAs in the upcoming season, which could potentially reduce the likelihood of entanglements in gillnet gear. Although C-MA 9 had a relatively high number of humpback whale sightings throughout the years (Table 33), there was a relatively small overlap with the fisheries. The degree of overlap in some of the C-MAs 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 2021.

Humpback whales are expected to overlap with C-MAs again in 2021 (e.g., C-MAs 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; Miller 2020) However, because we expect limited gillnet fishing in the areas that overlapped with humpback whales in 2017-2019, we anticipate fewer than the three interactions observed in 2018. Fishing effort in the Strait of Juan de Fuca was relatively high in 2018 due to the large abundance of Fraser sockeye salmon. Because there is no available catch of Fraser sockeye projected, the fishing effort in this area will be much lower than it was in 2018. While we cannot quantify the reduction in fishing effort or absolute risk, we find it is reasonable to conclude that the risk will be less in 2021-2022 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 2021-2022 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: 9% estimated from the Central America DPS and 28% to be from the Mexico DPS. The remaining 63% are considered to be from the unlisted Hawaii DPS. The 2 interactions estimated for the 2021-2022 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. 2020a) 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 2021 when compared to what occurred over the past few years. However, fishing effort in 2021 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.

2.6 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, the effects of which are described in the environmental baseline. 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 and continued vessel and construction noise 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, 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), the Howard Hansen Dam Operations and Maintenance (NMFS 2019d; 2020g). 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.

Multiple non-federal activities are reasonably certain to occur that impact SRKW interactions with vessels in the Salish Sea. These additional actions are designed to further reduce impacts from vessels on SRKW by limiting the potential for interactions including:

1. Washington State law (Senate Bill 5577) established a commercial whale watching license program and charged DFW with administering the licensing program and developing rules for commercial whale watching by January 2021 for inland Washington waters (see RCW 77.65.615 and RCW 77.65.620). The new rules were adopted in December 2020 and include limitations on the time, distance, and area that SRKW can be viewed within ½ nautical mile, in an effort to reduce vessel and nose disturbance:
    a. The commercial whale watching season is limited to 3 months/year for viewing SRKW closer than ½ nautical mile, and is limited to 4 hours per day in the vicinity of SRKW.
    b. Up to 3 commercial whale watching vessels are allowed within ½ nautical mile of SRKW at a given time, with exclusion from approaching within ½ nautical mile of SRKW groups containing a calf.
    c. Year-round closure of the “no-go” Whale Protection Zone along the western side of San Juan Island to commercial whale watching vessels, excluding a 100-yard corridor along the shoreline for commercial kayak tours.
2. Continued implementation and enforcement of the 2019 restrictions on speed and buffer distance around SRKW for all vessels.
3. Increased effort dedicated to outreach and education programs. This includes 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. Outreach content was created in the form of video, online (including social media), and print advertising targeting recreational boaters. On-site efforts include materials distributed at pumpout and re-fueling stations along Puget Sound, during Enforcement orca patrols, and signage at WA State Parks and WDFW water access sites. Additionally, State Parks integrated materials on whale watching regulations and guidelines in their boating safety education program to ensure all boaters are aware of current vessel regulations around SRKW.
4. Promotion of the Whale Report Alert System (WRAS) in Puget Sound, developed by the Ocean Wise Research Institute, which uses on-the-water reporting to alert large ships when whales are nearby. Reporting SRKW to WRAS is required for commercial whale

watching license holders, and on-the-water staff are also being trained to report their sightings.

5. Piloting a new program ("Quiet Sound") that will have topic-area working groups to lead projects and programs on vessel operations, incentives, innovations, notification, monitoring, evaluation, and adaptive management. This effort was developed with partners including Commerce, WA State Ferries, and the Puget Sound Partnership in collaboration with the Ports, NOAA, and others. Funding is anticipated to be secured in the 2021 state legislative session.
6. Continued promotion of the voluntary "No-Go" Whale Protection Zone along the western side of San Juan Island in R-MA and C-MA7 for all recreational boats—fishing and non-fishing—and commercial fishing vessels (with the exception of the Fraser Panel sockeye and pink fisheries[71]) (Figure 42). 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[72] extended in 2018 and the full protected area recognized by the Pacific Whale Watch Association[73] 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.

[71] Non-treaty Fraser River Panel commercial fisheries utilize purse seine gear within ¼ mile of San Juan Island and are required to release non-target species (Chinook and coho); (Cunningham 2021).

[72] https://www.sjcmrc.org/projects/southern-resident-killer-whales/

[73] https://www.pacificwhalewatchassociation.com/guidelines/

Figure 42. An approximation of the Voluntary "No-Go" Whale Protection Zone, from Mitchell Bay to Cattle Point (Shaw 2018). See https://wdfw.wa.gov/fishing/locations/marine-areas/san-juan-islands

7. Currently WDFW enforcement boats conduct coordinated patrols with the U.S. Coast Guard, NOAA Office of Law Enforcement, San Juan County Sheriff's Office, Sound Watch, and other partners year-round that include monitoring and enforcement of fisheries and Marine Mammal Protection Act requirements related to vessel operation in the presence of marine mammals throughout Puget Sound. Patrols in the marine areas of northern Puget Sound, particularly MA 7, are specifically targeted to enforce regulations related to killer whales. 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 MA7 during the summer (Cunningham 2021). Outreach and enforcement of vessel 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.

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 SRKW recovery. The Task Force provided recommendations in a final Year 1 report in November 2018[74] that addressed the three main threats to SRKW, including many actions

[74] Available here: https://www.governor.wa.gov/sites/default/files/OrcaTaskForce_reportandrecommendations_11.16.18.pdf

specific to salmon recovery. State legislation was put into place to protect salmon habitat (House Bill 1579) and address harmful contaminants (Senate Bill 5135 and reduce the risk of oil spills (House Bill 1578). In addition, a new state law was signed in 2019 increasing vessel viewing distances from 200 to 300 yards to the side of the whales and limiting vessel speed within ½ nautical mile of the whales to seven knots over ground. Senate Bill 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.

On November 8, 2019, the task force released its Year 2 report[75] that assessed progress made on 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, which is discussed in the environmental baseline.

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. These measures won't improve prey availability in the near term, but 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. Priority management actions identified in the workshop that should be considered included 1) targeted, area-based fishery management measures designed to improve Chinook salmon availability, and 2) reducing acoustic and vessel disturbance in key Southern Resident foraging areas. There was little support for broad scale coast-wide reductions in fishing to increase the prey available to the whales, which was consistent with the findings of the previous transboundary panel (i.e. Hilborn et al. 2012). In 2019 and 2020, Canada implemented conservation actions, including area-based fishery closures, interim sanctuary zones, and both voluntary initiatives and mandatory vessel regulations[76] as part of interim orders to protect the whales. For 2021, similar actions (fishery closures, sanctuary zones, vessel regulations) will be implemented though certain specific area fishery closures will be triggered by the first sighting of whales in the area (in the Southern Gulf Islands)[77].

There are several state and industry lead efforts underway to reduce impacts from entanglements and vessel activities. For example, the Port of Vancouver ECHO program has implemented voluntary vessel slowdown areas in the Salish Sea that reduce sound and could reduce severity in the event of a vessel strike. Lastly, the Be Whale Wise guidelines set viewing distance recommendations for marine mammals, including large whales, and are promoted broadly to reduce harmful interactions with marine mammals within the Salish Sea, including humpback whales, as discussed in Section 2.5.5.

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[75] Availablehere:https://www.governor.wa.gov/sites/default/files/OrcaTaskForce_FinalReportandRecommendations_11.07.19.pdf

[76] https://www.pac.dfo-mpo.gc.ca/whales-baleines/srkw-measures-mesures-ers-eng.html

[77] https://www.pac.dfo-mpo.gc.ca/fm-gp/mammals-mammiferes/whales-baleines/srkw-measures-mesures-ers-eng.html

2.7 Integration and Synthesis

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

2.7.1 Puget Sound Chinook

NMFS describes its approach to the analysis of the effects of the proposed actions to Puget Sound Chinook salmon 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. The derivation of the RERs, and the status and trends take into account 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. Here, in this Integration and Synthesis, risk to the survival and recovery of the ESU from the proposed action is 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. In addition, to evaluate the effects of the proposed actions on the ESU, we consider the effects of the actions combined with the effects of the activities in the Environmental Baseline and Cumulative Effects sections of the biological opinion, as well the status of the species and broader environmental conditions.

The analysis in this section, leading to our conclusion regarding jeopardy, is presented in two stages. In the first stage, potential areas of concern or risk are identified by population, within each region, based on the effects of the actions to the populations, relative to their escapement thresholds and RERs. We then 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 (i.e., what would be the implication of the action not taking place for the population?). The second stage of the analysis considers the results of the population-level analyses (first stage) at the regional and ESU level. It analyzes 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 of the effects of the action for each region and the ESU as a whole.

The results of our assessment of the risks to individual populations in the Effects analysis highlight the importance of habitat actions and hatchery conservation programs for the preservation and recovery of individual populations specifically. The importance of these actions carries forward to our consideration of the risks from the proposed action to the ESU in general. The status of many of the populations in the ESU is largely the result of reduced productivity in the wild from habitat loss and degradation and from other sources of human induced mortality. Our analysis 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 of the effects of the proposed action on the Puget Sound salmon ESU 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, and the mitigating impacts of hatchery production and harvest changes) in its assessment of the proposed actions. None of these factors in isolation are dispositive or dictate a particular conclusion. They are all factors that inform NMFS' conclusions with respect to the ESU and are considered comprehensively. 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. This regional summarization is synthesized so that NMFS can determine whether the proposed action poses jeopardy at the ESU level as the statute requires.

For 2021 the Chinook populations in the Georgia Basin Region are forecasted to have escapements below the critical status, for the North Fork Nooksack Chinook population, and 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 5) 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 5). Impacts from the proposed actions in Puget Sound fisheries are low (<8%), and our analysis indicates that further harvest reductions in 2021 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 are increasing for the North Fork Nooksack and stable for the South Fork Nooksack population. Growth rates for natural-origin recruitment are stable and negative for the North Fork and South Fork populations, respectively. Growth rates for natural-origin escapement are stable and negative for the North Fork and South Fork populations, respectively (Table 6). The South Fork long-term trends and growth rates (Table 6) do not yet fully account for the abundance and overall productivity increases seen in the recent years, based on the effects of the conservation hatchery program. 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 funding 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 2021 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 eight of ten of the populations is below their RERs with two exceeding their RER (Lower Skagit and South Fork Stillaguamish) by 1.8 and 2.9%, respectively. 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 total escapement trends, generally stable growth rates in natural-origin escapement, and, in particular, the relatively robust status of the populations compared with their abundance thresholds should mitigate any risk that results from exceeding the RER in 2021 for the two population. Although the North and South Fork Stillaguamish populations are forecast to be below their critical thresholds for 2021, the populations are PRA Tier 2 and their life history types is represented by other healthier populations in the region for which fishery rates are expected to be below their RERs (Table 21). Exploitation rates in 2021 Puget Sound fisheries are expected to be relatively low across the four management units in this Region (5%-16%) (Table 22). If the proposed actions were not to occur in 2021, we estimate that an additional 2 natural-origin spawners would return to the South Fork Stillaguamish River and an additional 11 natural-origin spawners would return to the North Fork Stillaguamish, which would not provide sufficient additional spawners to change the status or trends of these populations from what would occur without the fisheries. Growth rates for natural-origin escapement are generally higher than growth rates for natural-origin recruitment for most populations within the Region, including the two Stillaguamish populations (Table 6). Meaning that these additional constraints in fisheries are likely contributing to stabilizing escapement, offsetting the declining trends in overall abundance, thereby reducing demographic risks associated with low population size.

For the Central/South Sound Region, implementation of the proposed 2021 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 (White River) are anticipated to exceed their RERs in 2021, and the proposed action contributes substantially to the expected ER.

The risks associated with exceeding the RER in the 2021 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 2021 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 2021 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 2021 exceeds the critical threshold, and (4) the implementation of the long-term transitional strategy for the population, which began in 2018 and will continue in 2021 (Mercier 2021). 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 2021 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 2021 is also expected to be above its rebuilding threshold. Trends for escapement (total) and NOR growth rate are stable. Average natural origin escapement for the Puyallup population is very near its rebuilding threshold andtotal escapement in 2021 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. However, the increasing trends in total escapement and positive growth rate for natural-origin recruitment in the Sammamish should mitigate the increased risk that could result of from fisheries exceeding the RER. For the Sammamish population, the additional 16 natural-origin 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 2021 should not impede achievement of viability of five (White, Cedar, Duwamish-Green, Puyallup, and Nisqually) of the six populations in the Region in 2021; 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 2021 fisheries is consistent with the recovery plan guidance that two[78] 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, and the forecasted total, natural escapement in 2021 is well above the rebuilding threshold, which should mitigate near term demographic risk to the population 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 (Table 6) 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. While final exploitation rates are not yet available for recent years, indications are that the recent year changes to the pre-season harvest planning estimates based on the 2018 performance review, described in section 2.5.1.2, should result in impacts below the 50% ER ceiling, based on terminal harvest rates assessed through 2020. As part of the proposed actions for 2021, the fisheries put forward by the co-managers are expected to result in a total exploitation rate near 49% (Table 22). 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 will continue to 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

[78] 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.

management measures described in the proposed actions—spring and late-fall hatchery programs and reduction of harvest during the late-timed fall Chinook period, will be key to recovery of the populations in the Skokomish River. 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 2021 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 2021 is expected to be well below the critical abundance threshold. However, the available information indicates further constraints on 2021 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 2021 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 above the critical threshold for natural-origin spawners in 2021. Total fishery impacts on both are expected to exceed their RERs in 2021. Impacts from the proposed actions in Puget Sound fisheries are very low (<3%) and analysis suggests further harvest reductions in 2021 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 total escapement in the Dungeness is anticipated to be more than two times its critical threshold and total escapement in the Elwha is expected to greatly exceed the magnitude (roughly 3x) of the rebuilding threshold. The trend in total escapement is increasing for the Dungeness, indicating that the conservation program is increasing overall abundance. However, the growth rates for escapement and recruitment are both negative 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. For both populations, the growth rates for escapement are higher than the growth rates for recruitment, which may indicate that recent fishery rates are having a stabilizing impact on the population abundance, lowering demographic risk. 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. However, the work in both of these watersheds will likely take years to decades to affect the long-term recovery trajectory for these populations. Management of harvest and hatchery programs that stabilizes and conserves these populations and maximizes the current available habitat is key to conserving the populations to take advantage of the recent access to expanded habitat (Elwha) and future restoration existing habitat (both basins).

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 will 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 2021 fishing year 9 of 22 total populations (Lower Sauk, Upper Sauk, Upper Cascade, Suiattle, Upper Skagit, NF Stillaguamish, Skykomish, Snoqualmie, and White) are expected to be under their RER or RER surrogates (Table 34). The South Fork Stillaguamish Chinook salmon population is expected to exceed its RER by 1.1%. 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 2021, relative to critical and rebuilding thresholds, and stable or positive trends in escapement alleviated concerns about additional risk (Lower Skagit, Cedar, and Green);

(2) anticipated impacts from the proposed 2021 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 and Puyallup).

Sixteen of the 22 populations in the ESU are expected to exceed their critical thresholds for escapement and nine of those are expected to exceed their rebuilding thresholds, with two additional populations very near their rebuilding threshold (Upper Cascade and Duwamish-Green River; Table 34). Six populations are expected to be below their critical thresholds (North Fork Nooksack, North and South Fork Stillaguamish, Sammamish, Mid-Hood Canal, and Skokomish). For the latter populations, the fisheries resulting from implementing the proposed actions in 2021 would not meaningfully affect the persistence of the populations under the recovery strategies in place or the indigenous population has been extirpated a long-term transition strategy is in place, and the proposed actions are consistent with that long-term strategy.

As described in section 2.5.1.1, Assessment Approach, the co-managers may propose to open fisheries directed at spring Chinook in the April-May 14, 2022 timeframe. They propose to manage these fisheries under the same conservation objectives applied to the spring run MUs, as utilized for the 2021 fisheries (Table 24). NMFS has determined that fisheries managed consistent with these objectives in recent years have not posed jeopardy to the Puget Sound Chinook ESU. In addition, fisheries have had impacts well below the objectives during most of previous seven years. Given the relatively consistent patterns in exploitation rates across these years, we anticipate that the impacts to the Nooksack, Skagit and White River populations will continue be well below their management objectives as a result of the early spring 2022 fisheries and that the anticipated impacts would not change the status or trends of the populations.

Additionally, as the period of fisheries proposed to potentially take place in 2022 (April-May 14, 2022) would only act on a portion of the returns it would limiting the scale of overall impact to the management units and individual populations. The managers could adjust the fishery if needed to ensure that impacts remain below the applicable exploitation rate ceiling once abundance forecasts for 2022 are available.

In considering the likely effects of the proposed action on the Puget Sound Chinook salmon ESU, NMFS reviewed the current status of the 22 populations, relative to their critical and rebuilding escapement thresholds, their individual roles in the recovery of the ESU, including the historical lineage of each extant population, the role of and contribution of hatchery production to natural spawning, the ability of the current habitat to sustain and recover each population, the recovery strategy in place for each population, the impacts that harvest, in particular, Puget Sound harvest, has on the current populations' status, and the likely change in the status of each population in the absence of the proposed action.

For each population where the planned fisheries are expected to have exploitation rates that exceed the RERs, and thus present the potential for risk to the populations, this risk is mitigated in each case by factors described above. For the Nisqually and Skokomish populations in Puget Sound, population-specific transitional strategies are being employed to move management from hatchery-focused to, eventually, natural-origin-focused objectives, coordinated with habitat restoration to improve watershed productivity. These transitional strategies are designed to shape the current non-native hatchery dominated populations, which did not evolve in these watersheds, to populations more adapted to the current watershed conditions that are be better able to take advantage of improvements and increase productivity as habitat recovers. Other populations, such as the Lower Skagit, Cedar and Green, have levels of escapement associated with rebuilding even at exploitation rates higher than their individual RERs. This gives NMFS confidence that the effect of the proposed harvest on these populations, even though it is expected to result in exploitation rates higher than the RERs, are sufficiently low to allow these populations to maintain escapements that are maximizing production given the condition of the available habitat, and thereby conserving the populations' ability to respond to restoration of that habitat. Still other populations (North Fork Nooksack, South Fork Nooksack, Mid-Hood Canal Rivers, Dungeness, Elwha) are managed to stay within very low harvest rates in the Puget Sound fisheries. However, while the majority of the harvest that effects these population happens outside the Puget Sound region, the low amount of harvest in Puget Sound still contributes to overall exploitation rates higher that the RERs. In these cases NMFS must consider the impact that the proposed Puget Sound harvest has on the abundance of these populations, relative to the critical and rebuilding escapement thresholds, while also considering that the small numbers of additional fish that would return to the spawning grounds without the planned fisheries, which in many cases would not affect the status of the annual or long-term escapement trends, allow fisheries the ability to access abundant, harvestable hatchery and naturally-produced salmon species. Additionally, for most of these populations there are conservation hatchery programs, which augment the natural-origin spawning numbers, such that the resulting total escapement of fish into these watershed is sufficient to fully utilize the available habitat in its current condition. This ensures that, as habitat recovery builds, the population of fish can respond positively. Finally, there are some of the 22 Puget Sound Chinook populations (Sammamish and Puyallup) that have been identified for lesser roles in recovery of the ESU. These are populations whose life history and population characteristics are represented by other populations in their region and in the ESU, and consistent with the NMFS' recovery plan criteria, have not been identified as needing to reach high viability for recovery.   The level of risk posed to these populations from the planned fisheries would not impede the survival or recovery of the ESU. For 2021-22, and for the longer-term, we expect all of these factors to mitigate the risk from harvest to specific populations, while other populations in the ESU will experience harvest rates that pose low risk.

Recovery of Puget Sound Chinook requires that certain non-native hatchery populations be supplanted by self-sustaining populations that are suited to their watersheds (in order to achieve viability), and that fresh water habitat be restored to the point where productivity supports viable populations. In the meantime, the effects of Puget Sound harvest are limited or mitigated such that those effects are not likely to reduce the ESU's status. Efforts described in the environmental baseline and cumulative effects, in addition to actions proposed by the comanagers as part of transition strategies related to the planned fisheries, are expected to improve habitat conditions in the foreseeable future.   In that foreseeable future, given fisheries such as those planned, with the additional actions in the comanagers' proposal, we expect sufficient escapement of the affected populations to allow the populations to persist and fully utilize the existing habitat, while efforts continue to restore freshwater, estuarine and marine habitat to conditions that allow for the meaningful increases in productivity for Puget Sound Chinook necessary to recover the ESU. Combining the population- level effects and the effects at the regional (MPG) and ESU level with the environmental baseline and cumulative effects in light of the status of the ESU, NMFS concludes the proposed actions, and the planned fisheries that result, including the early 2022 spring fisheries, may have adverse effects to some populations in the ESU but that these effects do not pose risk to the survival of the ESU or to the ESU's ability to recover.

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/2018)	Total Escapement Trend[3]	Growth Rate Recruitment/ Escapement[3]	Exploitation Rate in PS fisheries[4]	Approach consistent with transitional strategy[4]	PRA Tier
Strait of Georgia	N.F. Nooksack early							**1**
	S.F. Nooksack early							**1**
Whidbey/Main Basin	Upper Skagit moderately early							1
	Lower Skagit late							1
	Lower Sauk moderately early							1
	Upper Sauk early							1
	Suiattle very early							1
	Upper Cascade moderately early							1
	N.F. Stillaguamish early							2
	S.F. Stillaguamish moderately early							2
	Skykomish late							2
	Snoqualmie late							3
South Sound	Sammamish							3
	Cedar							3
	Duwamish-Green							2
	White							1
	Puyallup							3
	Nisqually							1
Hood Canal	Mid-Hood Canal							1
	Skokomish							1
Strait of Juan de Fuca	Dungeness							1
	Elwha							1

[1] Table 19. NMFS considers fisheries to present a low risk to populations where estimated total fishery impacts are less than or equal to the RERs,
[2] Tables 5
[3] Table 6
[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.

NMFS 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 (NWFSC 2020) and reaffirmed the observation that harvest rates on natural-origin steelhead have remained stable and are unlikely to substantially affect the abundance of Puget Sound steelhead (NWFSC 2015; NMFS 2019h). 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 2021-2022 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 49% decline in marine area catches in recent years as described in Section 2.4.1 and summarized in Table 14.

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 (0.96%) and concluded that the average harvest rate had declined by 78% (Table 16).

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 5 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; NMFS 2019h) 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; NMFS and BIA 2015).

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. Continued 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 identifies 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

Status of 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). 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). 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. 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 and productivity has declined dramatically; spatial structure, connectivity, and diversity have been adversely impacted, largely due to recreational and commercial fisheries that peaked in the early 1980s (Drake et al. 2010; Williams et al. 2010b); and there continues to be an exposure risk to mortality from commercial and recreational fisheries bycatch, new derelict gear, and habitat degradation.

Critical habitat was designated for ESA-listed rockfish in 2014 under section 4(a)(3)(A) of the ESA (79 FR 68041, November 13, 2014). The specific areas designated for bocaccio 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.

The physical or biological features essential to the conservation of yelloweye rockfish and bocaccio fall into major categories reflecting key life history phases; including adult, juvenile, and early settlement from the larval stage. 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.

NMFS 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 habitat structure and water quality stressors. NMFS includes in the current analysis cumulative impacts from other previous ESA section 7(a)(2) consultations; including programmatic consultation for salmon and steelhead hatchery production (NMFS 2020c), bycatch from the halibut and other bottom fish fisheries (NMFS 2018e), the impacts from derelict fishing gear, and the annual take allotments for scientific research (Dishman 2021).

To evaluate the effects of proposed fisheries on individual yelloweye rockfish and bocaccio NMFS analyzed direct effects on listed rockfish in two steps. First, NMFS estimated the number of listed rockfish likely to be caught in the salmon fishery and assessed both the sublethal and lethal effects on individuals. Second, NMFS considered the consequences of those sublethal and lethal effects at the population/DPS level. Impacts from bycatch within the hook and line fishery and net fishery were each analyzed, and NMFS analyzed indirect effects by considering the potential effects of fishing activities on benthic habitats.

Throughout, NMFS identified data gaps and uncertainties, and explained how the assumptions in the analysis are based on the best available science. Mortality estimates are highly variable, thus NMFS used the highest available catch estimates for bocaccio and yelloweye rockfish to form a precautionary analysis.

Effects of Puget Sound Fisheries on 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 and bottom fish, by researchers, and larval rockfish by hatchery released salmon. To assess if the effects from the salmon fisheries within the area of the listed rockfish DPSs threatens the viability of each species, in combination with all sources of bycatch identified in the environmental baseline, NMFS reviewed the population-level impact from all fisheries, hatcheries, research combined. In order to conduct this analysis, NMFS must assess numbers of fish harmed or killed 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, NMFS adopted methodologies used by the PFMC for rockfish species as described in the Effects section (Section 2.5.3.1). Given the similar life histories of yelloweye rockfish and bocaccio to coastal rockfish managed by the PFMC, NMFS 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, NMFS calculated the range of anticipated annual percent mortalities based on the range of estimate take and abundance scenarios (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 1.67
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 (0.5 (or less) of natural mortality) and risk-neutral level (0.75 or less) used in the PFMC methodology (Section 2.5.3.1).

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 within the environmental baseline, hatchery salmon take within the environmental baseline, and fishery take associated with the proposed actions, NMFS 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	Levels of Acceptable Mortality	Percent of DPS Killed (total lethal takes)
Bocaccio	138(+77)	90[a](+77)= 167	4,606	4 - 6%	3.63
Yelloweye rockfish	501(+66)	390[b](+66)= 456	143,086	1 - 3.45%	0.32

[a] This includes the following estimated bocaccio mortalities: 40 from the halibut fishery, 26 during research, 17 in other fisheries, and 7 from larval consumption by hatchery salmon.
[b] This includes the following estimated yelloweye rockfish mortalities: 270 from the halibut fisheries, 51 during research, 65 in other fisheries, and 4 from larval consumption by hatchery salmon.

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, predation by hatchery salmon, 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. Our analysis of potential mortality for each species uses precautionary assumptions and thus the actual level 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 that the population estimates 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 NMFS is 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 from the proposed action 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.

NMFS 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. NMFS 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.

Most adult yelloweye rockfish and bocaccio occupy waters much deeper than surface waters fished by commercial nets, therefore the bycatch of adults in commercial salmon fisheries is likely extremely low to non-existent. The recreational bycatch levels from the 2021/22 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. New derelict gear from the proposed action is a source of potential incidental mortality, but for reasons described above such mortality is expected to be quite low. 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, hatcheries, 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.

Current Status of SRKWs

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 98 whales in 1995, though the population declined to 81 whales by 2001. At present, the SRKW population has declined to near historically low levels (Figure 11). As of the 2020 summer census, the population is at 72 whales (one whale is missing and presumed dead since the 2019 summer census), and additionally two calves were born in fall of 2020 and one was born in February 2021.

The NWFSC continues to evaluate changes in demographic rates (fecundity and survival), and has recently updated the previous population viability analyses (Krahn et al. 2004a; Hilborn et al. 2012; Ward et al. 2013). The majority of the population projections using different estimates of fecundity and survival show a continued steady decline over the next 25 years ((Ward 2019). This predicted downward trend in the model is likely driven by the current age and sex structure of young animals in the population, as well as the number of older animals ((Ward 2019); Figure 12). The population trajectories reflect the endangered status of the SRKWs and variable periods of decline experienced over the long and short term and is based on a limited data set for the small population. The analysis ((Ward 2019) does not link population growth or decline to any specific threat, but reflects the combined impacts of all of the threats in the past. As a long-lived and slow to reproduce species that has shown capacity to grow in the past, SRKW response to actions to limit threats will take time and it will be difficult to link specific actions to potential improvements in the population trajectory in the future.

As we have described in our Effects Analysis, the status of the whales is important because SRKWs are already stressed due to the cumulative effects of multiple stressors, and the stressors can interact additively or synergistically. Any additional stress can likely have a greater physiological effect than it would for a healthy population, which may have negative implications for SRKW vital rates and population viability (e.g., (NAS 2017a)). We have also identified periods of low Chinook salmon abundance as higher risk conditions for SRKW when effects are more likely to impact the health of the whales.

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

14). During the spring, summer, and fall months, SRKWs 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 (particularly the west coast of San Juan Island in summer). Although seasonal movements are somewhat predictable, there can be large inter-annual variability in arrival time and days present in the Salish Sea from spring through fall, with late arrivals and fewer days present in inland waters in recent years. There is also variability in occurrence across the three pods with J pod more consistently encountered in inland waters year round (Hanson and Emmons (2010); Ettinger et al. in revision; The Whale Museum unpubl. Data, Figure 32). Over more than 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 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, and multiple Puget Sound Chinook stocks were ranked in the top 10 priority stocks (NOAA and WDFW 2018).

The proposed action is set within a backdrop of the current condition of SRKW, their main prey Chinook, and their critical habitat in the action area and other past and present Federal, State, or private actions and other human activities that impact SRKWs, their Chinook prey, and their designated critical habitat in the action area (Environmental Baseline).

A number of baseline natural conditions and human actions affect the abundance, productivity, spatial structure, and diversity of Chinook salmon and these actions also affect prey availability for SRKWs. Natural occurrences that affect Chinook status can include changes in climate and ocean conditions (e.g. the Pacific Decadal Oscillation and the El Nino/Southern Oscillation). The most notable human activities that cause adverse effects on salmon include land use activities that result in habitat loss and degradation, hatchery practices, harvest, and hydropower systems. The potential impacts of climate and oceanographic change on whales and other marine mammals from natural occurrences and human actions will likely involve effects on habitat availability and food availability. For example, changing ocean conditions driven by climate change may influence ocean survival and distribution of Chinook and other Pacific salmon further affecting the prey available to SRKWs (for predicted distribution shifts see (Shelton et al. 2020)). Prey availability may also be affected by the increased competition from other predators including other resident killer whales and pinnipeds (Chasco et al. 2017a; Chasco et al. 2017b) as well as pelagic fish, sharks, and birds.

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). As discussed in the Environmental Baseline section, we are limited in our ability to compare impacts from different fisheries because of the differing methodologies used to estimate prey reduction. All of these fisheries are managed under the PST. The 2019 - 2028 PST Agreement includes provisions limiting harvest impacts in all Chinook salmon fisheries within its scope (including fisheries that will impact salmon abundance in the action area; PFMC, Southeast Alaska, Canada, and Puget Sound salmon fisheries). 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. Also, the adoption of proposed Amendment 21 to the salmon fishery management plan for Council-area (PFMC) fisheries may further limit the reductions in prey availability by PFMC fisheries on Salish Sea (action area) prey in years with low salmon abundance (below the threshold established in Amendment 21) when additional fishery management measures will be implemented. In sum, fishery impacts on Chinook have been reduced coastwide over the past decade, including areas where SRKWs are more likely to occur. The fishery management frameworks used to manage all of these fisheries reduce to some degree allowable catch levels in years of low Chinook abundance.

The funding initiative associated with the implementation of the new PST agreement, is designed to produce hatchery fish to conserve Puget Sound Chinook critical populations, increase hatchery production of Chinook to provide additional prey for SRKWs, and restore habitat for Puget Sound Chinook populations. The funding initiative (consulted on in (NMFS 2019e)) has a goal of a 4-5% increase in available prey throughout inland waters in the summer and coastal waters in the winter that are frequented by SRKW's and affected by fisheries managed under the PST, with increased abundance beginning to accrue in the next 3 - 5 years following implementation with FY20 and 21 funds. WDFW is contributing toward the goal of producing additional Chinook as prey for SRKWs. As a result of the additional funding for hatchery production to support SRKW (FY20 PST funding and 2019-2021 Washington State Legislature funding), over 11.6 million additional hatchery-origin Chinook salmon were released in 2020 and over 18.3 million additional hatchery-origin Chinook salmon are expected to be released in 2021 relative to the base period considered in NMFS' 2019 biological opinion on the delegation of management authority for specified salmon fisheries to the State of Alaska.

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 SRKWs. The FY20 and FY21 appropriated funds for implementation of U.S. domestic actions associated with the new PST Agreement includes $10.4 million in support of this habitat restoration effort. Furthermore, 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 salmon abundance in these watersheds, including Chinook salmon, would increase, also potentially benefiting SRKWs. However, the benefits of these actions for SRKW will not occur in 2021-22, thus we don't expect them to mitigate the short-term effects of the 2021-22 salmon fisheries in Puget Sound.

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 due to COVID-19 orders (as there were reductions in 2020, (Frayne 2021)) and through new Washington State programs. Vessels used for a variety of purposes occur in the action area and several studies in inland waters of Washington State and British Columbia have linked interactions of vessels and SRKWs with short-term behavioral changes (see review in Ferrara et al. (2017)). According to these studies, vessel activities may affect foraging efficiency (thus prey and energy acquisition), communication (which also may impact energy acquisition due to prey sharing), and/or energy expenditure through the physical presence of the vessels, underwater sound created by the vessels, or both. Multiple actions have been implemented that have targeted management actions identified in the recovery plan (NMFS 2008a) to reduce impacts of threats including vessel and noise impacts. For example, in addition to the 2011 federal vessel regulations, Washington State regulations were updated in 2019 to increase vessel SRKW viewing distances (see RCW 77.15.740). In 2020 Washington State law (Senate Bill 5577) established a commercial whale watching license program and charged WDFW with administering the licensing program and developing rules for commercial whale watching by January 2021 for inland Washington waters (see RCW 77.65.615 and RCW 77.65.620). The increased viewing distance and licensing program will reduce the impacts of vessel noise and disturbance on the whales' ability to forage, rest, and socialize in the Salish Sea.

Effects of Puget Sound Fisheries on SRKWs

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. Fishing vessels and effort mainly overlap with SRKW occurrence in marine area 7 off the west coast of San Juan island because killer whales typically spend the majority of their time foraging in this area in summer months and fishing vessels are active in the area particularly in summer. There is overlap in other areas and times of year to a lesser extent as outlined above. The overlap of fisheries and whales informs our analysis of the potential for direct impacts of fishing vessels on SRKW and indirect effects of reduction of prey in the vicinity of SRKW. We have analyzed the potential overlap between SRKWs and fishing vessels for 2021-2022 and the potential for direct interaction between vessels or fishing gear and SRKWs, and impacts of vessel disturbance on SRKWs, which also forms the basis for our analysis of impacts to the passage feature of critical habitat. Also, we have analyzed the effects of the 2021-2022 Puget Sound salmon fisheries on prey of SRKWs and this analysis also forms the basis for the analysis of the effects to SRKW critical habitat through reduction in available prey.

Vessel Interactions

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 (including off the west coast of San Juan Island), 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 due to potential increased energy expenditure and reduced energy acquisition through multiple pathways (lower prey availability and reduction in foraging due to a disturbance). While some trends in vessel activities that could disturb the whales have declined in recent years (Ferrara et al. 2017) vessels continue to operate in ways that are inconsistent with guidelines and out of compliance with regulations (see (Frayne 2021)). 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. State regulations described in the Effects and Cumulative Effects sections of this opinion, will continue protections for the whales in 2021 similar to recent years and enforcement presence in 2021 is expected to improve compliance by vessel operators and reduce overall vessel impacts that may impact foraging or passage.

Based on monitoring data, interactions between SRKWs and fishing vessels could occur and fishing vessels likely contribute to the total effects of direct disturbance from all vessels (including effects on critical habitat passage conditions) due to overlap between fishing vessels and SRKWs. At the same time, it is difficult to assess cumulative impacts and population level consequences, and difficult to quantify loss to energy acquisition, of vessel disturbance. There is some potential for direct interaction between SRKWs and salmon fishing vessels and gear in the action area, particularly in recreational and commercial marine area 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. However, vessel strikes or reports of entanglement in general are rare, none have been observed in association with Puget Sound salmon fisheries, and fishing vessels operate at low speeds while fishing, therefore strikes and entanglements are considered unlikely. The proposed action (compared to no fishing) will likely 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 commercial and recreational vessels associated with the proposed fisheries. Again, this may be of particular concern where fisheries overlap with the highest number of sightings and foraging observations of SRKWs along the west side of San Juan Island in MA 7. We do not know how many recreational vessels would still engage in recreational boating near the whales if the proposed fishery were not authorized, so we do not know the exact level of vessel effects caused by the action. Overall, some of the exposure to fishing vessels may result in less efficient foraging by the whales compared to conditions without fishing vessels, but decreasing the number of repeated disruptions from vessels would likely reduce the impact on foraging and, in turn, reduce the potential for nutritional stress.

We compared the direct impacts from fishing vessels from the proposed action analyzed in this opinion to such impacts in previous years. Impacts in 2021 are expected to be similar to 2020 (and lower than previous years) 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 marine areas 6,7,8,9, and 12 in winter months (except non-retention in 12 in 2 months) and continued restrictions in summer months, such as non-retention management measures in September and part of August (specifically in Southern Resident killer whale foraging hot spots along the west side of San Juan Island, MA 7). Furthermore, commercial fishing will likely be reduced in 2021 compared to years prior to 2020 based on the low Fraser River sockeye forecast with no harvestable surplus. Tribal fisheries are also not expected to be higher in 2021-2022 compared to the previous decade and are expected to have a small number of vessels in summer months near the San Juan Islands (2.5 boats per day), no more than 5 boats per day in other areas of SRKW occurrence in summer, and even fewer in areas of high SRKW occurrence in other times of year. In general, exposure to tribal fishing vessels and associated noise is expected to be low because the majority of tribal fisheries occur in terminal areas or in times/areas where SRKWs are more rare, and sonar/depth-finder use is not standard practice. In addition, WDFW will continue to promote the Be Whale Wise guidelines and voluntary No-Go zone (now mandatory for commercial whale watch vessels), and continue conservation efforts including education to fishing vessels to maintain slow transit speeds (restricted to 7 knots or less near whales) 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 because this level falls within the hearing range of killer whales, (Branstetter et al. 2017)). Ongoing monitoring of vessel activities near the whales by the Soundwatch Boater Education Program and WDFW vessel patrols are a part of the proposed action. Both are likely to reduce vessel impacts and allow for tracking reductions in fishing vessel activity when whales are in key foraging areas. In summary, vessel and acoustic disturbances may cause short-term behavioral changes, avoidance, or a decrease in foraging (if interactions occur). However, based on the operation of fishing vessels, that are not targeting the whales, the limited number of tribal vessels, the implementation of area restrictions, and existing mitigation efforts, we expect that any transitory or small amount of disturbance caused by the fishing vessels is not likely to disrupt normal behavioral patterns or distribution, or cause harm to the whales.

Reduction of Prey Availability

As described in the Effects Section, to analyze indirect impacts on SRKWs from the action due to effects to prey, we focused our analysis on SRKW's primary prey, Chinook salmon, and impacts in inland waters mainly in summer months where the fisheries overlap with foraging areas. While there are several challenges to quantitatively characterize the relationship between Chinook abundance and SRKW health and status, available science supports a relationship, and intuitively, at some low Chinook abundance level, the prey available to the whales may not be sufficient to allow for successful foraging leading to adverse effects (such as reduced body condition and growth and/or poor reproductive success). 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 2021 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 605,100, which is similar to the recent 10 year post-season average of 612,400. The proposed fishing is expected to reduce the annual abundance of prey in inland waters by approximately 3%, i.e. similar to the average reductions over the recent 10 years.

Also, the Puget Sound fisheries respond to changes in salmon abundance over time and are sustainable by accounting for the available information on the productivity, abundance and status of individual salmon stocks. The fisheries are designed to ensure salmon stocks (ESA-listed and non-listed) impacted in the fishery meet the applicable conservation objectives. We concluded 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.

Given the 2021-2022 Chinook abundance in October is estimated to be average (compared to the recent 10 years, 2007-2016), we anticipate the prey available in 2021-2022 will be relatively average (i.e. not relatively low). The proposed fishing is expected to reduce the annual abundance of prey in inland waters by approximately 3%, which is relatively low compared to previous decades, and similar to the average for the last decade. But modeling limitations add a level of uncertainty to these percent reduction estimates. For example, the PFMC Workgroup methods may bias estimates in percent reductions from fisheries because methods assume 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. At the same time, reduction by the fisheries may be an overestimate of reduction in availability to SRKWs because it is unlikely the whales would consume all the fish caught by the fisheries if the fisheries were closed. Reductions of prey from fishing are expected to be highest in summer in the inland waters, but apply to a broad area with varying overlap with SRKWs. Therefore, it is also 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 reductions throughout the action area may not accurately predict reductions in prey available in known foraging hot spots (such as MA 7 especially off the west side of San Juan Island), however recreational fishery restrictions (closures, non-retention limitations) should limit the removal of potential prey in important foraging areas of SRKWs. We also estimate that Chinook prey available in 2021-2022 will be at levels where prey energy available is greater than that required by the whales (based on our analysis and NWIFC analysis of energy requirements of the current SRKW population). However, there are significant limitations and uncertainties in this analysis. Here and in past years, NMFS and the NWIFC estimated the Chinook food energy available to the whales and compared available kilocalories to needs including after reductions from fishing in the past and proposed fishing this year. We have low confidence in forage ratios (prey available compared to needs of the whales), though under both the NWFIC and our analysis for 2021-2022, the estimated kcal based on the projected abundance of Chinook salmon for this year are expected to exceed the metabolic needs of the whales. However, we are unable to quantify how a reduction in the ratio of prey available compared to the whales' needs could affect the foraging efficiency of the whales and therefore apply a low weight to this part of the analysis.

In summary, although there is uncertainty in exact reductions of prey availability to the whales, the proposed actions will reduce prey compared to no fishing, and some amount of the prey reduction occurs in an area known for its high use and considered a foraging hot spot (e.g. MA 7). In response to reduced prey, the whales may increase their searching effort and move to other potential foraging areas within their geographic range. We would expect increased energy expenditure or reduced foraging to have more significant impacts on the health and reproduction of the whales in times of low Chinook salmon abundance, but 2021 is expected to be at an average level. The expected reduction of Chinook by the fishery is relatively low compared to historic levels, is expected to be similar to the average of this last decade, and Chinook abundance is expected to be similar to the average of the last decade. WDFW and the NWIFC have provided information on how the salmon fisheries were set for 2021-2022. They identified how the fisheries are managed in ways that account for the distribution of SRKW and important foraging areas, described aspects of the fishery that limit potential effects on the whales, and also outlined specific measures to limit potential impacts from vessels. Recreational fishery restrictions in the summer (mark selective and non-retention) and winter (closure), likely limited commercial fishing due to no harvestable surplus in Fraser River sockeye, and minimal tribal fishing (approximately 2.5 boats per day and primarily terminal), will likely limit the impacts to SRKW in foraging hot spots. Efforts to reduce vessel interactions and 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. Therefore, though a reduction in prey will occur, it is expected to be small, and during a year with average Chinook abundance

Effects to Critical Habitat

In addition to the effects to SRKWs discussed above, the proposed action affects critical habitat designated for SRKWs in inland waters of Washington.

Critical habitat includes approximately 2,560 square miles of inland waters of Washington and includes three physical or biological features essential to the conservation of SRKWs: (1) water quality, (2) prey quantity, quality, and availability, and (3) passage conditions (see section 2.2.2.4). The Section on Effects on Southern Resident Killer Whales considers pathways of effects related to prey as well as vessel effects that could affect movements and foraging and therefore, this analysis draws heavily on the previous assessment of impacts to the whales when considering effects on the habitat features, which are summarized here.

Fisheries actions outlined in this biological opinion have the potential to affect (1) prey quantity and availability and, (2) passage, in designated critical habitat, and these features 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 near average for 2021 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, fishing restrictions are in place in summer in the killer whale core critical habitat area (including around the San Juan islands), 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. Similar to our assessment of the impacts to the whales, reductions in prey by fisheries is expected to be relatively low (compared to historic levels) and we expect that any transitory or small amount of disturbance caused by the fishing vessels is not likely to disrupt normal behavioral patterns or distribution, and therefore the proposed action is not likely to impair the prey (i.e., availability and access to prey) and passage features of SRKW critical habitat.

Summary Conclusion

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 whales' status has continued to decline over the last decade—likely due to a combination of the three top limiting factors: prey availability, vessel noise and disturbance, and toxic contaminants. Chinook salmon are probably the predominant prey species and there is intuitively a linkage between Chinook abundance and the whales' status although certain available analyses have not been able to identify a quantitative relationship. There is likely a spectrum of risk and at some low level of Chinook abundance there is higher risk that fishery removals would adversely affect the whales' status or reduce the conservation value of the prey habitat feature. Prey reductions, particularly during periods of low Chinook abundance, could affect the foraging behavior of the whales, their energy balance, and subsequently their health, reproduction and survival. 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 efforts to improve salmon habitat conditions in Washington.

The effects of the proposed action in this biological opinion add a measurable but small adverse effect in addition to the existing conditions compared to no action. The most significant impacts of the action will occur where the fisheries overlap with key foraging areas for the whales. The action in 2021-2022 will add some vessel disturbance and reduce available prey for the one year fishing period, and any reduction in prey or interference with foraging is a concern for the SRKWs because of their status. However, we anticipate average Chinook salmon abundance in inland waters, average percent reduction by the fisheries relative to the most recent 10 years for which FRAM model data is available. Conditions in specific areas are anticipated to be improved (similar to 2020) compared to average conditions in the last decade based on area closures and other fishing restrictions. Specifically, changes in the fisheries 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. In addition, a number of conservation measures, identified by WDFW as part of the action, and limited pre-terminal tribal fishing as described by the NWIFC, are expected to limit the impact of the prey reduction and limit 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. In addition, the action will also not jeopardize the listed salmon that the whales depend on over the long term.

In conclusion, this proposed action adds one year of average, 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 the whales in the form of 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 with a measurable effect, we find that the proposed action will not likely appreciably reduce the likelihood of survival of SRKWs, and is not likely to appreciably diminish the conservation value of designated critical habitat. We will continue to monitor the abundance of Chinook salmon prey, the condition and health of individual whales, and overall population status to evaluate the effectiveness of the proposed actions and mitigation, along with other recovery actions, in improving conditions for listed Chinook salmon and SRKWs compared to recent years.

Similarly, we do not expect the 2021 fisheries to appreciably reduce the likelihood of the whales' recovery. First, the action will also not jeopardize the listed salmon that the whales depend on over the long term. Also 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 improve vessel regulations and reduce impacts of vessels on foraging. In light of these ongoing efforts addressing the three primary limiting factors and projecting into the future beyond 2021 with reasonably certain assumptions, we do not expect that the 2021 fisheries will impede the recovery of the whales. With these efforts to ensure that recovery progresses, we find that the 2021 fisheries are not likely to appreciably reduce the likelihood of survival and recovery of SRKWs or adversely modify SRKW designated critical habitat over the long run.

2.7.5 Central America and Mexico DPSs of Humpback whales

Humpback whales were historically abundant in the Salish Sea, but were effectively removed from the region by the early 1900s due to overharvesting. Following the end of commercial whaling in the U.S. and the placement of environmental protections, such as the ESA, the species has been recovering and returning to its historic range. In 2016, NMFS divided humpback whales into 14 DPSs. 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 three DPSs.

NMFS takes a proportional approach to assign estimates of each DPS that are applied off the West Coast. Approximately 9% of humpback whales found off of Washington and British Columbia are considered to be from the endangered Central America DPS, while 28% are considered to be from the threatened Mexico DPS, with the majority 63% 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.

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 and the slow speeds at which fishing vessels operate.

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 public sighting reports of humpback whales in 2017, 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. There were three entanglements in unknown gear in 2019 and one entanglement in unknown gear in 2020 reported in the action area. 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 2021, humpback whales have been returning to the Salish Sea in increasing numbers in recent years (Calambokidis et al. 2017; Miller 2020), 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.

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 activities caused by the proposed action, 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 activities caused by the proposed action , 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, any effects of activities caused by the proposed action, 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 activities caused by the proposed action , 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 activities caused by the proposed action 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 and is not likely to adversely modify their designated critical habitat.

2.9 Incidental Take Statement

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

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

2.9.1 Amount or Extent of Take

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

2.9.1.1 Puget Sound Chinook

NMFS anticipates incidental take of listed Puget Sound Chinook to occur in the proposed Puget Sound salmon and steelhead fisheries from May 1, 2021 through May 14, 2022 through contact with fishing gear. NMFS anticipates Puget Sound salmon fisheries occurring in 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. 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 14 adult, 74 immature, and 7 juvenile Chinook incidental mortalities will occur in the research studies discussed in this opinion from May 1, 2021 through May 14, 2022.

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, 2021 through May 14, 2022 through contact with fishing gear.

NMFS anticipates that a maximum of 324steelhead will be incidentally caught in marine area. This estimate includes an unknown proportion of ESA listed steelhead, unlisted hatchery steelhead, non-listed Olympic Peninsula fish, and hatchery and natural-origin fish from Canada.

NMFS also anticipates that the harvest rate on natural-origin steelhead in terminal tribal and non-tribal 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 four Puget Sound winter steelhead reference populations (i.e., Snohomish, Green, Puyallup and Nisqually). This rate is not a population-specific terminal 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 reference populations discussed above based on the similarity of expected fishing effort, 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 5 adult and 3 juvenile steelhead mortalities will occur in the research test fisheries discussed in this opinion (PSC chum test fishery and Lake Washington predator removal and assessment) from May 1, 2021 through May 14, 2022.

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 2021/22 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, as quantitative regression analyses have limitations (see section 2.5.4.1). Therefore, NMFS is using the level of Chinook salmon catch in the Puget Sound fisheries, which we can quantify, as a surrogate for incidental take of SRKW. Chinook salmon catch in Puget Sound 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 2021-2022 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 an approximate 3% annual reduction in the abundance of large (age 3-5) Chinook in the action area as estimated by FRAM. This approximate 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. We believe these exploitation rates are the best surrogate for take of Southern Resident killer whales because these rates are used to manage the fisheries, are the best measure of fishing effort that results in prey reduction, and are monitored. 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 2021-2022, 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 2021-2022 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.

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

(5) NMFS, in consultation with the co-managers, will estimate the observed abundance of Chinook before and after fishery removals, using postseason information as it becomes available.
(6) Harvest impacts (percent reductions of prey by fisheries) on Southern Resident killer whales shall be monitored and periodically reviewed using the best available measures.

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

(7) Monitor and report the extent of fishery interactions with ESA-listed marine mammals, including individuals that are likely, but not confirmed as part of an ESA-listed DPS.

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

(8) Derelict gear impacts on listed rockfish shall be reported using best available measures.
(9) 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.

For *Puget Sound Chinook salmon and Steelhead*:

1a. The action agencies will work with the Puget Sound 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. 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).

1c. The co-managers and NMFS will meet by phone to discuss the initial results of the Green River inseason run size update (weeks 29-31). 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 2021-2022 List of Agreed to Fisheries.

1d. 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.

1e. 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. .

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

2. The action agencies will 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 will be assessed in the postseason report.

3. The action agencies will 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 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. The action agencies will work with the Puget Sound treaty tribes and WDFW to provide post season reports for the 2021-2022 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. The action agencies will work with the affected treaty tribes and WDFW, to provide postseason reports for the 2021 steelhead 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 February 18, 2022. 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.

4c. The action agencies will work with the Puget Sound treaty 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.

4d. The action agencies shall confer with the affected co-managers to account for the Chinook 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 (section 2.9.1.1).

4e. The co-managers shall monitor salmon catch using measures and procedures that provide reliable accounting of the catch of Chinook.

4f. The action agencies, in cooperation with the affected co-managers, shall monitor the

Chinook 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.

For *Southern Resident Killer Whale*:

5a. 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

5b. NMFS will continue to explore improvements to the PFMC ad-hoc Workgroup methods, including analytic assessessment of the amount of Chinook removals by fisheries, assessing fishery effects to SRKW through prey removal, and providing a method for managing these effects as necessary. This work should:

- assess annual post-season fishery abundance reductions (in percent reduction) using Ad Hoc Workgroup or appropriate updated methodology for application to Puget Sound Chinook salmon

·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.

5c. 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.

For *Humpback Whale*:

6a. 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.

6b. 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.

For *Puget Sound/Georgia Basin rockfish*:

7. NMFS, in cooperation with BIA, the USFWS, WDFW and the Puget Sound tribes, shall minimize take and monitor the number of derelict fishing nets that occur on an annual basis by:
   a. Derelict Gear Reporting. Requiring all derelict gear to be reported to appropriate authorities within 24 hours of its loss.
   b. Derelict Gear Accounting and Location. Recording the total number and approximate locations of nets lost (and subsequently recovered) on an annual basis.
   c. Derelict Gear Prevention. The BIA, USFWS and NMFS in collaboration with the state and tribes, shall continue to conduct outreach and evaluate technologies and practices to prevent the loss of commercial fishing nets, and systems to track nets upon their loss, to better aid their retrieval and other measure necessary to prevent and track lost gear.
8. 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 Action Agencies 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 Action Agencies in collaboration with WDFW and the Puget Sound treaty tribes should continue to improve on the monitoring of the salmon and steelhead populations that are affected by the proposed action using available resources.
(3) The Action Agencies 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.
(4) The Action Agencies in collaboration with the WDFW and the Puget Sound treaty Tribes, should continue to collect data on steelhead populations where insufficient data exist and improve upon catch accounting for all steelhead populations as resources become available.
(5) The Action Agencies in collaboration with the WDFW, and the Puget Sound treaty tribes, should implement the recommendations for the prevention, retrieval and investigation of gear modifications of gill nets used in Puget Sound treaty tribal and U.S. Fraser Panel salmon fisheries reported in Gibson (2013).
(6) The Action Agencies 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.
(7) The Action Agencies 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.
(8) NMFS should pursue research into the co-occurrence between humpback whales and fisheries within the action area, particularly as it relates to the composition and distribution of humpback whale prey and predictive models for whale concentrations and foraging conditions.
(9) NMFS should continue to support humpback whale photo-identification research in order to understand which DPSs are found within the action area
(10) The Action Agencies in collaboration with the WDFW, and the Puget Sound treaty tribes should work to train commercial fishermen on how to respond if they encounter an entangled humpback whale or other marine mammal as part of fishermen participation in the fishery.
(11) NMFS, in cooperation with the co-managers, should continue to explore potential improvements to the Workgroup modeling efforts for application to inland, Salish Sea waters, particularly improvements to the modeling and analysis assessing percent prey

abundance reductions by the Puget Sound fishery in Salish Sea.

(12) Continue and expand education and outreach for fishing communities through promoting Be Whale Wise guidelines and regulations, online training for professional mariners, and encouraging reports of killer whale sightings.

(13) NMFS should continue to review and monitor the SRKW status, which includes diet, spatial and temporal geographic distribution, and SRKW body condition and health when new data are available.

(14) NMFS, will improve understanding of links between prey availability and SRKW body condition and any links to reproduction or survival, and continue to explore relationships between body condition of SRKWs and specific Chinook abundance indicators (similar to Stewart et al. Accepted) for potential use in management as an indication of high risk conditions for SRKWs.

(15) NMFS will update prey ratio estimates (SRKWs metabolic needs compared to prey available) to reflect current population estimates and utilize current salmon modeling methodologies. NMFS will also improve understanding of foraging efficiency to validate estimates of metabolic needs and inform evaluation of levels of abundance and distribution of prey needed to support growth and reproduction.

2.11 Reinitiation of Consultation

This concludes formal consultation for the impacts of the Role of the BIA Under its Authority to Assist with the Development of the 2021-2022 Puget Sound Chinook Harvest Plan, the Role of the U.S. Fish and Wildlife Service in Activities Carried out under the Hood Canal Salmon Management Plan and in Funding the Washington Department of Fish and Wildlife under the Sport Fish Restoration Act in 2021-22, and the Role of the National Marine Fisheries Service in authorizing fisheries consistent with management by the Fraser Panel and Funding Provided to the Washington Department of Fish and Wildlife for Activities Related to Puget Sound Salmon Fishing in 2021-2022

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. Additionally, NMFS does not anticipate adverse impacts on designated critical habitat for Central America and

Mexico humpback whale DPSs.

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.

Humpback Whale Critical Habitat

NMFS designated critical habitat for humpback whales on April 21, 2021 (86 Federal Regulation (FR) 21082). The area proposed stretches across the majority of the west coast of the United States and includes 59,411 square nautical miles $(nmi)^2$ for the Western North Pacific DPS, 48,521 nmi^2 for the Central American DPS, and 116,098 nmi^2 for the Mexico DPS. The 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. Of the designated critical habitat areas, only 3,441 nmi^2 of critical habitat for the Central America and Mexico DPSs is designated along the Washington coast and into the Strait of Juan de Fuca. The action area includes the portion of the critical habitat within the Strait of Juan de Fuca and near Cape Flattery on the outer coast. No critical habitat for the Western North Pacific DPS is designated within the action area.

The Critical Habitat Review Team (CHRT) identified a prey biological feature that is essential to the conservation of the two humpback whale DPSs. Prey species for the Central America DPS are defined in the designation as "primarily euphausiids (*Thysanoessa, Euphausia, Nyctiphanes,* and *Nematoscelis*) and small pelagic schooling fishes, such as Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), and Pacific herring (*Clupea pallasii*) of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth." Prey species for the Mexico DPS are defined in the designation as "primarily euphausiids (*Thysanoessa, Euphausia, Nyctiphanes*, and *Nematoscelis*) and small pelagic schooling fishes, such as Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasii*), capelin (*Mallotus villosus*), juvenile walleye pollock (*Gadus chalcogrammus*), and Pacific sand lance (*Ammodytes personatus*) of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth."

The proposed action would have minimal overlap with the designated critical habitat. There will be limited fishing effort in the Strait of Juan de Fuca, especially the portion that includes the critical habitat, due in part to the small size of the sockeye run. Additionally, the type of fishing gear used by the co-managers is not likely to result in bycatch of humpback whale prey species. Because the designated 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, the essential biological feature identified in the designation, any impacts of the action on humpback whale critical habitat are considered to be insignificant and discountable. As such, the proposed salmon fisheries are not likely to adversely affect humpback whale 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 2019, an estimated seven nets became derelict, and five of them were recovered (James 2020). 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.

5. REFERENCES

Adicks, K. 2010. Memorandum regarding escapement trends in Mid-Hood Canal Chinook and hatchery production changes Memorandum to Hood Canal Tribal Co-managers from Kyle Adicks, Anadromous Resource Policy Analyst, Washington Department of Fish and Wildlife, Olympia, Washington. February 3.

Adicks, K. 2016. Fisheries Biologist, Washington Department of Fish and Wildlife, Olympia, Washington. June 8, 2016. Personal communication via email with Susan Bishop, NMFS, transmitting comanagers 2016 Terminal Freshwater Fishery Performance Report: Skagit Summer/Fall, Puyallup Fall, Nisqually Fall, and Skokomish Fall Chinook Management Units. 7 p.

Aguilar, A., A. Borrell, and P. J. H. Reijnders. 2002. Geographical and temporal variation in levels of organochlorine contaminants in marine mammals. Marine Environmental Research. 53(5): 425-452.

Akiyama, S., E. Saito, and T. Watanabe. 2007. Relationship between soak time and number of enmeshed animals in experimentally lost gill nets. Fisheries Science. 73: 881-888.

Al-Humaidhi, A. W., M. A. Bellman, J. Jannot, and J. Majewski. 2012. Observed and Estimated total Bycatch of Green Sturgeon and Pacific Eulachon in 2002-2010 U.S. West Coast Fisheries. West Coast Groundfish Observer Program. NWFSC, Seattle, Washington. 27p.

Ames, E. P. 2004. Atlantic cod structure in the Gulf of Maine. Fisheries. 29(1): 10-28.

Apgar-Kurtz, B. 2018. Breena Apgar-Kurtz, Lummi Tribal Natural Resources, personal communication via email with Susan Bishop, National Marine Fisheries Service regarding 2017 Nooksack early Chinook escapement. April 24, 2018.

Appleby, A., and K. Keown. 1994. History of White River spring chinook broodstocking and captive rearing efforts. Wash. Dep. Fish Wildl., 53 p. (Available from Washington Dept. of Fish and Wildlife, 600 Capitol Way N., Olympia, WA 98501-1091).

Au, W. W. L., J. K. Horne, and C. Jones. 2010. Basis of acoustic discrimination of Chinook salmon from other salmons by echolocating *Orcinus orca*. The Journal of the Acoustical Society of America. 128(4): 2225-2232.

Au, W. W. L., A. A. Pack, M. O. Lammers, L. M. Herman, M. H. Deakos, and K. Andrews. 2006. Acoustic properties of humpback whale songs. The Journal of the Acoustical Society of America. 120(2): 1103-1110. https://www.ncbi.nlm.nih.gov/pubmed/16938996.

Ayres, K. L., R. K. Booth, J. A. Hempelmann, K. L. Koski, C. K. Emmons, R. W. Baird, K. Balcomb-Bartok, M. B. Hanson, M. J. Ford, and S. K. Wasser. 2012. Distinguishing the impacts of inadequate prey and vessel traffic on an endangered Killer Whale (*Orcinus orca*) Population. PLoS One. 7(6): e36842.

Bachman, M. J., J. M. Keller, K. L.West, and B. A. Jensen. 2014. Persistent organic pollutant concentrations in blubber of 16 species of cetaceans stranded in the Pacific Islands from 1997 through 2011. Science of the Total Environment. 488-489(115–123).

Bain, D. 1990. Examining the validity of inferences drawn from photo-identification data, with special reference to studies of the killer whale (Orcinus orca) in British Columbia. Report of the International Whaling Commission, Special 12. 12: 93-100.

Baird, R. W. 2000. The killer whale. Cetacean societies: Field studies of dolphins and whales, pages 127-153.

Baker, C. S. 1985. The population structure and social organization of humpback whales (Megaptera novaeangliae) in the Central and Eastern North Pacific. University of Hawaii. 313p.

Baker, C. S., D. Steel, J. Calambokidis, E. Falcone, U. González-Peral, J. Barlow, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán, P. R. Wade, D. Weller, B. H. Witteveen, and M. Yamaguchi. 2013. Strong maternal fidelity and natal philopatry shape genetic structure in North Pacific humpback whales. Marine Ecology Progress Series. 494: 291-306.

Barlow, J., J. Calambokidis, E. A. Falcone, C. S. Baker, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. K. Mattila, T. J. Q. II, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. U. R., P. Wade, D. Weller, B. H. Witteveen, and M. Yamaguchi. 2011. Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Marine Mammal Science. 27(4): 793-818.

Barnett-Johnson, R., C. B. Grimes, C. F. Royer, and C. J. Donohoe. 2007. Identifying the contribution of wild and hatchery Chinook salmon (*Oncorhynchus tshawytscha*) to the ocean fishery using otolith microstructure as natural tags. Canadian Bulletin of Fisheries and Aquatic Sciences. 64(12): 1683-1692.

Bassett, C., B. Polagye, M. Holt, and J. Thomson. 2012. A vessel noise budget for Admiralty Inlet, Puget Sound, Washington (USA). The Journal of the Acoustical Society of America. 132(6): 3706–3719.

Battin, J., M. W. Wiley, M. H. Ruckelshaus, R. N. Palmer, E. Korb, K. K. Bartz, and H. Imaki. 2007. Projected impacts of climate change on salmon habitat restoration. Proceedings of the National Academy of Science. 104(16): 6720-6725.

Baylis, H. A. 1920. A Revision of the Nematode Family Gnathostomidae. *In* Proceedings of the Zoological Society of London (Vol. 90, No. 3, pp. 245-310). September. 16, 1920. Oxford, UK: Blackwell Publishing Ltd. 74p.

Beattie, W. 2013. Letter describing derelict fishing nets in the Puget Sound area. On file with NMFS West Coast Region Sand Point Office.

Beattie, W. 2014. Conservation Planning Coordinator, NWIFC, Olympia, Washington. April 16, 2014. Personal communication via email with Amilee Wilson, NMFS, regarding native steelhead incidental encounters in Puget Sound treaty marine salmon and steelhead fisheries.

Beattie, W., and K. Adicks. 2012. Letter describing derelict fishing nets in the Puget Sound area. On file with NMFS West Coast Region, Sand Point Office.

Beechie, T. J., E. Buhle, M. Ruckelshaus, A. Fullerton, and L. Holsinger. 2006. Hydrologic regime and the conservation of salmon life history diversity. Biological Conservation. 130(4): 560-572.

Berkeley, S. A., C. Chapman, and S. M. Sogard. 2004. Maternal age as a determinant of larval growth and survival in a marine fish, *Sebastes Melanops*. Ecology. 85(5): 1258–1264.

Besseling, E., E. M. Foekema, J. A. V. Franeker, M. F. Leopold, S. Kühn, E. L. B. Rebolledo, E. Hebe, L. Mielke, J. Izer, P. Kamminga, and A. A. Koelmans. 2015. Microplastic in a macro filter feeder: Humpback whale Megaptera novaeangliae. Marine pollution bulletin. 95(1): 248-252. https://www.ncbi.nlm.nih.gov/pubmed/25916197.

Bettridge, S., C. S. Baker, J. Barlow, P. J. Clapham, M. Ford, D. Gouveia, D. K. Mattila, R. M. Pace III, P. E. Rosel, G. K. Silber, and P. R. Wade. 2015. Status review of the humpback whale (*Megaptera novaeangliae*) under the Endangered Species Act. La Jolla, California. NOAA-TM-NMFS-SWFSC-540. Available at: http://www.nmfs.noaa.gov/pr/species/Status%20Reviews/humpback_whale_sr_2015.pdf.

BIA. 2021. U.S. Bureau of Indian Affairs. Draft Environmental Assessment - 2021-2022 Puget Sound Salmon and Steelhead Fisheries. Northwest Regional Office. 911 Northeast 11th Avenue, Portland, OR. May 6, 2021. 447p.

Bigg, M. 1982. An assessment of killer whale (*Orcinus orca*) stocks off Vancouver Island, British Columbia. Report of the International Whaling Commission. 32(65): 655-666.

Bigg, M. A., P. F. Olesiuk, G. M. Ellis, J. K. B. Ford, and K. C. Balcomb. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Report of the International Whaling Commission. 12: 383-405.

Bishop, S., and A. Morgan. 1996. Critical habitat issues by basin for natural Chinook salmon stocks in the coastal and Puget Sound areas of Washington State. Susan Bishop and Amy Morgan, eds. Northwest Indian Fisheries Commission, Olympia, Washington.

Blain, B. 2014. The effects of barotrauma and deepwater-release mechanisms on the reproductive viability of yelloweye rockfish in Prince William Sound, Alaska (Doctoral dissertation). 92p.

Bobko, S. J., and S. A. Berkeley. 2004. Maturity, ovarian cycle, fecundity, and age-specific parturition of black rockfish (*Sebastes melanops*). Fishery Bulletin. 102(3): 418-429.

Boehlert, G. W., W. H. Barss, and P. B. Lamberson. 1982. Fecundity of the widow rockfish, Sebastes entomelas, off the coast of Oregon. Fishery bulletin United States, National Marine Fisheries Service.

Bonar, S. A., B. D. Bolding, and M. Divins. 2000. Standard fish sampling guidelines for Washington ponds and lakes. Washington Department of Fish and Wildlife. Olympia, WA.

Bonefeld-Jørgensen, E. C., H. R. Andersen, T. H. Rasmussen, and A. M. Vinggaard. 2001. Effect of highly bioaccumulated polychlorinated biphenyl congeners on estrogen and androgen receptor activity. Toxicology. 158: 141–153.

Booth, D. B., D. Hartley, and R. Jackson. 2002. Forest cover, impervious-surface area, and the mitigation of stormwater impacts. Journal of the American Water Resources Association. 38(3): 835-947.

Bowhay, C., and R. Warren. 2016. Director, Fishery Program, Northwest Indian Fisheries Commission and Assistant Director, Fish Program, Washington Department of Fish and Wildlife. June 1, 2016. Letter to Dr. James Unsworth (Director, Washington Department of Fish and Wildlife) and Mike Grayum (Director, Northwest Indian Fisheries Commission) regarding the 2016-2017 List of Agreed Fisheries (LOAF) for salmon fisheries in the ocean north of Cape Falcon, Oregon and in Puget Sound. On file with NMFS West Coast Region, Sand Point office.

Bradford, A. L., D. W. Weller, A. E. Punt, Y. V. Ivashchenko, A. M. Burdin, G. R. Vanblaricom, and R. L. B. Jr. 2012. Leaner leviathans: body condition variation in a critically endangered whale population. Journal of Mammalogy. 93(1): 251-266.

Branstetter, B. K., J. S. Leger, D. Acton, J. Stewart, D. Houser, J. J. Finneran, and K. Jenkins. 2017. Killer Whale (*Orcinus orca*) Behavioral Audiograms. J. Acoust. Soc. Am. 141 (4):

2387-2398.

Burns, R. 1985. The Shape and Form of Puget Sound: Seattle, Washington, University of Washington Press, Washington Sea Grant.

Busack, C., and K. P. Currens. 1995. Genetic risks and hazards in hatchery operations: Fundamental concepts and issues. AFS Symposium 15: 71-80.

Calambokidis, J., and J. Barlow. 2020a. Update on blue and humpback whale abundances using data through 2018. Report PSRG-2020-15 provided to the Pacific Scientific Review Group. March, 2020.

Calambokidis, J., and J. Barlow. 2020b. Updated Abundance for Blue and Humpback Whales Along the U.S. West Coast Using Data Through 2018. NOAA Technical Memorandum NMFS. September 2020. NOAA-TM-NMFS-SWFSC-634. 20p.

Calambokidis, J., J. Barlow, K. Flynn, E. Dobson, and G. H. Steiger. 2017. Update on abundance, trends, and migrations of humpback whales along the US West Coast. International Whaling Commission Paper SC/A17/NP/13. 18p.

Calambokidis, J., J. A. Fahlbusch, A. R. Szesciorka, B. L. Southall, D. E. Cade, A. S. Friedlaender, and J. A. Goldbogen. 2019. Differential Vulnerability to Ship Strikes Between Day and Night for Blue, Fin, and Humpback Whales Based on Dive and Movement Data From Medium Duration Archival Tags. Frontiers in Marine Science. 6: 543.

Calambokidis, J., E. A. Falcone, T. J. Quinn, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. Mattila, L. RojasBracho, J. M. Straley, B. L. Taylor, J. U. R., D. Weller, B. H. Witteveen, M. Yamaguchi, A. Bendlin, and D. Camacho. 2008. SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final report for Contract AB133F-03-RP-00078. Cascadia Research, Olympia, Washington. 57p.

Calambokidis, J., G. H. Steiger, J. M. Straley, L. M. Herman, S. Cerchio, D. R. Salden, J. U. R., J. K. Jacobsen, O. V. Ziegesar, K. C. Balcomb, C. M. Garbiele, M. E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. L. D. G. P., M. Yamaguchi, F. Sato, S. A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow, and T. J. Q. II. 2001. Movements and population structure of humpback whales in the North Pacific. Marine Mammal Science. 17(4): 769-794.

Canada, F. a. O. 2013. Recovery Strategy for the North Pacific Humpback Whale (*Megaptera novaeangliae*) in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa. x + 67p.

Carr, M. H. 1983. Spatial and temporal patterns of recruitment of young-of-the-year rockfishes (*Sebastes*) into a central California kelp forest (Doctoral dissertation, MA Thesis, California State University, San Francisco).

Carretta, J. V., B. Delean, V. Helker, M. M. Muto, J. Greenman, K. Wilkinson, D. Lawson, J. Viezbicke, and J. Jannot. 2020a. Sources of Human-Related Injury and Mortality for U.S. Pacific West Coast Marine Mammal Stock Assessments, 2014-2018, U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-631. June 2020. 147p.

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell. 2020b. U.S. Pacific Marine Mammal Stock Assessment: 2019. NOAA-TM-NMFS-SWFSC-629. U.S. Department of Commerce. NOAA, NMFS, and SWFSC. 385p.

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. B. Jr. 2018. U.S. Pacific Draft Marine Mammal Stock Assessments: 2018. NOAA Technical Memorandum NMFS. NOAA-TM-NMFS-SWFSC-XXX. Published for public review and comment on September 18, 2018. 102p.

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. B. Jr. 2017a. U.S. Pacific Marine Mammal Stock Assessments: 2016. NOAA Technical Memorandum NMFS. June 2017. NOAA-TM-NMFS-SWFSC-577. 414p.

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. B. Jr. 2019. NOAA Technical Memorandum NMFS. U.S. Pacific Marine Mammal Stock Assessments: 2018. NOAA-TM-NMFS-SWFSC-617. June 2019. 382p.

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and Robert L. Brownell Jr. 2017b. U.S. Pacific Marine Mammal Stock Assessments: 2016. June 2017. U.S. Department of Commerce. NOAA-TM-NMFS-SWFSC-577. 414p.

Carretta, J. V., M. Muto, S. M. Wilkin, J. Greenman, K. M. Wilkinson, M. DeAngelis, J. Viezbicke, D. D. Lawson, J. D. Rusin, and J. E. Jannot. 2015. Sources of human-related injury and mortality for US Pacific west coast marine mammal stock assessments, 2009-2013. August 2015. 110p.

Carretta, J. V., S. M. Wilkin, M. Muto, and K. M. Wilkinson. 2013. Sources of human-related injury and mortality for US Pacific west coast marine mammal stock assessments, 2007-2011. July 2013. 87p.

Chapman, A. 2013. ESA Coordinator, Lummi Natural Resources, Bellingham, Washington. December 30, 2013. Personal communication via email with Susan Bishop, NMFS, regarding projected returns from the South Fork early Chinook captive broodstock program.

Chapman, A. 2016. ESA Coordinator, Lummi Natural Resources, Bellingham, Washington. May 6, 2016. Personal communication via email with Susan Bishop, NMFS, regarding escapement of the South Fork early Chinook captive broodstock program in 2015.

Chasco, B., I. C. Kaplan, A. Thomas, A. Acevedo-Gutiérrez, D. Noren, M. J. Ford, M. B. Hanson, J. Scordino, S. Jeffries, S. Pearson, K. N. Marshall, and E. J. Ward. 2017a. Estimates of Chinook salmon consumption in Washington State inland waters by four marine mammal predators from 1970 to 2015. Canadian Journal of Fisheries and Aquatic Sciences. 74(8): 1173–1194.

Chasco, B. E., I. C. Kaplan, A. C. Thomas, A. Acevedo-Gutiérrez, D. P. Noren, M. J. Ford, M. B. Hanson, J. J. Scordino, S. J. Jeffries, K. N. Marshall, A. O. Shelton, C. Matkin, B. J. Burke, and E. J. Ward. 2017b. Competing tradeoffs between increasing marine mammal predation and fisheries harvest of Chinook salmon. Scientific Reports. 7(1): 1-14.

Clapham, P. 2001. Why do baleen whales migrate? A response to Corkeron and Connor. Marine Mammal Science. 17(2): 432-436.

Clapham, P., S. Leatherwood, I. Szczepaniak, and R. L. Brownell. 1997. Catches of humpback and other whales from shore stations at Moss Landing and Trinidad, California, 1919-1926. Marine Mammal Science. 13(3): 368-394.

Clapham, P. J. 2009. Humpback whale: Megaptera novaeangliae. In Encyclopedia of Marine Mammals (Second Edition) (pages 582-585).

Clark, C. W., W. T. Ellison, B. L. Southall, L. Hatch, S. M. V. Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking of baleen whale communications: potential impacts from anthropogenic sources. Eighteenth Biennial Conference on the Biology of Marine Mammals, Quebec City, Canada. Page 56

Cloutier, R. N. 2011. Direct and Indirect Effects of Marine Protection: Rockfish Conservation Areas as a Case Study (Doctoral dissertation, Science: Biological Sciences Department). 86p.

Clutton-Brock, T. H. 1988. Reproductive Success. Studies of individual variation in contrasting breeding systems. University of Chicago Press; Chicago, Illinois.

Corkeron, P. J., and R. C. Connor. 1999. Why do baleen whales migrate? Marine Mammal Science. 15(4): 1228-1245.

Coulson, T., T. G. Benton, P. Lundberg, S. R. X. Dall, B. E. Kendall, and J.-M. Gaillard. 2006. Estimating individual contributions to population growth: evolutionary fitness in ecological time. Proceedings of the Royal Society of London B: Biological Sciences. 273(1586): 547-555.

Crawford, B. A. 1979. The Origin and History of the Trout Brood Stocks of the Washington Department of Game. WDG, Olympia, Washington. 86p.

Croll, D. A., C. W. Clark, J. Calambokidis, W. T. Ellison, and B. R. Tershy. 2001. Effect of anthropogenic low-frequency noise on the foraging ecology of Balaenoptera whales. Animal Conservation forum. 4(1): 13-27.

Crozier, L. G., M. M. McClure, T. Beechie, S. J. Bograd, D. A. Boughton, M. Carr, T. D. Cooney, J. B. Dunham, C. M. Greene, M. A. Haltuch, E. L. Hazen, D. M. Holzer, D. D. Huff, R. C. Johnson, C. E. Jordan, I. C. Kaplan, S. T. Lindley, N. J. Mantua, P. B. Moyle, J. M. Myers, M. W. Nelson, B. C. Spence, L. A. Weitkamp, T. H. Williams, and E. Willis-Norton. 2019. Climate vulnerability assessment for Pacific salmon and steelhead in the California Current Large Marine Ecosystem. PLoS One. 14(7): 1-49. https://www.ncbi.nlm.nih.gov/pubmed/31339895.

Cunningham, K. 2020. Letter to Lynne Barre from Kelly Cunningham (WDFW) regarding Actions taken in development of WDFW managed fishery season for 2020-2021 beneficial for Southern Resident killer whales. April 16, 2020.

Cunningham, K. 2021. Letter from Kelly Cunningham (WDFW) to Lynne Barre (NMFS) regarding actions taken in development of WDFW managed fishery season for 2021-2022 beneficial for Southern Resident killer whales. April 21, 2021.

D'Vincent, C. G., R. M. Nilson, and R. E. Hanna. 1985. Vocalization and coordinated feeding behavior of the humpback whale in southeastern. Alaska. Sci. Rep. Whales Res. Inst. 36: 41-47.

Daan, S., C. Deerenberg, and C. Dijkstra. 1996. Increased daily work precipitates natural death in the kestrel. Journal of Animal Ecology. 65(5): 539-544.

Dapp, D., and A. Dufault. 2018. Derek Dapp, Washington Department of Fish and Wildlife, and Aaron Dufault, Washington Department of Fish and Wildlife personal communication via email with Susan Bishop, National Marine Fisheries Service regarding the adjustment factor for the Area 7 marine sport fishery. April 7, 2018.

Darnerud, P. O. 2003. Toxic effects of brominated flame retardants in man and in wildlife. Environment International. 29: 841–853.

Darnerud, P. O. 2008. Brominated flame retardants as possible endocrine disrupters. International Journal of Andrology. 31(2): 152–160.

de Guise, S., M. Levin, E. Gebhard, L. Jasperse, L. B. Hart, C. R. Smith, S. Venn-Watson, F. Townsend, R. Wells, B. Balmer, E. Zolman, T. Rowles, and L. Schwacke. 2017. Changes in immune functions in bottlenose dolphins in the northern Gulf of Mexico associated with the Deepwater Horizon oil spill. Endangered Species Research. 33: 291–303.

de Mitcheson, Y. S. 2016. Mainstreaming fish spawning aggregations into fishery management calls for a precautionary approach. BioScience. 6: 295-306.

de Swart, R. L., P. S. Ross, J. G. Vos, and A. D. M. E. Osterhaus. 1996. Impaired immunity in harbour seals (*Phoca vitulina*) exposed to bioaccumulated environmental contaminants: Review of a long-term feeding study. Environmental Health Perspectives. 104(Suppl 4): 823.

Deagle, B. E., D. J. Tollit, S. N. Jarman, M. A. Hindell, A. W. Trites, and M. J. Gales. 2005. Molecular scatology as a tool to study diet: analysis of prey DNA in scats from captive Steller sea lions. Molecular Ecology. 14(6): 1831–1842.

Department of Fish and Oceans. 2010. Population Assessment Pacific Harbour Seal (*Phoca vitulina richardsi*). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/011. 10p.

DFO. 1999. Fraser River Chinook Salmon. DFO Science Stock Status Report D6-11 (1999). 7p.

DFO. 2011. Pacific region integrated fisheries management plan – groundfish. February 21, 2011 to February 20, 2013. Updated: February 16, 2011, Version 1.0.

DFO. 2018. Pre-season Run Size Forecasts for Fraser River sockeye *(Oncorhynchus Nerka*) and pink salmon (*Oncorhynchus Gorbuscha*) in 2019. Fraser Stock Assessment Technical Memo. February 2018. 55p.

Dierauf, L. A., and F. M. D. Gulland. 2001. CRC Handbook of Marine Mammal Medicine, Second Edition, CRC Press.

Diewert, R. E., D. A. Nagtegaal, and K. Hein. 2005. A comparison of the results of the 1998 Georgia Strait Creel Survey with an Independent Observer Program. Canadian Manuscript of Fisheries and Aquatic Sciences 2716, 1-39.

Dishman, D. 2021. Draft Natural Resource Management Specialist, Protected Resources Division, West Coast Region. Portland, Oregon. February 24, 2021. Personal communication via email, regarding estimated take of listed Puget Sound Chinook salmon and steelhead, and Puget Sound rockfish in scientific research. 3p.

Dorneles, P. R., J. Lailson-Brito, E. R. Secchi, A. C. Dirtu, L. Weijs, L. D. Rosa, M. Bassoi, H. A. Cunha, A. F. Azevedo, and A. Covaci. 2015. Levels and profiles of chlorinated and brominated contaminants in Southern Hemisphere humpback whales, *Megaptera novaeangliae*. Environmental Research. 138: 49-57.

Drake, J. S., E. A. Berntson, J. M. Cope, R. G. Gustafson, E. E. Holmes, P. S. Levin, N. Tolimieri, R. S. Waples, S. M. Sogard, and G. D. Williams. 2010. Status Review of Five Rockfish Species in Puget Sound, Washington Bocaccio (*Sebastes paucispinis*), Canary Rockfish (*S. pinniger*), Yelloweye Rockfish (*S. ruberrimus*), Greenstriped Rockfish (*S. elongatus*), and Redstripe Rockfish (*S. proriger*). December 2010. NOAA Technical Memorandum NMFS-NWFSC-108. 247p.

Drinkwin, J. 2016. Derelict fishing gear program progress and updates March 21, 2016. Northwest Straits Foundation. Powerpoint presentation on file with NMFS Sand Point Office, 7600 Sand Point Way, NE 98115.

Duffield, D. A., D. K. Odell, J. F. McBain, and B. Andrews. 1995. Killer Whale (Orcinus orca) reproduction at Sea World. Zoo Biology. 14(5): 417-430.

Dumbauld, B. R., D. L. Holden, and O. P. Langness. 2008. Do sturgeon limit burrowing shrimp populations in Pacific Northwest Estuaries? Enviromental Biology Fishes. 83(3): 283–296.

Durban, J., H. Fearnbach, and L. Barrett-Lennard. 2016. No Child Left Behind Evidence of a killer whale's miscarriage. Natural History. 124(8): 14-15.

Durban, J., H. Fearnbach, D. Ellifrit, and K. Balcomb. 2009. Size and body condition of Southern Resident Killer Whales. February 2009. Contract report to NMFS, Seattle, Washington. 23p.

Durban, J. W., H. Fearnbach, L. Barrett-Lennard, M. Groskreutz, W. Perryman, K. Balcomb, D. Ellifrit, M. Malleson, J. Cogan, J. Ford, and J. Towers. 2017. Photogrammetry and Body Condition. Availability of Prey for Southern Resident Killer Whales. Technical Workshop Proceedings. November 15-17, 2017.

Dygert, P. 2018. Memo to Robert Turner (NMFS) from Peter Dygert (NMFS). Hatchery Production Initiative for Increasing Prey Abundance of Southern Resident Killer Whales. August 1, 2018. NMFS, Seattle, Washington. 3p.

Eisenhardt, E. 2001. Effect of the San Juan Islands Marine Preserves on demographic patterns of nearshore rockyreef fish. (Doctoral dissertation, University of Washington).

Elfes, C. T., G. R. Vanblaricom, D. Boyd, J. Calambokidis, P. J. Clapham, R. W. Pearce, J. Robbins, J. C. Salinas, J. M. Straley, P. R. Wade, and M. M. Krahn. 2010. Geographic variation of persistent organic pollutant levels in humpback whale (*Megaptera novaeangliae*) feeding areas of the North Pacific and North Atlantic. Environmental Toxicology and Chemistry. 29: 824-834.

Elwha-Dungeness Planning Unit. 2005. Elwha-Dungeness Watershed Plan, Water Resource Inventory Area 18 (WRIA 18) and Sequim Bay in West WRIA 17. May 2005. Published by Clallam County. Volume 1: Chapters 1-3 and 15 Appendices; Volume 2: Appendix 3-E.

Emmons, C. K., M. B. Hanson, and M. O. Lammers. 2019. Monitoring the occurrence of Southern resident killer whales, other marine mammals, and anthropogenic sound in the Pacific Northwest. Prepared for: U.S. Navy, U.S. Pacific Fleet, Pearl Harbor, HI. Prepared by: National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center under MIPR N00070-17-MP-4C419. 25 February 2019. 23p.

Erickson, A. W. 1978. Population studies of killer whales (*Orcinus orca*) in the Pacific Northwest: a radio-marking and tracking study of killer whales. September 1978. U.S. Marine Mammal Commission, Washington, D.C.

Erickson, D. L., J. A. North, J. E. Hightower, J. Weber, and L. Lauck. 2002. Movement and habitat use of green sturgeon *Acipenser medirostris* in the Rogue River, Oregon, USA. Journal of Applied Ichthyology. 18: 565-569.

Ettinger, A. K., C. J. Harvey, J. F. Samhouri, C. Emmons, M. B. Hanson, E. J. Ward, and J. K. Olson. In Review. In review at Biological Conservation. Shifting phenology of an endangered apex predator tracks changes in its favored prey.

Fagan, W. F., and E. E. Holmes. 2006. Quantifying the extinction vortex. Ecology Letters. 9(1): 51-60.

Fearnbach, H., J. W. Durban, D. K. Ellifrit, and K. C. Balcomb. 2011. Size and long-term growth trends of Endangered fish-eating killer whales. Endangered Species Research. 13(3): 173–180.

Fearnbach, H., J. W. Durban, D. K. Ellifrit, and K. C. Balcomb. 2018. Using aerial photogrammetry to detect changes in body condition of endangered southern resident killer whales. Endangered Species Research. 35: 175–180.

Feely, R. A., S. R. Alin, J. Newton, C. L. Sabine, M. Warner, A. Devol, C. Krembs, and C.

Maloy. 2010. The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary. Estuarine, Coastal and Shelf Science. 88(4): 442-449.

Feist, B. E., J. J. Anderson, and R. Miyamoto. 1996. Potential impacts of pile driving on juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon behavior and distribution. Fisheries Research Institute Report No. FRI-UW-9603. 67p.

FEMAT. 1993. Forest Ecosystem Management: An Ecological, Economic, and Social Assessment. Report of the Forest Ecosystem Management Assessment Team. 1993-793-071. U.S. Gov. Printing Office. 1039p.

Ferrara, G. A., T. M. Mongillo, and L. M. Barre. 2017. Reducing Disturbance from Vessels to Southern Resident Killer Whales: Assessing the Effectiveness of the 2011 Federal Regulations in Advancing Recovery Goals. December 2017. NOAA Technical Memorandum NMFS-OPR-58. 82p.

Field, J. C., and S. Ralston. 2005. Spatial variability in rockfish (*Sebastes* spp.) recruitment events in the California Current System. Canadian Journal of Fisheries and Aquatic Sciences. 62: 2199-2210.

Fisher, R., S. M. Sogard, and S. A. Berkeley. 2007. Trade-offs between size and energy reserves reflect alternative strategies for optimizing larval survival potential in rockfish. Marine Ecology Process Series. 344: 257-270.

Fisheries, N. 2018. 2017 West Coast Entanglement Summary. Overview of Entanglement Data. NMFS West Coast Region. May 2018. 8p.

Fisheries, N. 2019. 2019 West Coast Entaglement Summary. NMFS WCR. Spring 2020.

Fleming, A., and J. Jackson. 2011. Global review of humpback whales (*Megaptera novaeangliae*). NOAA-TM-NMFS-SWFSC-474. March 2011. NOAA Technical Memorandum NMFS, U.S. Department of Commerce, NOAA, NMFS, Southwest Fisheries Science Center. 209p.

Fonnum, F., E. Mariussen, and T. Reistad. 2006. Molecular mechanisms involved in the toxic effects of polychlorinated biphenyls (PCBs) and brominated flame retardants (BFRs). Journal of Toxicology and Environmental Health, Part A. 69(1-2): 21-35. https://doi.org/10.1080/15287390500259020.

Ford, J. K. B., and G. M. Ellis. 2006. Selective foraging by fish-eating killer whales *Orcinus orca* in British Columbia. Marine Ecology Progress Series 316: 185–199.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 2000. Killer Whales: The Natural History and

Genealogy of *Orcinus orca* in British Columbia and Washington State. Vancouver, British Columbia, UBC Press, 2nd Edition.

Ford, J. K. B., G. M. Ellis, L. G. Barrett-Lennard, A. B. Morton, R. S. Palm, and K. C. B. III. 1998. Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. Canadian Journal of Zoology. 76(8): 1456-1471.

Ford, J. K. B., G. M. Ellis, and P. F. Olesiuk. 2005. Linking Prey and Population Dynamics: did food limitation cause recent declines of 'resident' killer whales (*Orcinus orca*) in British Columbia? Pages 1-27 in Fisheries and Oceans. Canadian Science Advisory Secretariat.

Ford, J. K. B., G. M. Ellis, P. F. Olesiuk, and K. C. Balcomb. 2009. Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator. Biology Letters. 6(1): 139–142.

Ford, J. K. B., J. F. Pilkington, A. Reira, M. Otsuki, B. Gisborne, R. M. Abernethy, E. H. Stredulinsky, J. R. Towers, and G. M. Ellis. 2017. Habitats of Special Importance to Resident Killer Whales (*Orcinus orca*) off the West Coast of Canada. Fisheries and Oceans Canada, Ecosystems and Oceans Science. 66p.

Ford, J. K. B., and R. R. Reeves. 2008. Fight or flight: antipredator strategies of baleen whales. Mammal Review. 38(1): 50-86.

Ford, J. K. B., B. M. Wright, G. M. Ellis, and J. R. Candy. 2010. Chinook salmon predation by resident killer whales: seasonal and regional selectivity, stock identity of prey, and consumption rates. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/101. iv + 43 p.

Ford, M. J. 2002. Selection in captivity during supportive breeding may reduce fitness in the wild. Conservation Biology. 16(3): 815-825.

Ford, M. J., T. Cooney, P. McElhany, N. J. Sands, L. A. Weitkamp, J. J. Hard, M. M. McClure, R. G. Kope, J. M. Myers, A. Albaugh, K. Barnas, D. Teel, and J. Cowen. 2011a. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. November 2011. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-113. 307p.

Ford, M. J., M. B. Hanson, J. A. Hempelmann, K. L. Ayres, C. K. Emmons, G. S. Schorr, R. W. Baird, K. C. Balcomb, S. K. Wasser, K. M. Parsons, and K. Balcomb-Bartok. 2011b. Inferred paternity and male reproductive success in a killer whale (*Orcinus orca*) population. Journal of Heredity. 102(5): 537–553.

Ford, M. J., J. Hempelmann, B. Hanson, K. L. Ayres, R. W. Baird, C. K. Emmons, J. I. Lundin, G. S. Schorr, S. K. Wasser, and L. K. Park. 2016. Estimation of a killer whale (*Orcinus* *orca*) population's diet using sequencing analysis of DNA from feces. PLoS ONE. 11(1): 1-14.

Ford, M. J., K. M. Parsons, E. J. Ward, J. A. Hempelmann, C. K. Emmons, M. B. Hanson, K. C. Balcomb, and L. K. Park. 2018. Inbreeding in an endangered killer whale population. Animal Conservation. 1-10.

Foster, E. A., D. W. Franks, L. J. Morrell, K. C. Balcomb, K. M. Parsons, A. v. Ginneken, and D. P. Croft. 2012. Social network correlates of food availability in an endangered population of killer whales, Orcinus orca. Animal Behaviour. 83: 731-736.

Francis, C. D., and J. R. Barber. 2013. A framework for understanding noise impacts on wildlife: an urgent conservation priority. Frontiers in Ecology and the Environment. 11(6): 305–313.

Frankel, A. S., and C. W. Clark. 2000. Behavioral responses of humpback whales *(Megaptera novaeangliae*) to full-scale ATOC signals. The Journal of the Acoustical Society of America. 108(4): 1930-1937.

Fraser, M. D., L. H. McWhinnie, R. R. Canessa, and C. T. Darimont. 2020. Compliance of small vessels to minimum distance regulations for humpback and killer whales in the Salish Sea. Marine Policy. 121: 104171.

Frayne, A. 2021. 2020 Soundwatch Program Annual Contract Report: Soundwatch Public Outreach/Boater Education Project. Contract Number: 1305M138DNFFP0011 Tasks C.2.2.2a & C.6.2.

Fresh, K. L. 1997. The Role of Competition and Predation in the Decline of Pacific Salmon and Steelhead. In Pacific Salmon and their Ecosystems, Status and Future Options, pages 245-275. D.J. Stouder, D.A. Bisson, and R.J. Naiman, editors, Chapman and Hall, New York.

Friedlaender, A. S., E. L. Hazen, D. P. Nowacek, P. N. Halpin, C. Ware, M. T. Weinrich, T. Hurst, and D. Wiley. 2009. Diel changes in humpback whale Megaptera novaeangliae feeding behavior in response to sand lance Ammodytes spp. behavior and distribution. Marine Ecology Progress Series. 395: 91-100.

Fuss, H. J., and C. Ashbrook. 1995. Hatchery Operation Plans and Performance Summaries, Annual Report. Volume I, Number 2, Puget Sound. Assessment and Development Division. Hatcheries Program. November 1995. WDFW, Olympia, Washington. 567p.

Gamel, C. M., R. W. Davis, J. H. M. David, M. A. Meyer, and E. Brandon. 2005. Reproductive energetics and female attendance patterns of Cape fur seals (*Arctocephalus pusillus pusillus*) during early lactation. The American Midland Naturalist. 153(1): 152-170.

Garcia, T. 1998. Letter from Terry Garcia, Assistant Secretary for Oceans and Atmosphere, to Ted Strong, Executive Director, Columbia Inter-Tribal Fish Commission, July 21, 1998.

Geraci, J. R., D. M. Anderson, R. J. Timperi, D. J. S. Aubin, G. A. Early, J. H. Prescott, and C. A. Mayo. 1989. Humpback whales (*Megaptera novaeangliae*) fatally poisoned by dinoflagellate toxin. Canadian Journal of Fisheries and Aquatic Sciences. 46(11): 1895-1898.

Geraci, J. R., and D. J. S. Aubin. 1990. Sea Mammals and Oil: Confronting the Risks.

Gibson, C. 2013. Preventing the Loss of Gillnets in Puget Sound Salmon Fisheries. August 2013. Northwest Straits Marine Conservation Foundation. 15p.

Gilpin, M. E., and S. Michael. 1986. Minimum Viable Populations: Processes of Species Extinction. Conservation biology: The science of scarcity and diversity Sunderland, Massachusetts. Pages 19-34.

Good, T. P., J. A. June, M. A. Etnier, and G. Broadhurst. 2010. Derelict fishing nets in Puget Sound and the Northwest Straits: Patterns and threats to marine fauna. Marine Pollution Bulletin. 60(1): 39–50.

Gordon, J., and A. Moscrop. 1996. Underwater noise pollution and its significance for whales and dolphins. Pages 281-319 *in* M.P. Simmonds and J.D. Hutchinson, editors. The conservation of whales and dolphins: science and practice. John Wiley and Sons, Chichester, United Kingdom.

Gray, C., and M. Downen. 2021. Skokomish Indian Tribe and WDFW. Email exchange with NOAA Fisheries, Hood Canal Terminal Run Reconstruction 1998-2020 xls. May 7, 2021.

Grayum, M., and P. Anderson. 2014. Directors, Northwest Indian Fisheries Commission and Washington Department of Fish and Wildlife. July 21, 2014. Letter to Bob Turner (Regional Assistant Administrator, NMFS West Coast Region, Sustainable Fisheries Division) describing harvest management objectives for Puget Sound Chinook for the 2014-2015 season. On file with NMFS West Coast Region, Sand Point office.

Grayum, M., and J. Unsworth. 2015. Directors, Northwest Indian Fisheries Commission and Washington Department of Fish and Wildlife. April 28, 2015. Letter to Bob Turner (Regional Assistant Administrator, NMFS West Coast Region, Sustainable Fisheries Division) describing harvest management objectives for Puget Sound Chinook for the 2015-2016 season. On file with NMFS West Coast Region, Sand Point office.

Greene, C., L. Kuehne, C. Rice, K. Fresh, and D. Penttila. 2015. Forty Years of Change in

Forage Fish and Jellyfish Abundance across Greater Puget Sound, Washington (USA): Anthropogenic and Climate Associations. Marine Ecology Press Series 525 (April). 153-170. https://doi.org/10.3354/meps11251.

Groskreutz, M. J., J. W. Durban, H. Fearnbach, L. G. Barrett-Lennard, J. R. Towers, and J. K. Ford. 2019. Decadal changes in adult size of salmon-eating killer whales in the eastern North Pacific. Endangered Species Research, 40, 183-188.

Guenther, T. J., R. W. Baird, R. L. Bates, P. M. Willis, R. L. Hahn, and S. G. Wischniowski. 1995. Strandings and fishing gear entanglements of cetaceans off the west coast of Canada in 1994. International Whaling Commission Document SC/47 O, 6.

Gustafson, R. G., M. J. Ford, D. Teel, and J. S. Drake. 2010. Status review of Eulachon (*Thaleichthys pacificus*) in Washington, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-105. March 2010. 377p.

Gustafson, R. G., L. Weitkamp, Y.-W. Lee, E. Ward, K. Somers, V. Tuttle, and J. Jannot. 2016. Status Review update of Eulachon (*Thaleichthys pacificus*) listed under the Endangered Species Act: Southern Distinct Population Segment. March 25, 2016. NMFS, Seattle, Washington. 121p.

Haggarty, D. 2013. Rockfish conservation areas in B.C.: Our current state of knowledge. Prepared for the David Suzuki Foundation and Gordon and Betty Moore Foundation. August 12, 2013. 84p.

Halderson, L., and L. J. Richards. 1987. Habitat use and young of the year copper rockfish in British Columbia. In Proc. *In*, Rockfish Symp. Anchorage, Alaska. Proc. R. Soc. B. 129: 87-2.

Hamilton, M. 2008. Evaluation of Management Systems for KS^n Fisheries and Potential Application to British Columbia's Inshore Rockfish Fishery. Summer 2008. (Doctoral dissertation, School of Resource and Environmental Management-Simon Fraser University). 76p.

Hamilton, T. J., A. Holcombe, and M. Tresguerres. 2014. CO2-induced ocean acidification increases anxiety in Rockfish via alteration of $GABA^A$ receptor functioning. Proceedings of the Royal Society B. 281(1775): 20132509.

Hannah, R. W., and K. M. Matteson. 2007. Behavior of nine species of Pacific rockfish after hook-and-line capture, recompression, and release Transactions of the American Fisheries Society. 136(24-33).

Hannah, R. W., P. S. Rankin, and M. T. O. Blume. 2014. The divergent effect of capture depth and associated barotrauma on post-recompression survival of canary (*Sebastes pinniger*) and yelloweye rockfish (*S. ruberrimus*). Fisheries Research. 157: 106-112.

Hanson, M. B., R. W. Baird, J. K. B. Ford, J. Hempelmann-Halos, D. M. V. Doornik, J. R. Candy, C. K. Emmons, G. S. Schorr, B. Gisborne, K. L. Ayres, S. K. Wasser, K. C. Balcomb, K. Balcomb-Bartok, J. G. Sneva, and M. J. Ford. 2010. Species and stock identification of prey consumed by endangered Southern Resident Killer Whales in their summer range. Endangered Species Research. 11 (1): 69-82.

Hanson, M. B., and C. K. Emmons. 2010. Annual Residency Patterns of Southern Resident Killer Whales in the Inland Waters of Washington and British Columbia. Revised Draft - 30 October 10. 11p.

Hanson, M. B., C. K. Emmons, M. J. Ford, M. Everett, K. Parsons, L. K. Park, J. Hempelmann, D. M. V. Doornik, G. S. Schorr, J. K. Jacobsen, M. F. Sears, M. S. Sears, J. G. Sneva, R. W. Baird, and L. Barre. 2021. Endangered predators and endangered prey: Seasonal diet of Southern Resident killer whales. PLoS ONE. 16(3): e0247031.

Hanson, M. B., C. K. Emmons, E. J. Ward, J. A. Nystuen, and M. O. Lammers. 2013. Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. The Journal of the Acoustical Society of America. 134(5): 3486–3495.

Hanson, M. B., E. J. Ward, C. K. Emmons, and M. M. Holt. 2018. Modeling the occurrence of endangered killer whales near a U.S. Navy Training Range in Washington State using satellite-tag locations to improve acoustic detection data. Prepared for: U.S. Navy, U.S. Pacific Fleet, Pearl Harbor, HI. Prepared by: National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center under MIPR N00070-17-MP-4C419. 8 January 2018. 41p.

Hanson, M. B., E. J. Ward, C. K. Emmons, M. M. Holt, and D. M. Holzer. 2017. Assessing the movements and occurrence of Southern Resident Killer Whales relative to the U.S. Navy's Northwest Training Range Complex in the Pacific Northwest. Prepared for: U.S. Navy, U.S. Pacific Fleet, Pearl Harbor, HI. Prepared by: National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center under MIPR N00070-15-MP-4C363. 30 June 2017. 23p.

Hard, J. J., J. M. Myers, E. J. Connor, R. A. Hayman, R. G. Kope, G. Lucchetti, A. R. Marshall, G. R. Pess, and B. E. Thompson. 2015. Viability Criteria for Steelhead within the Puget Sound Distinct Population Segment. May 2015. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-129. 367p.

Hard, J. J., J. M. Myers, M. J. Ford, R. G. Kope, G. R. Pess, R. S. Waples, G. A. Winans, B. A. Berejikian, F. W. Waknitz, P. B. Adams, P. A. Bisson, D. E. Campton, and R. R. Reisenbichler. 2007. Status review of Puget Sound steelhead (*Oncorhynchus mykiss*). June 2007. NOAA Technical Memorandum NMFS-NWFSC-81. 137p.

Harvey, C. J. 2005. Effects of El Nino events on energy demand and egg production of rockfish (Scorpaenidae: *Sebastes*): a bioenergetics approach. Fishery Bulletin. 103(1): 71-83.

Hatchery Scientific Review Group. 2002. Hatchery Reform Recommendations for the Puget Sound and Coastal Washington Hatchery Reform Project. Long Live the Kings, Seattle, Washington. (available from .

Hauser, D. D. W., M. G. Logsdon, E. E. Holmes, G. R. VanBlaricom, and R. W. Osborne. 2007. Summer distribution patterns of Southern Resident Killer Whales *Orcinus orca*: core areas and spatial segregation of social groups. Marine Ecology Process Series. 351: 301-310.

Hay, D. E., and P. B. McCarter. 2000. Status of the eulachon *Thaleichthys pacificus* in Canada. DFO Canadian Stock Assessment Secretariat, Research Document 2000-145. Fisheries and Oceans Canada, Nanaimo, B.C. 92p.

Hayden-Spear, J. 2006. Nearshore habitat associations of young-of-year copper (*Sebastes caurinus*) and quillback *(S. maliger*) rockfish in the San Juan Channel, Washington (Doctoral dissertation, University of Washington). 38p.

HCCC. 2005. Hood Canal and Eastern Strait of Juan de Fuca Summer Chum Salmon Recovery Plan. Hood Canal Coordinating Council.

Hilborn, R., S. P. Cox, F. M. D. Gulland, D. G. Hankin, N. T. Hobbs, D. E. Schindler, and A. W. Trites. 2012. The Effects of Salmon Fisheries on Southern Resident Killer Whales: Final Report of the Independent Science Panel. November 30, 2012. Prepared with the assistance of D.R. Marmorek and A.W. Hall, ESSA Technologies Ltd., Vancouver, B.C. for NMFS, Seattle, Washington and Fisheries and Oceans Canada (Vancouver. BC). 87p.

Hilborn, R., T. P. Quinn, D. E. Schindler, and D. E. Rogers. 2003. Biocomplexity and fisheries sustainability. Proceedings of the National Academy of Sciences. 100(11): 6564–6568.

Hildebrand, J. A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series. 395: 5-20.

Hochachka, W. M. 2006. Unequal lifetime reproductive success and its implications for small, isolated populations.

Holt, M. M. 2008. Sound Exposure and Southern Resident Killer Whales (*Orcinus orca*): A Review of Current Knowledge and Data Gaps. February 2008. NOAA Technical Memorandum NMFS-NWFSC-89, U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-89. 77p.

Holt, M. M., M. B. Hanson, D. A. Giles, C. K. Emmons, and J. T. Hogan. 2017. Noise levels received by endangered killer whales *Orcinus orca* before and after implementation of vessel regulations. Endangered Species Research. 34: 15-26.

Holt, M. M., D. P. Noren, R. C. Dunkin, and T. M. Williams. 2015. Vocal performance affects metabolic rate in dolphins: implications for animals communicating in noisy environments. Journal of Experimental Biology. 218: 1647–1654.

Holt, M. M., D. P. Noren, V. Veirs, C. K. Emmons, and S. Veirs. 2009. Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. he Journal of the Acoustical Society of America. 125(1): EL27-EL32.

Holt, M. M., J. B. Tennessen, E. J. Ward, M. B. Hanson, C. K. Emmons, D. A. Giles, and J. T. Hogan. 2021. Effects of vessel distance and sex on the behavior of endangered killer whales. Frontiers in Marine Science. 7: 1211.

Houghton, J. 2014. The relationship between vessel traffic and noise levels received by killer whales and an evaluation of compliance with vessel regulations. Master's Thesis. University of Washington, Seattle. 103p.

Houghton, J., M. M. Holt, D. A. Giles, M. B. Hanson, C. K. Emmons, J. T. Hogan, T. A. Branch, and G. R. VanBlaricom. 2015. The relationship between vessel traffic and noise levels received by Killer Whales (*Orcinus orca*). PLoS ONE. 10(12): 1-20.

Hoyt, E. 2001. Whale watching 2001: Worldwide Tourism Numbers, Expenditures, and Expanding Socioeconomic Benefits. International Fund for Animal Welfare, Yarmouth Port, Massachusetts. 165p.

HSRG. 2000. Scientific framework for artificial propagation of salmon and steelhead. Puget Sound and Coastal Washington hatchery reform project. Long Live the Kings. Seattle, Washington. 65p.

HSRG. 2009. Columbia River Hatchery Reform System-Wide Report. February 2009. Prepared by Hatchery Scientific Review Group. 278p.

HSRG. 2014. On the Science of Hatcheries: An updated perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest. June 2014, (updated October 2014). 160p.

Hunter, M. A. 1992. Hydropower flow fluctuations and salmonids: A review of the biological effects, mechanical causes, and options for mitigation. Washington Department of Fisheries. Technical Report No. 119. Olympia, Washington. 58p.

ISAB. 2007. Climate Change Impacts on Columbia River Basin Fish and Wildlife. May 11,

2007. Report ISAB 2007-2. Northwest Power and Conservation Council, Portland, Oregon. 146p

Ivashchenko, Y. V., A. N. Zerbini, and P. J. Clapham. 2016. Assessing the status and pre-exploitation abundance of North Pacific humpback whales. International Whaling Commission Paper SC/66a/IA/16.

Jacobsen, J. K. 1986. The behavior of *Orcinus orca* in the Johnstone Strait, British Columbia. Behavioral Biology of Killer Whale, 135-186.

James, C. 2015. Letter to Dan Tonnes, NMFS Protected Resources Division, describing derelict fishing nets in the Puget Sound area. April 23, 2015.

James, C. 2016. Chris James, Conservation Planning Biologist, Northwest Indian Fisheries Commission, Olympia, Washington. May 5, 2016. Personal communication via email with Susan Bishop, NMFS, regarding responses to questions concerning the 2016 Puget Sound Tribal Chinook Harvest Management Plan.

James, C. 2017. 2016 reported loss of salmon fishing gear. Electronic letter from Chris James (Northwest Indian Fisheries Commission) to Dan Tonnes (National Marine Fisheries Service). Sent May 10, 2017.

James, C. 2018a. 2017 reported loss of salmon fishing gear. Electronic letter from Chris James (Northwest Indian Fisheries Commission) to Dan Tonnes (National Marine Fisheries Service). Sent June 19, 2018.

James, C. 2018b. Chinook Salmon Harvest Performance Report for Skokomish and Puyallup River Chinook Salmon: 2011-2014 Fishing Years. Received via email from Chris James, Conservation Planning Biologist, Northwest Indian Fisheries Commission. January 26, 2018. 57 p.

James, C. 2018cJames, C.; Chris James, Conservation Planning Biologist, Northwest Indian Fisheries Commission. April 18, 2018. Personal communication via phone with Molly Gorman, NMFS contractor, regarding steelhead assessment for marks in treaty fisheries.

James, C. 2018d. Chris James, Conservation Planning Biologist, Northwest Indian Fisheries Commission. April 23, 2018. Personal communication via phone with Susan Bishop, NMFS, regarding projected steelhead harvest for coming fishing season.

James, C. 2019. 2018 reported loss of salmon fishing gear. Electronic letter from Chris James (Northwest Indian Fisheries Commission) to Dan Tonnes (National Marine Fisheries Service). Sent July 19, 2019.

James, C. 2020. 2019 reported loss of salmon fishing gear. Electronic letter from Chris James

(Northwest Indian Fisheries Commission) to Dan Tonnes (National Marine Fisheries Service). Sent August 17, 2020. 2p.

Jarvela-Rosenberger, A. L., M. MacDuffee, A. G. J. Rosenberger, and P. S. Ross. 2017. Oil spills and marine mammals in British Columbia, Canada: Development and application of a risk-based conceptual framework. Archives of Environmental Contamination and Toxicology. 73(1): 131–153.

Jarvela Rosenberger, A. L., M. MacDuffee, A. G. J. Rosenberger, and P. S. Ross. 2017. Oil spills and marine mammals in British Columbia, Canada: development and application of a risk-based conceptual framework. Archives of Environmental Contamination and Toxicology. 73(1): 131–153.

Jarvis, E. T., and C. G. Lowe. 2008. The effects of barotrauma on the catch-andrelease survival of southern California nearshore and shelf rockfish (Scorpaenidae, *Sebastes* spp.). Canadian Journal of Fisheries and Aquatic Sciences. 65: 1286–1296.

Jefferson, T. A., P. J. Stacey, and R. W. Baird. 1991. A review of killer whale interactions with other marine mammals: predation to co-existence. Mammal review. 21(4): 151-180.

Jeffries, C. 2011. Trends in other Chinook salmon predators. Presentation to Southern Resident Killer Whale Workshop. September 22, 2011. Power Point presentation.

Jeffries, S., H. Huber, J. Calambokidis, and J. Laake. 2003. Trends and Status of Harbor Seals in Washington State: 1978-1999. Journal of Wildlife Management. 67(1): 208-219.

Joblon, M. J., M. A. Pokras, B. Morse, C. T. Harry, K. S. Rose, S. M. Sharp, M. E. Niemeyer, K. M. Patchett, W. B. Sharp, and M. J. Moore. 2014. Body condition scoring system for delphinids based on short-beaked common dolphins (Delphinus delphis). Journal of Marine Animals and Their Ecology. 7(2): 5-13.

Jones, R. 2015. 2015 5-Year Review - Listing Status under the Endangered Species Act for Hatchery Programs Associated with 28 Salmon Evolutionarily Significant Units and Steelhead Distinct Population Segments. Memorandum from Rob Jones, SFD NMFS WCR, to Chris Yates, PRD NMFS WCR. September 28, 2015. 54 p.

Joy, R., D. Tollit, J. Wood, A. MacGillivray, Z. Li, K. Trounce, and O. Robinson4. 2019. Potential benefits of vessel slowdowns on endangered southern resident killer whales. Frontiers in Marine Science. 6: 344.

Kellar, N. M., T. R. Speakman, C. R. Smith, S. M. Lane, B. C. Balmer, M. L. Trego, K. N. Catelani, M. N. Robbins, C. D. Allen, R. S. Wells, E. S. Zolman, T. K. Rowles, and L. H. Schwacke. 2017. Low reproductive success rates of common bottlenose dolphins *Tursiops truncatus* in the northern Gulf of Mexico following the Deepwater Horizon disaster (2010-2015). Endangered Species Research. 33: 143-158.

Kondolf, G. M. 1997. Hungry water: Effects of dams and gravel mining on river channels. Environmental Management. 21(4): 533-551.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein, and R. S. Waples. 2004a. 2004 Status Review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. December 2004. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-62. NMFS, Seattle, Washington. 95p.

Krahn, M. M., M. B. Hanson, R. W. Baird, R. H. Boyer, D. G. Burrows, C. K. Emmons, J. K. B. Ford, L. L. Jones, D. P. Noren, P. S. Ross, G. S. Schorr, and T. K. Collier. 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident Killer Whales. Marine Pollution Bulletin. 54(12): 1903-1911.

Krahn, M. M., M. B. Hanson, G. Schorr, C. K. Emmons, D. G. Burrows, J. L. Bolton, R. W. Baird, and G. M. Ylitalo. 2009. Effects of age, sex and reproductive status on persistent organic pollutant concentrations in ‘‘Southern Resident” killer whales. Marine Pollution Bulletin. 58(10): 1522–1529.

Krahn, M. M., D. P. Herman, G. M. Ylitalo, C. A. Sloan, D. G. Burrows, R. C. Hobbs, B. A. Mahoney, G. K. Yanagida, J. Calambokidis, and S. E. Moore. 2004b. Stratification of lipids, fatty acids and organochlorine contaminants in blubber of white whales and killer whales. Journal of Cetacean Research and Management. 6(2): 175-189.

Krahn, M. M., P. R. Wade, S. T. Kalinowski, M. E. Dahlheim, B. L. Taylor, M. B. Hanson, G. M. Ylitalo, R. P. Angliss, J. E. Stein, and R. S. Waples. 2002. Status Review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. December 2002. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-54. 159p.

Kuehne, L. M., C. Erbe, E. Ashe, L. T. Bogaard, M. S. Collins, and R. Williams. 2020. Above and below: Military Aircraft Noise in Air and under Water at Whidbey Island, Washington. Journal of Marine Science and Engineering, 8(11), 923.

Lachmuth, C. L., L. G. Barrett-Lennard, D. Q. Steyn, and W. K. Milsom. 2011. Estimation of Southern Resident Killer Whale exposure to exhaust emissions from whale-watching vessels and potential adverse health effects and toxicity thresholds. Marine Pollution Bulletin. 62: 792–805.

Lacy, R. C., R. Williams, E. Ashe, Kenneth C. Balcomb III, L. J. N. Brent, C. W. Clark, D. P. Croft, D. A. Giles, M. MacDuffee, and P. C. Paquet. 2017. Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. Scientific Reports. 7(1): 1-12.

Lambertsen, R. H. 1992. Crassicaudosis: a parasitic disease threatening the health and population recovery of large baleen whales. Revue Scientifique Et Technique-office International Des Epizooties. 11(4): 1131-1141.

Landahl, J. T., L. L. Johnson, J. E. Stein, T. K. Collier, and U. U. Varanasi. 1997. Approaches for determining effects of pollution on fish populations of Puget Sound. Transactions of the American Fisheries Society. 126: 519-535.

Lawson, T. M., G. M. Ylitalo, S. M. O'Neill, M. E. Dahlheim, P. R. Wade, C. O. Matkin, V. Burkanov, and D. T. Boyd. 2020. Concentrations and profiles of organochlorine contaminants in North Pacific resident and transient killer whale (*Orcinus orca*) populations. Science of The Total Environment. 722: 137776. https://doi.org/10.1016/j.scitotenv.2020.137776.

Learmonth, J. A., C. D. MacLeod, M. B. Santos, G. J. Pierce, H. Q. P. Crick, and R. A. Robinson. 2006. Potential effects of climate change on marine mammals. Oceanography and Marine Biology. 44: 431-464.

Lebon, K. M., and R. P. Kelly. 2019. Evaluating alternatives to reduce whale entanglements in commercial Dungeness Crab fishing gear. Global Ecology and Conservation. 18: e00608.

Lefebvre, K. A., L. Quakenbush, E. Frame, K. B. Huntington, G. Sheffield, R. Stimmelmayr, A. Bryan, P. Kendrick, H. Ziel, T. Goldstein, J. A. Snyder, T. Gelatt, F. Gulland, B. Dickerson, and V. Gill. 2016. Prevalence of algal toxins in Alaskan marine mammals foraging in a changing arctic and subarctic environment. Harmful Algae. 55: 13-24. http://www.sciencedirect.com/science/article/pii/S1568988315301244.

Legler, J. 2008. New insights into the endocrine disrupting effects of brominated flame retardants. Chemosphere. 73(2): 216-222.

Legler, J., and A. Brouwer. 2003. Are brominated flame retardants endocrine disruptors? Environment International. 29(6): 879– 885.

Leland, R. 2010Leland, R.; Fish and Wildlife Biologist, WDFW. April 1, 2010. Personal communication with Amilee Wilson, NMFS NWR Salmon Management Division, regarding steelhead encounters in Puget Sound recreational salmon fisheries. WDFW, Olympia, Washington.

Levin, P. S., and J. G. Williams. 2002. Interspecific effects of artifically propagated fish: An additional conservation risk for salmon. Conservation Biology. 16(6): 1581-1587.

LLTK. 2015. Why focus on Salish Sea? Salish Sea Marine Survival Project. Long Live The Kings and Pacific Salmon Fund: https://marinesurvivalproject.com/the-project/why/.

LN. 2015. Skookum Creek hatchery South Fork Chinook HGMP. November 25, 2015. Lummi Nation, Bellingham, Washington. 68p.

Long, D. J., and R. E. Jones. 1996. White shark predation and scavenging on cetaceans in the eastern North Pacific Ocean. Great white sharks: the biology of *Carcharodon carcharias*, pp 293-307.

Loomis, L. 2021. Letter from Lorraine Loomis (NWIFC) to Lynne Barre (NMFS) regarding Tribal Salmon Fisheries Interactions with Southern Resident Killer Whales. April 21, 2021.

Love, M. S., M. H. Carr, and L. J. Haldorson. 1991. The ecology of substrate-associated juveniles of the genus *Sebastes*. Environmental Biology of Fishes. 30(1-2): 225-243.

Love, M. S., M. M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley, California.

Lundin, J. I., R. L. Dills, G. M. Ylitalo, M. B. Hanson, C. K. Emmons, G. S. Schorr, J. Ahmad, J. A. Hempelmann, K. M. Parsons, and S. K. Wasser. 2016a. Persistent organic pollutant determination in killer whale scat samples: Optimization of a gas chromatography/mass spectrometry method and application to field samples. Archives of Environmental Contamination and Toxicology. 70(1): 9-19.

Lundin, J. I., G. M. Ylitalo, R. K. Booth, B. Anulacion, J. A. Hempelmann, K. M. Parsons, D. A. Giles, E. A. Seely, M. B. Hanson, C. K. Emmons, and S. K. Wasser. 2016b. Modulation in persistent organic pollutant concentration and profile by prey availability and reproductive status in Southern Resident Killer Whale scat samples. Environmental Science & Technology. 50: 6506−6516.

Lundin, J. I., G. M. Ylitalo, D. A. Giles, E. A. Seely, B. F. Anulacion, D. T. Boyd, J. A. Hempelmann, K. M. Parsons, R. K. Booth, and S. K. Wasser. 2018. Pre-oil spill baseline profiling for contaminants in Southern Resident killer whale fecal samples indicates possible exposure to vessel exhaust. Marine Pollution Bulletin. 136: 448-453.

Lusseau, D., D. E. Bain, R. Williams, and J. C. Smith. 2009. Vessel traffic disrupts the foraging behavior of southern resident killer whales *Orcinus orca*. Endangered Species Research. 6(3): 211-221.

Lusseau, D., and L. Bejder. 2007. The long-term consequences of short-term responses to disturbance experience from whalewatching impact assessment. International Journal of Comparative Psychology. 20(2): 228-236.

Macleod, C. D. 2009. Global climate change, range changes and potential implications for the conservation of marine cetaceans: A review and synthesis. Endangered Species Research. 7(2): 125-136.

Maggini, S., A. Pierre, and P. C. Calder. 2018. Immune function and micronutrient requirements change over the life course. Nutrients. 10(10): 1531.

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. Pages 217 to 253 (Chapter 6) *in*: Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate. Climate Impacts Group, University of Washington, Seattle, Washington. 37p.

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. Climate Change. 102: 187-223.

Marshall, A. 1999. Genetic analyses of 1998 Hood Canal area Chinook samples. Memorandum to Distribution List. May 4, 1999. 6 p.

Marshall, A. 2000. Genetic analyses of 1999 Hood Canal area Chinook samples. Memorandum to Distribution List. May 31, 2000. 10 p.

Matkin, C. 1994. An observer's guide to the killer whales of Prince William Sound. Prince William Sound Books, Valdez, Alaska.

Matkin, C. O., E. L. Saulitis, G. M. Ellis, P. Olesiuk, and S. D. Rice. 2008. Ongoing population-level impacts on killer whales *Orcinus orca* following the 'Exxon Valdez' oil spill in Prince William Sound, Alaska. Marine Ecology Progress Series. 356: 269-281.

Matthews, K. R. 1989. A comparative study of habitat use by young-of-the year, subadult, and adult rockfishes on four habitat types in Central Puget Sound. Fishery Bulletin, U.S. 88(2): 223-239.

Mauger, G. S., J. H. Casola, H. A. Morgan, R. L. Strauch, B. Jones, B. Curry, T. M. B. Isaksen, L. W. Binder, M. B. Krosby, and A. K. Snover. 2015. State of Knowledge: Climate Change in Puget Sound. Report prepared for the Puget Sound Partnership and the National Oceanic and Atmospheric Administration. Climate Impacts Group, University of Washington, Seattle. November 2015. 309p.

May, C. L., J. R. Koseff, L. V. Lucas, J. E. Cloern, and D. H. Schoellhamer. 2003. Effects of spatial and temporal variability of turbidity on phytoplankton blooms. Marine Ecology Progress Series. 254: 111-128.

Mazzuca, L., S. Atkinson, and E. Nitta. 1998. Deaths and entanglements of humpback whales, *Megaptera novaeangliae*, in the main Hawaiian Islands, 1972-1996. Pacific Science. 52(1): 1-13.

McCullough, D. A. 1999. A Review and Synthesis of Effects of Alterations to the Water Temperature Regime on Freshwater Life Stages of Salmonids, with Special Reference to Chinook Salmon. EPA 910-R-99-010, July 1999. CRITFC, Portland, Oregon. 291p.

McDonald, M. A., J. A. Hildebrand, and S. M. Wiggins. 2006. Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. The Journal of the Acoustical Society of America. 120(2): 711-718.

McElhany, P., M. H. Rucklelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-42. 174p.

McGilliard, C. R., R. Hilborn, A. MacCall, A. E. Punt, and J. C. Field. 2011. Can information from marine protected areas be used to inform control-rule-based management of small-scale, data-poor stocks? ICES Journal of Marine Science. 68(1): 201-211.

McKenna, M. F., S. M. Wiggins, and J. A. Hildebrand. 2013. Relationship between container ship underwater noise levels and ship design, operational and oceanographic conditions. Scientific Reports. 3: 1-10.

Mehta, A. V., J. M. Allen, R. Constantine, C. Garrigue, B. Jann, C. Jenner, M. K. Marx, C. O. Matkin, D. K. Mattila, G. Minton, S. A. Mizroch, C. Olavarría, J. Robbins, K. G. Russell, R. E. Seton, G. H. Steiger, G. A. Víkingsson, P. R. Wade, B. H. Witteveen, and P. J. Clapham. 2007. Baleen whales are not important as prey for killer whales *Orcinus orca* in high-latitude regions. Marine Ecology Progress Series. 348: 297-307.

Melbourne, B. A., and A. Hastings. 2008. Extinction risk depends strongly on factors contributing to stochasticity. Nature. 454(7200): 100-103.

Mercier, B. 2020. Letter to Barry Thom (Regional Administrator, NMFS West Coast Region) requesting consultation on the 2020-2021 Puget Sound Chinook Harvest Plan. Northwest Regional Director, Bureau of Indian Affairs. April 20, 2020. On file with NMFS West Coast Region, Sand Point office.

Mercier, B. 2021. Letter to Barry Thom (Regional Administrator, NMFS West Coast Region) requesting consultation on the 2021-2022 Puget Sound Chinook Harvest Plan. Northwest Regional Director, Bureau of Indian Affairs. April 26, 2021. On file with NMFS West Coast Region, Sand Point office.

Miller, A. W., A. C. Reynolds, C. Sobrino, and G. F. Riedel. 2009. Shellfish face uncertain future in high CO2 world: Influence of acidification on oyster larvae calcification and growth in estuaries. PLoS ONE. 4(5): e5661.

Miller, B. S., and S. F. Borton. 1980. Geographical distribution of Puget Sound fishes: Maps and data source sheets. University of Washington Fisheries Research Institute, 3 vols. September 1980. 221p.

Miller, H. 2020. Relating the Distribution of Humpback Whales to Environmental Variables and Risk Exposure. Masters Thesis. University of Washington. 2020. 56p.

Mongillo, T. M., G. M. Ylitalo, L. D. Rhodes, S. M. O'Neill, D. P. Noren, and M. B. Hanson. 2016. Exposure to a mixture of toxic chemicals: Implications to the health of endangered Southern Resident killer whales. November 2016. NOAA Technical Memorandum NMFS-NWFSC-135. 118p.

Moore, M., and B. Berejikian. 2019. Steelhead at the Surface: Impacts of the Hood Canal Bridge on Migrating Steelhead Smolts. Presentation. November 2019. NOAA Fisheries Northwest Fisheries Science Center. 35p.

Moore, M., B. Berejikian, F. Goetz, T. Quinn, S. Hodgson, E. Connor, and A. Berger. 2014. Early marine survival of steelhead smolts in Puget Sound. Salish Sea Ecosystem Conference. May 1, 2014; Paper 199: http://cedar.wwu.edu/ssec/2014ssec/Day2/199. Accessed March 5, 2015. 23p.

Moore, M. J., and J. M. v. d. Hoop. 2012. The painful side of trap and fixed net fisheries: chronic entanglement of large whales. Journal of Marine Biology.

Moscrip, A. L., and D. R. Montgomery. 1997. Urbanization, flood frequency, and salmon abundance in Puget lowland streams. Journal of the American Water Resources Association. 33(6): 1289-1297.

Moser, H. G., R. L. Charter, W. Watson, D. A. Ambrose, J. L. Butler, J. Charter, and E. M. Sandknop. 2000. Abundance and distribution of rockfish (Sebastes) larvae in the southern California Bight in relation to environmental conditions and fishery exploitation. California Cooperative Oceanic Fisheries Investigations Report. 41: 132-147.

Moser, M. L., and S. T. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes. 79(3-4): 243–253.

Mote, P. W., and E. P. Salathé. 2009. Future climate in the Pacific Northwest. *In*: Washington Climate Change Impacts Assessment: Evaluating Washington's future in a changing climate. Climate Impacts Group, University of Washington, Seattle, Washington. 23p.

Moulton, L. L., and B. S. Miller. 1987. Characterization of Puget Sound marine fishes: survey of available data. Final Report. Fisheries Research Institute, School of Fisheries, University of Washington. FRI-UW-8716. October 1987. 104p.

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. Fish Species of Special Concern in California. Second edition. California Department of Fish and Game. Department of Wildlife & Fisheries Biology University of California, Davis, CA. June 1995. Final report for Contract No. 2128IF. 277p.

Murray, C. C., L. Hannah, T. Donoil-Valcroze, B. Wright, E. Stredulinsky, A. Locke, and R. Lacy. 2019. Cumulative effects of assessment for Northern and Southern Resident killer whale populations in the Northeast Pacific. Canadian Science Advisory Secretariat (CSAS). Research Document 2019/056.

Murray, C. C., L. C. Hannah, T. Doniol-Valcroze, B. M. Wright, E. H. Stredulinsky, J. C. Nelson, A. Locke, and R. C. Lacy. 2021. A Cumulative Effects Model for Population Trajectories of Resident Killer Whales in the Northeast Pacific. Biological Conservation 257: 109124.

Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2018a. Alaska Marine Mammal Stock Assessments, 2017. NOAA Technical Memorandum NMFS-AFSC-378. June 2018. 381p.

Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2018b. Draft 2018 Alaska marine mammal stock assessments. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX. Published for public review and comment on September 18, 2018. 177p.

Muto, M. M., V. T. Helker, R. P. Angliss, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, K. L. Sweeney, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2019. Alaska marine mammal stock assessments, 2018. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-393. June 2019. 390p.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. February 1998. U.S. Dept. Commer., NOAA Tech Memo., NMFS-NWFSC-35. 476p.

Naish, K. A., Joseph E. Taylor III, P. S. Levin, T. P. Quinn, J. R. Winton, D. Huppert, and R. Hilborn. 2007. An evaluation of the effects of conservation and fishery enhancement hatcheries on wild populations of salmon. Advances in Marine Biology. 53: 61-194.

NAS. 2017a. Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/23479.

NAS. 2017b. Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals. Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/23479.

National Research Council. 2003. Ocean noise and marine mammals. National Academy Press, Washington, D.C.

Neale, J. C. C., F. M. D. Gulland, K. R. Schmelzer, J. T. Harvey, E. A. Berg, S. G. Allen, D. J. Greig, E. K. Grigg, and R. S. Tjeerdema. 2005. Contaminant loads and hematological correlates in the harbor seal (Phoca vitulina) of San Francisco Bay, California. Journal of Toxicology and Environmental Health, Part A. 68: 617–633.

Newton, J., and K. V. Voorhis. 2002. Seasonal Patterns and Controlling Factors of Primary Production in Puget Sound's Central Basin and Possession Sound. Publication No. 02-03-059. December 2002. 38p.

Nichol, D. G., and E. K. Pikitch. 1994. Reproduction of darkblotched rockfish off the Oregon coast. Transactions of the American Fisheries Society. 123(4): 469-481.

Nichol, L. M., B. M. Wright, P. O'Hara, and J. K. B. Ford. 2017. Risk of lethal vessel strikes to humpback and fin whales off the west coast of Vancouver Island, Canada. Endangered Species Research. 32: 373-390.

Nickelson, T. E., M. F. Solazzi, and S. L. Johnson. 1986. Use of hatchery coho salmon (*Oncorhynchus kisutch*) presmolts to rebuild wild populations in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences. 43: 2443-2449.

Nisqually Chinook Work Group. 2011. Draft Nisqually Chinook Stock Management Plan. January 2011. 81p.

Nisqually Chinook Work Group. 2017. Stock Management Plan for Nisqually Fall Chinook Recovery. December 2017. 105 p.

NMFS. 1991. Final Recovery Plan for the Humpback Whale *Megaptera novaeangliae*. November 1991. Prepared by the Humpback Whale Recovery Team for the National

Marine Fisheries Service, Silver Spring, Maryland. 115p.

NMFS. 1999. Endangered Species Act – Section 7 Consultation – Supplemental Biological Opinion and Incidental Take Statement. The Pacific Coast Salmon Plan and Amendment 13 to the Plan. NMFS, Protected Resources Division. April 28, 1999. 53p.

NMFS. 2000a. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. NMFS, Northwest Region, Portland, Oregon.

NMFS. 2000b. RAP - A Risk Assessment Procedure for Evaluating Harvest Mortality of Pacific salmonids. May 30, 2000. NMFS, Seattle, Washington. 34p.

NMFS. 2001a. Determination Memorandum: Summer Chum Salmon Conservation Initiative - An Implementation Plan to Recover Summer Chum in the Hood Canal and Strait of Juan de Fuca - Harvest Management Component. April 27, 2001.

NMFS. 2001b. Endangered Species Act Reinitiated Section 7 Consultation Biological Opinion and Incidental Take Statement Effects of the Pacific Coast Salmon Plan and U.S. Fraser Panel fisheries on Upper Willamette River Chinook, Lower Columbia River Chinook, Lower Columbia River chum. April 30, 2001. Consultation No.: NWR-2001-609. 57p.

NMFS. 2004a. Endangered Species Act (ESA) Section 7 Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat Consultation. Effects of the Pacific Coast Salmon Plan and U.S. Fraser Panel fisheries on the Puget Sound Chinook and Lower Columbia River Chinook Salmon Evolutionarily Significant Units. National Marine Fisheries Service, Northwest Region. 89 p.

NMFS. 2004b. NOAA Fisheries' Approach to Making Determinations Pursuant to the Endangered Species Act about the Effects of Harvest Actions on Listed Pacific Salmon and Steelhead. November 16, 2004. Prepared by the Northwest Region Sustainable Fisheries Division. 85p.

NMFS. 2004c. Puget Sound Chinook Harvest Resource Management Plan Final Environmental Impact Statement. December 2004. National Marine Fisheries Service, Northwest Region, Seattle, Washington. 1537p.

NMFS. 2005a. Appendix A CHART assessment for the Puget Sound salmon evolutionary significant unit from final assessment of NOAA Fisheries' Critical Habitat Analytical Review Teams for 12 ESUs of West Coast salmon and steelhead. August 2005. 55p.

NMFS. 2005b. Evaluation of and Recommended Determination on a Resource Management Plan (RMP), Pursuant to the Salmon and Steelhead 4(d) Rule. Puget Sound Comprehensive Chinook Management Plan: Harvest Management Component. NMFS, Northwest Region, Sustainable Fisheries Division. January 27, 2005. 2004/01962. 100p.

NMFS. 2005c. Final assessment of NOAA Fisheries' Critical Habitat Analytical Review Teams for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead. NMFS NWR Protected Resources Division, Portland, Oregon. 587p.

NMFS. 2005d. A Joint Tribal and State Puget Sound Chinook salmon harvest Resource Management Plan (RMP) submitted under Limit 6 of a section 4(d) Rule of the Endangered Species Act (ESA) - Decision Memorandum. Memo from S. Freese to D. Robert Lohn. NMFS NW Region. March 4, 2005.

NMFS. 2005e. Memorandum to the Record. From Rodney R. McInnis. Subject: Endangered Species Section 7 Consultation on the Effects of Ocean Salmon Fisheries on California Coastal Chinook Salmon: Performance of the Klamath Ocean Harvest Model in 2004 and Implementation of the Reasonable and Prudent Alternative of the April 28, 2000, Biological Opinion. June 13, 2005. 14 p.

NMFS. 2005f. Policy on the consideration of hatchery-origin fish in Endangered Species Act listing determinations for Pacific salmon and steelhead. Federal Register, Volume 70 No. 123(June 28, 2005):37204-37216.

NMFS. 2006a. Endangered Species Act Section 7 Consultation Biological Opinion and Section 10 Statement of Findings and Magnuson-Stevens Fishery Conservation and Managment Act Essential Fish Habitat Consultation. Washington State Forest Practices Habitat Conservation Plan. NMFS Consultation No.: NWR-2005-07225. 335p.

NMFS. 2006b. Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan. November 17, 2006. NMFS, Portland, Oregon. 47p.

NMFS. 2006c. Pacific Coastal Salmon Recovery Fund Performance Goals, Measures and Reporting Framework. December 2006. 51p.

NMFS. 2008a. Endangered Species Act- Section 7 Formal Consultation Biological Opinion. Effects of the 2008 Pacific Coast Salmon Plan Fisheries on the Southern Resident Killer Whale Distinct Population Segment (*Orcinus orca*) and their Critical Habitat. NMFS Northwest Region. May 19, 2008. NMFS Consultation No.: NWR-2008-02612. 60p.

NMFS. 2008b. Endangered Species Act Section 7 Biological Opinion on the Effects of the Pacific Coast Salmon Plan and U.S. Fraser Panel Fisheries on the Lower Columbia River Coho and Lower Columbia River Chinook Evolutionarily Significant Units Listed under the Endangered Species Act and Magnuson-Stevens Act Essential Fish Habitat Consultation. April 28, 2008. NMFS, Portland, Oregon. Consultation No.: NWR-2008-02438. 124p.

NMFS. 2008c. Endangered Species Act Section 7 Consultation Biological Opinion and

Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on EPA's Proposed Approval of Revised Washington Water Quality Standards for Designated Uses, Temperature, Dissolved Oxygen, and Other Revisions. February 5, 2008. NMFS Consultation No.: NWR-2007-02301. 137p.

NMFS. 2008d. Endangered Species Act Section 7 Consultation Final Biological Opinion and Magnuson-Stevens Fishery Conservation and Managment Act Essential Fish Habitat Consultation. Implementation of the National Flood Insurance Program in the State of Washington Phase One Document-Puget Sound Region. NMFS Consultation No.: NWR-2006-00472. 226p.

NMFS. 2008e. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Consultation on the Approval of Revised Regimes under the Pacific Salmon Treaty and the Deferral of Management to Alaska of Certain Fisheries Included in those Regimes. December 22, 2008. NMFS Consultation No.: NWR-2008-07706. 422p.

NMFS. 2008f. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Consultation on Treaty Indian and Non-Indian Fisheries in the Columbia River Basin Subject to the 2008-2017 *U.S. v. Oregon* Management Agreement. May 5, 2008. NMFS, Portland, Oregon. NMFS Consultation No.: NWR-2008-02406. 685p.

NMFS. 2008g. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service, Seattle, Washington. 251p.

NMFS. 2008h. Supplemental Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of the Upper Snake and other Tributary Actions. May 5, 2008. NMFS, Portland, Oregon. 1230p.

NMFS. 2009a. Designation of Critical Habitat for the threatened Southern Distinct Population Segment of North American Green Sturgeon: Final Biological Report. Prepared by the Department of Commerce, National Marine Fisheries Service, Southwest Region, Protected Resources Division, Long Beach, California. 144p. Available online at: https://repository.library.noaa.gov/view/noaa/18683.

NMFS. 2009b. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion. Effects of the Pacific Coast Salmon Plan on the Southern Resident Killer Whale (*Orcinus orca*) Distinct Population Segment. May 5, 2009. NMFS Consultation No.: NWR-2009-02298. 82p.

NMFS. 2010a. Biological Opinion on the Effects of the Pacific Coast Salmon Plan and U.S. Fraser Panel Fisheries in 2010 and 2011 on the Lower Columbia River Chinook

Evolutionarily Significant Unit and Puget Sound/Georgia Basin Rockfish Distinct Populations Segments Listed Under the Endangered Species Act and Magnuson-Stevens Act Essential Fish Habitat Consultation. April 30, 2010. Consultation No.: NWR-2010-01714. 155p.

NMFS. 2010b. Draft Puget Sound Chinook Salmon Population Recovery Approach (PRA). NMFS Northwest Region Approach for Distinguishing Among Individual Puget Sound Chinook Salmon ESU Populations and Watersheds for ESA Consultation and Recovery Planning Purposes. November 30, 2010. Puget Sound Domain Team, NMFS, Seattle, Washington. 19p.

NMFS. 2010c. Endangered Species Act Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat Consultation on the Impacts of the 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 Puget Sound from August 1, 2010 through April 30, 2011. NMFS Northwest Region. July 28, 2010. NMFS Consultation No.: NWR-2010-03521. 96p.

NMFS. 2010d. Final Environmental Assessment for New Regulations to Protect Killer Whales from Vessel Effects in Inland Waters of Washington. National Marine Fisheries Service, Northwest Region. November 2010. 224p.

NMFS. 2011a. Evaluation of and recommended determination on a Resource Management Plan (RMP), pursuant to the salmon and steelhead 4(d) Rule comprehensive management plan for Puget Sound Chinook: Harvest management component. Salmon Management Division, Northwest Region, Seattle, Washington.

NMFS. 2011b. Evaluation of and Recommended Determination on a Resource Management Plan (RMP), Pursuant to the Salmon and Steelhead 4(d) Rule. Comprehensive Management Plan for Puget Sound Chinook: Harvest Management Component. NMFS Seattle, Washington. May 27, 2011. NMFS Consultation No.: NWR-2010-06051. 244p.

NMFS. 2012a. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation - Consultation on the Issuance of Four ESA Section l0(a)(1)(A) Scientific Research Permits and One ESA Section l0(a)(1)(B) permit affecting Salmon, Steelhead, Rockfish, and Eulachon in the Pacific Northwest. October 2, 2012. NMFS Consultation No.: NWR-2012-01984. NMFS, Northwest Region. 125p.

NMFS. 2012b. Jeopardy and Destruction or Adverse Modification of Critical Habitat Endangered Species Act Biological Opinion for Environmental Protection Agency's Proposed Approval of Certain Oregon Administrative Rules Related to Revised Water Quality Criteria for Toxic Pollutants. August 14, 2012. NMFS Consultation No.: NWR-

2008-00148. 784p.

NMFS. 2013a. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation - Washington State Department of Transportation Preservation, Improvement, and Maintenance Activities. January 2, 2013. NMFS Consultation No.: 2012-00293. NMFS, Seattle, Washington. 82p.

NMFS. 2013b. ESA Recovery Plan for Lower Columbia River coho salmon, Lower Columbia River Chinook salmon, Columbia River chum salmon, and Lower Columbia River steelhead. June 2013. 503p.

NMFS. 2014a. Draft Environmental Impact Statement on Two Joint State and Tribal Resource Management Plans for Puget Sound Salmon and Steelhead Hatchery Programs. 1650p.

NMFS. 2014b. Endangered Species Act Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat Consultation. Impacts of Programs Administered by the Bureau of Indian Affairs that Support Puget Sound Tribal Salmon Fisheries, Salmon Fishing Activities Authorized by the U.S. Fish and Wildlife Service, and Fisheries. Authorized by the U.S. Fraser Panel in 2014. May 1, 2014. NMFS Consultation No.: WCR-2014-578. 156p.

NMFS. 2014c. Endangered Species Act Section 7 Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Reinitiated Consultation. Elwha Channel Hatchery Summer/Fall Chinook Salmon Fingerling and Yearling, Lower Elwha Fish Hatchery Steelhead, Lower Elwha Fish Hatchery Coho Salmon, Lower Elwha Fish Hatchery Fall Chum Salmon, and Elwha River Odd and Even Year Pink Salmon Programs. December 15, 2014. NMFS Consultation No.: WCR-2014-1841.

NMFS. 2014d. Endangered Species Act Section 7 Biological Opinion, Conference Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation: Mud Mountain Dam, Operations, and Maintenance White River HUC 17110014 Pierce and King Counties, Washington. October 3, 2014. NMFS Consultation No.: NWR-2013-10095. 140p.

NMFS. 2014e. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat Consulation on impacts of programs administered by the Bureau of Indian Affairs that support 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 2014. NMFS, Seattle, Washington.

NMFS. 2014f. Endangered Species Act Section 7(a)(2) Biological Opinion, Conference Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish

Habitat Consultation, Mud Mountain Dam, Operations and Maintenance. NMFS, West Coast Region. October 3, 2014. .

NMFS. 2014g. Final Environmental Impact Statement to inform Columbia River Basin Hatchery Operations and the Funding of Mitchell Act Hatchery Programs. West Coast Region. National Marine Fisheries Service. Portland, Oregon.

NMFS. 2015a. Designation of Critical Habitat for Lower Columbia River Coho Salmon and Puget Sound Steelhead, Final Biological Report. December 2015. NMFS, Portland, Oregon. 171p.

NMFS. 2015b. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Effects of the Pacific Coast Salmon Plan on the Lower Columbia River Coho Evolutionarily Significant Unit Listed Under the Endangered Species Act. April 9, 2015. NMFS Consultation No.: WCR-2015-2026. 67p.

NMFS. 2015c. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Impacts of Programs Administered by the Bureau of Indian Affairs that Support Puget Sound Tribal Salmon Fisheries, Salmon Fishing Activities Authorized by the U.S. Fish and Wildlife Service, and Fisheries. Authorized by the U.S. Fraser Panel in 2015. NMFS, Seattle, Washington. May 7, 2015. NMFS Consultaton No.: WCR-2015-2433. 172p.

NMFS. 2015d. Workshop to Assess Causes of Decreased Survival and Reproduction in Southern Resident Killer Whales: Priorities Report. December 2015. 18p.

NMFS. 2016a. 5-Year Review: Summary & Evaluation of Yelloweye rockfish *(Sebastes ruberrimus*), canary rockfish (*Sebastes pinniger*), and bocaccio (*Sebastes paucispinis*) of the Puget Sound/Georgia Basin. April 2016. NMFS, West Coast Region. 131p.

NMFS. 2016b. 2016 5-Year Review: Summary & Evaluation of Snake River Sockeye Snake River Spring-Summer Chinook Snake River Fall-Run Chinook Snake River Basin Steelhead. National Marine Fisheries Service, West Coast Region, Portland, Oregon. 128p.

NMFS. 2016c. Draft Rockfish Recovery Plan: Puget Sound / Georgia Basin Yelloweye Rockfish (*Sebastes ruberrimus*) and Bocaccio (*Sebastes paucispinis*). National Marine Fisheries Service, Seattle, Washington. June 2016. 157p.

NMFS. 2016d. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation, Impacts of Programs Administered by the Bureau of Indian Affairs that Support Puget Sound Tribal Salmon Fisheries, Salmon Fishing Activities Authorized by the U.S. Fish and Wildlife Service, and Fisheries Authorized by the U.S. Fraser Panel in 2016. June 6, 2016. NMFS Consultation No.: F/WCR-2016-4418. 192p.

NMFS. 2016e. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Impact of Programs Administered by the Bureau of Indian Affairs that Support Puget Sound Tribal Salmon Fisheries in 2016. NMFS West Coast Region. May 9, 2016. NMFS Consultation No.: WCR-2016-4675. 118p.

NMFS. 2016f. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Impacts of the Role of the BIA with Respect to the Management, Enforcement, and Monitoring of 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. June 24, 2016. NMFS Consultation No.: WCR-2016-4914. 196p.

NMFS. 2016g. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. National Marine Fisheries Service (NMFS) Evaluation of Ten Hatchery and Genetic Management Plans for Salmon and Steelhead in Hood Canal under Limit 6 of the Endangered Species Act Section 4(d) Rule. September 30, 2016. NMFS Consultation No.: WCR-2014-1688. 91p.

NMFS. 2016h. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. National Marine Fisheries Service (NMFS) Evaluation of Three Hatchery and Genetic Management Plans for Early Winter Steelhead in the Dungeness, Nooksack, and Stillaguamish River basins under Limit 6 of the Endangered Species Act Section 4(d) Rule. April 15, 2016. NMFS Consultation No.: WCR-2015-2024. 220p.

NMFS. 2016i. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. National Marine Fisheries Service (NMFS) Evaluation of Two Hatchery and Genetic Management Plans for Early Winter Steelhead in the Snohomish River basin under Limit 6 of the Endangered Species Act Section 4(d) Rule. April 15, 2016. NMFS Consultation No.: WCR-2015-3441. 189p.

NMFS. 2016j. Endangered Species Act Section 7(a)(2) Biological Opinion, Conference Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. National Marine Fisheries Service (NMFS) Evaluation of Three Hatchery and Genetic Management Plans for Dungeness River Basin Salmon Under Limit 6 of the Endangered Species Act Section 4(d) Rule. Portland, Oregon. May 31, 2016. NMFS Consultation No.: NWR-2013-9701. 158p.

NMFS. 2016k. Final Environmental Impact Statement to Analyze Impacts of NOAA's National Marine Fisheries Service Proposed 4(d) Determination under Limit 6 for Five Early Winter Steelhead Hatchery Programs in Puget Sound. March 2016. NMFS, Lacey, Oregon. 326p.

NMFS. 2016l. Memorandum for Protected Resources Division, West Coast Region From Chris Yates, Assistant Regional Administrator for Protected Resources. Memorandum Regarding: West Coast Regions's Endangered Species Act Implementation and Considerations About "Take" Given the September 2016 Humpback Whale DPS Status Review and Species-Wide Revision of Listings. December 7, 2016.

NMFS. 2016m. Southern Resident Killer Whales (*Orcinus orca*) 5-Year Review: Summary and Evaluation. December 2016. NMFS, West Coast Region, Seattle, Washington. 74p.

NMFS. 2017a. 2016 5-Year Review: Summary & Evaluation of Puget Sound Chinook Salmon, Hood Canal Summer-run Chum, Salmon Puget Sound Steelhead. NMFS, Portland, Oregon. 51p.

NMFS. 2017b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response:. Impacts of the Role of the BIA Under its Authority to Assist with the Development of the 2017-2018 Puget Sound Chinook Harvest Plan, Salmon Fishing Activities Authorized by the U.S. Fish and Wildlife Service, and Fisheries Authorized by the U.S. Fraser Panel in 2017. May 3, 2017. NMFS Consultation No.: F/WCR-2017-6766. 201p.

NMFS. 2017c. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. National Marine Fisheries Service (NMFS) Evaluation of Six Hatchery and Genetic Management Plans for Snohomish River basin Salmon under Limit 6 of the Endangered Species Act Section 4(d) Rule. September 27, 2017. NMFS Consultation No.: NWR-2013-9699. 189p.

NMFS. 2017d. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. NOAA's National Marine Fisheries Service's implementation of the Mitchell Act Final Environmental Impact Statement preferred alternative and administration of Mitchell Act hatchery funding. January 15, 2017. NMFS Consultation No.: WCR-2014-697. 535p.

NMFS. 2017e. Reinitiation of Section 7 Consultation Regarding the Pacific Fisheries Management Council's Groundfish Fishery Management Plan. December 11, 2017. NMFS Consultation No.: WCR-2017-7552. 313p.

NMFS. 2017f. Rockfish Recovery Plan: Puget Sound/Georgia Basin yelloweye rockfish (*Sebastes ruberrimus*) and boccacio (*Sebastes paucispinis*). October 13, 2017. NMFS, Seattle, Washington. 164p.

NMFS. 2018a. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response. Consultation on effects of the 2018-2027 *U.S. v. Oregon* Management Agreement. February 23, 2018. NMFS Consultation No.: WCR-2017-7164. 597p.

NMFS. 2018b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response. ESA Section 4(d), Limit 6, determination for the Skagit River steelhead fishery Resource Management Plan (RMP), as submitted by the Sauk-Suiattle Indian Tribe, Swinomish Indian Tribal Community, Upper Skagit Indian Tribe, Skagit River System Cooperative, and the Washington Department of Fish and Wildlife (WDFW). April 11, 2018. NMFS Consultation No.: WCR-2017-7053. 118p.

NMFS. 2018c. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response. Impacts of the Role of the BIA Under its Authority to Assist with the Development of the 2018-2019 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 2018. May 9, 2018. NMFS, West Coast Region. NMFS Consultation No.: WCR-2018-9134. 258p.

NMFS. 2018d. National Marine Fisheries Service Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Manguson-Stevens Act Essential Fish Habitat (EFH) Consultation. Consultation on the implementation of the Area 2A (U.S. West Coast) Pacific halibut catch sharing plan. March 2018. NMFS Consultation No.: WCR-2017-8426. 208p.

NMFS. 2018e. National Marine Fisheries Service Endangered Species Act (ESA) Section 7(a)(2) Management Act Essential Fish Habitat Biological Opinion and Magnuson-Stevens Fishery Conservation and (EFH) Consultation Consultation on the Issuance of Nine ESA Section 10(a)(1)(A) Scientific Research Permits affecting Salmon, Steelhead, Rockfish, and Eulachon in the West Coast Region. NMFS Consultation No.: WCR-2017-8526. 135p.

NMFS. 2018f. An Updated Literature Review Examining the Impacts of Tourism on Marine Mammals over the Last Fifteen Years (2000-2015) to Inform Research and Management Programs. NOAA Technical Memorandum NMFS-SER-7. NMFS, St. Petersburg, Florida. 73p.

NMFS. 2019a. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. National Marine Fisheries Service (NMFS) Evaluation of Four Hatchery and Genetic Management Plans for Salmon in the Stillaguamish River basin under Limit 6 of the Endangered Species Act Section 4(d) Rule. June 20, 2019. NMFS Consultation No.: WCR-2018-8876. 151p.

NMFS. 2019b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response: Impacts of the Role of the BIA Under its Authority to Assist with the Development of the 2019-2020 Puget Sound Chinook Harvest Plan, Salmon Fishing Activities Authorized by the U.S. Fish and Wildlife Service, and Fisheries Authorized by the U.S. Fraser Panel in 2019. May 3, 2019. National Marine Fisheries Service, West Coast Region. NMFS Consultation No.: WCR-2019-00381. 284p.

NMFS. 2019c. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and MagnusonStevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Ten Hatchery Programs for Salmon and Steelhead in the Duwamish/Green River Basin. April 15, 2019. NMFS Consultation No.: WCR-2016-00014. 160p.

NMFS. 2019d. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, Conference Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation for the Howard Hanson Dam, Operations, and Maintenance Green River (HUC 17110013) King County, Washington. February 15, 2019. NMFS Consultation No.: WCR-2014-997. 167p.

NMFS. 2019e. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response Consultation on the Delegation of Management Authority for Specified Salmon Fisheries to the State of Alaska. NMFS Consultation No.: WCR-2018-10660. April 5, 2019. 443p.

NMFS. 2019f. Endangered Species Act Section 7(a)(2) Biological Opinion, Conference Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation, Howard Hanson Dam, Operations and Maintenance Green River (HUC17110013) King County, Washington. NMFS, West Coast Region. February 15, 2019. .

NMFS. 2019g. ESA Recovery Plan for the Puget Sound Steelhead Distinct Population Segment (Oncorhynchus mykiss). National Marine Fisheries Service. Seattle, WA. 174p.

NMFS. 2019h. ESA Recovery Plan for the Puget Sound Steelhead Distinct Population Segment (*Oncorhynchus mykiss*). WCR/NMFS/NOAA. December 20, 2019. 174p.

NMFS. 2019i. Proposed Revision of the Critical Habitat Designation for Southern Resident Killer Whales Draft Biological Report. September 2019. 122p. available online at: https://archive.fisheries.noaa.gov/wcr/publications/protected_species/marine_mammals/killer_whales/CriticalHabitat/0648-bh95_biological_report_september_2019_508.pdf.

NMFS. 2020a. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Conference Opinion Consultation on Implementation of the Pacific Fishery Management Council Salmon Fishery Management Plan in 2020 for Southern Resident Killer Whales and their Current and Proposed Critical Habitat. April 29, 2020. NMFS Consultation No.: WCRO/2019/04040. 149p. shoughton.

NMFS. 2020b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Conference Opinion Consultation on Implementation of the Pacific Fishery Management Council Salmon Fishery Management Plan in 2020 for Southern Resident Killer Whales and their Current and Proposed Critical Habitat. NMFS WCRO-2019-04040.

NMFS. 2020c. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation Wells Summer Chinook Hatchery Program for Southern Resident Killer Whales NMFS Consultation No.: WCR0-2020-00825. May 11, 2020. 112p.

NMFS. 2020d. 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. May 8, 2020. NMFS Consultation No: WCR-2020-00960. 345p.

NMFS. 2020e. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Continued Operation and Maintenance of the Columbia River System. NMFS Consultation Number: WCRO 2020-00113.

NMFS. 2020f. Endangered Species Act Section 7(a)(2) Biological for NMFS Sustainable Fisheries Division's determinations on salmon and steelhead hatchery programs in Puget Sound under limit 6 of the ESA 4(d) rules for listed salmon and steelhead in Puget Sound (50 CFR § 223.203(b)(6)). Consultation No.: WCRO 2020-01366. November 4, 2020. 81p.

NMFS. 2020g. Endangered Species Act Section 7(a)(2) Jeopardy Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Issuance of Permits for 39 Projects under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act for Actions related to Structures in the Nearshore Environment of Puget Sound. NMFS Consultation Number: WCRO-2020-01361. November 9, 2020. 327p.

NMFS. 2021a. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Conference Opinion Biological Opinion on the Authorization of the West Coast Ocean Salmon Fisheries Through Approval of the Pacific Salmon Fishery Management Plan Including Amendment 21 and Promulgation of Regulations Implementing the Plan for Southern Resident Killer Whales and their Current and Proposed Critical Habitat. NMFS Consultation Number: WCRO-2019-04074. April 21, 2021. 190p.

NMFS. 2021b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation: A Hatchery Program for Summer Steelhead in the Skykomish River and the Sunset Falls Trap and Haul Fishway Program in the South Fork Skykomish River. WCRO-2019-04075. April 23, 2021.

NMFS. 2021c. Memorandum for Protected Resources Division, West Coast Region from Chris Yates regarding West Coast Region's revised Endangered Species Act implementation and considerations about "take" given the September 2016 humpback whale DPS status review, species-wide revision of listings, and updates to best available scientific information. March 24, 2021.

NMFS. 2021d. Memorandum to the File from Scott Rumsey (NMFS) regarding Biological Opinion on the Delegation of Management Authority for Specified Salmon Fisheries to the State of Alaska – Status Update on the Hatchery Production Initiative for Southern Resident Killer Whales. April 29, 2021.

NMFS, and BIA. 2015. Biological Assessment for a Determination that Puget Sound Treaty and Non-Treaty (All-Citizens) Fisheries Qualify for Limitation of ESA Take Prohibitions Pursuant to Section 7(a)(2) for Listed Marbled Murrelets. December 15, 2015. 104p.

NMFS, and NWFSC. 2018. Developing Rebuilding Exploitation Rates for Puget Sound Chinook Salmon. The Viability and Risk Assessment Procedure (VRAP) Including the use of the Dynamic Model (DM) for computing Rebuilding Exploitation Rates (RERs). November 18, 2018.

NOAA. 2016. Guidelines for Preparing Stock Assessment Reports Pursuant to Section 117 of the Marine Mammal Protection Act. 24p.

NOAA. 2019a. 2018 West Coast Whale Entanglement Summary. NMFS West Coast Region. June 2019. 10p.

NOAA. 2019b. 2019 Summary preliminary data through August 23, 2019. Retrieved from: https://www.biologicaldiversity.org/campaigns/fisheries/pdfs/2019-Whale-

Entanglements-summary-8-23-2019.pdf.

NOAA, and WDFW. 2018. Southern Resident Killer Whale Priority Chinook Stocks Report. June 22, 2018. 8p.

NOAA Fisheries. 2020. 2019 West Coast Whale Entanglement Summary. NOAA Fisheries West Coast Region. Spring 2020. 4p.

NOAA Fisheries. 2021. 2020 West Coast Whale Entanglement Summary. NOAA Fisheries West Coast Region. March 2021. 4p.

Noren, D. P. 2011. Estimated field metabolic rates and prey requirements of resident killer whales. Marine Mammal Science. 27(1): 60–77.

Noren, D. P., R. C. Dunkin, T. M. Williams, and M. M. Holt. 2012. Energetic cost of behaviors performed in response to vessel disturbance: One link the in population consequences of acoustic disturbance model. In: Anthony Hawkins and Arthur N. Popper, Eds. The Effects of Noise on Aquatic Life, pp. 427–430. Project number: anth.

Noren, D. P., M. M. Holt, R. C. Dunkin, and T. M. Williams. 2013. The metabolic cost of communicative sound production in bottlenose dolphins (*Tursiops truncatus*). The Journal of Experimental Biology. 216: 1624-1629.

Noren, D. P., A. H. Johnson, D. Rehder, and A. Larson. 2009. Close approaches by vessels elicit surface active behaviors by Southern Resident Killer Whales. Endangered Species Research. 8(3): 179–192.

Norman, S. A., C. E. Bowlby, M. S. Brancato, J. Calambokidis, D. Duffield, P. J. Gearin, T. A. Gornall, M. E. Gosho, B. Hanson, J. Hodder†, S. J. Jeffries, B. Lagerquist, D. M. Lambourn, B. Mate, B. Norberg, R. W. Osborne, J. A. Rash, S. Riemer, and J. Scordino. 2004. Cetacean strandings in Oregon and Washington between 1930 and 2002. Journal of Cetacean Research and Management. 6(1): 87-99.

Norton, G. 2019a. Acting Northwest Regional Director, Bureau of Indian Affairs. April 24, 2019. Letter to Barry Thom (Regional Administrator, NMFS West Coast Region) requesting consultation on the 2019-2020 Puget Sound Chinook Harvest Plan. On file with NMFS West Coast Region, Sand Point office.

Norton, G. 2019b. Letter to Barry Thom (Regional Administrator, NMFS West Coast Region) from Grey Norton (Acting Northwest Regional Director, Bureau of Indian Affairs). April 24, 2019. Requesting consultation on the 2019-2020 Puget Sound Chinook Harvest Plan. On file with NMFS West Coast Region, Sand Point office. 2p.

NRC. 2007. Derelict fishing gear priority ranking project. Prepared for the Northwest Straights

Initiative.

NRC. 2008. Rates of marine species mortality caused by derelict fishing nets in Puget Sound, Washington. Prepared for the Northwest Straits Initiative.

NRC. 2010. Rockfish within derelict gear. Electronic communication from Jeff June to Dan Tonnes. Sent February 8, 2010.

NRC. 2014. Estimates of remaining derelict fishing gear in the Puget Sound. Electronic communication between Kyle Antonelis (NRC) and Dan Tonnes (NOAA) April 4, 2014.

NWFSC. 2015. Status Review Update for Pacific Salmon and Steelhead listed under the Endangered Species Act: Pacific Northwest. December 21, 2015. NWFSC, Seattle, Washington. 356p.

NWFSC. 2020. Draft Status review update for Pacific Salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. In prep April 2021.

NWIFC. 2016. 2016 State of Our Watersheds, WRIAs 1-23. A report by the Treaty Tribes in Western Washington. Northwest Indian Fisheries Commission Member Tribes. 336p.

NWIFC. 2020. 2020 State of Our Watersheds A Report by the Treaty Tribes in Western Washington. 390p.

O'Neill, S. M., and J. E. West. 2009. Marine distribution, life history traits, and the accumulation of polychlorinated biphenyls in Chinook salmon from Puget Sound, Washington. Transactions of the American Fisheries Society. 138(3): 616-632.

O'Neill, S. M., G. M. Ylitalo, and J. E. West. 2014. Energy content of Pacific salmon as prey of northern and Southern Resident Killer Whales. Endangered Species Research. 25: 265–281.

O'Shea, T. J. 1999. Environmental Contaminants and Marine Mammals, *In* Biology of Marine Mammals. p. 485-563. Smithsonian Institution Press: Washington, D.C. 82p.

O’Connor, S., R. Campbell, H. Cortez, and T. Knowles. 2009. Whale Watching Worldwide: Tourism numbers, expenditures and expanding economic benefits, a special report from the International Fund for Animal Welfare. Economists at Large, Yarmouth, Massachusetts. 295p.

O’Neill, S. M., G. M. Ylitalo, J. E. West, J. Bolton, C. A. Sloan, and M. M. Krahn. 2006. Regional patterns of persistent organic pollutants in five Pacific salmon species (*Oncorhynchus spp*) and their contributions to contaminant levels in northern and southern resident killer whales (*Orcinus orca*). *In* 2006 Southern Resident Killer Whale

Symposium, NOAA Fisheries, Northwest Fisheries Science Center, Seattle, Washington. 5p.

Ohlberger, J., D. E. Schindler, E. J. Ward, T. E. Walsworth, and T. E. Essington. 2019a. Resurgence of an apex marine predator and the decline in prey body size. Proceedings of the National Academy of Sciences. 116(52): 26682-26689. https://www.ncbi.nlm.nih.gov/pubmed/31843884.

Ohlberger, J., D. E. Schindler, E. J. Ward, T. E. Walsworth, and T. E. Essington. 2019b. Resurgence of an apex marine predator and the decline in prey body size. PNAS. 116(52): 26682-26689.

Ohlberger, J., E. J. Ward, D. E. Schindler, and B. Lewis. 2018. Demographic changes in Chinook salmon across the Northeast Pacific Ocean. Fish and Fisheries. 19(3): 533-546.

Olander, D. 1991. Northwest Coastal Fishing Guide. Frank Amato Publications, Portland, Oregon.

Olesiuk, P. F., M. A. Bigg, and G. M. Ellis. 1990. Life History and Population Dynamics of Resident Killer Whales (*Orcinus orca*) in the Coastal Waters of British Columbia and Washington State. Pages 209-244 in International Whaling Commission, Individual Recognition of Cetaceans: Use of Photo-Identification and Other Techniques to Estimate Population Parameters (Special Issue 12), incorporating the proceedings of the symposium and workshop on individual recognition and the estimation of cetacean population parameters.

Olesiuk, P. F., G. M. Ellis, and J. K. B. Ford. 2005. Life history and population dynamics of northern resident killer whales (*Orcinus orca*) in British Columbia (pages 1-75). Canadian Science Advisory Secretariat.

Olson, J. K., J. Wood, R. W. Osborne, L. Barrett-Lennard, and S. Larson. 2018. Sightings of southern resident killer whales in the Salish Sea 1976-2014: the importance of a long-term opportunistic dataset. Endangered Species Research. 37: 105-118.

Orr, J. W., M. A. Brown, and D. C. Baker. 2000. Guide to rockfishes (Scorpaenidae) of the genera Sebastes, Sebastolobus, and Abelosebastes of the northeast Pacific Ocean, Second Edition. NOAA Technical Memorandum NMFS-AFSC.

Osborne, R. W. 1999. A historical ecology of Salish Sea "resident" killer whales (*Orcinus orca*): With implications for management. Doctoral dissertation. University of Victoria,Victoria, British Columbia. 277p.

Pacunski, R. E., W. A. Palsson, and H. G. Greene. 2013. Estimating fish abundance and community composition on rocky habitats in the San Juan Islands using a small remotely operated vehicle. Washington Department of Fish and Wildlife Fish Program Fish Management Division. FPT 12-02. January 2013. 57p.

Palsson, W. A. 1998. Monitoring the response of rockfishes to protected areas. Pages 64-73. In: Marine Harvest Refugia for West Coast Rockfish: A Workshop, M. Yoklavich ed., NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-255, 159 p.

Palsson, W. A. 2004. The development of criteria for establishing and monitoring no-take refuges for rockfishes and other rocky habitat fishes in Puget Sound. Washington Department of Fish and Wildlife.

Palsson, W. A., and R. E. Pacunski. 1995. The response of rocky reef fishes to harvest refugia in Puget Sound. Pages 224-234, *In*: Puget Sound Research '95, Volume 1, Puget Sound Water Quality Authority, Olympia, Washington. 11p.

Palsson, W. A., T.-S. Tsou, G. G. Bargmann, R. M. Buckley, J. E. West, M. L. Mills, Y. W. Cheng, and R. E. Pacunski. 2009. The Biology and Assessment of Rockfishes in Puget Sound. Washington Department of Fish and Wildlife Fish Program. FPT 09-04. September 2009. 208p.

Parker, S. J., H. I. McElderry, P. S. Rankin, and R. W. Hannah. 2006. Buoyancy regulation and barotrauma in two species of nearshore rockfish. Transactions of the American Fisheries Society 135(5): 1213-1223.

Parks, S. E. 2003. Response of North Atlantic right whales (*Eubalaena glacialis*) to playback of calls recorded from surface active groups in both the North and South Atlantic. Marine Mammal Science. 19(3): 563-580.

Parks, S. E. 2009. Assessment of acoustic adaptations for noise compensation in marine mammals. Office of Naval Research. 4p.

Parsons, K. M., K. C. Balcomb, J. K. B. Ford, and J. W. Durban. 2009. The social dynamics of southern resident killer whales and conservation implications for this endangered population. Animal Behaviour, 77(4), 963-971.

Pashin, Y. V., and L. M. Bakhitova. 1979. Mutagenic and carcinogenic properties of polycyclic aromatic hydrocarbons. Environmental Health Perspectives. 30: 185-189.

Pearcy, W., and N. Mantua. 1999. Changing ocean conditions and their effects on steelhead. University of Washington. Seattle, Washington. 13 p.

Penttila, D. 2007. Marine Forage Fishes in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-03. Published by Seattle District, U.W. Army Corps of Engineers, Seattle, Washington. 30p.

Pess, G., M. McHenry, K. Denton, J. Anderson, and M. Liermann. 2020. Initial response of Chinook salmon (Oncorhynchus tshwytscha) and steelhead (Oncorhynchus mykiss) to removal of two dams on the Elwha River, Washington State, U.S.A. Draft 75p. .

Pettis, H. M., R. M. Rolland, P. K. Hamilton, S. Brault, A. R. Knowlton, and S. D. Kraus. 2004. Visual health assessment of North Atlantic right whales (*Eubalaena glacialis*) using photographs. Canadian Journal of Zoology. 82(1): 8-19.

PFMC. 2000. Pacific Fisheries Management Council Scientific and Statistical Committee statement on default maximum sustainable yield fishing rate within the harvest rate policy. Supplemental SSC Report D. 13. (2). June 2000.

PFMC. 2008a. Fisheries Regulation Assessment Model (FRAM). An Overview for coho and Chinook v 3.0. October 2008. PFMC, Portland, Oregon. 43p.

PFMC. 2008b. Groundfish Management Team (GMT) report on the development of a discard mortality matrix for ocean and estuary recreational fisheries. MS Report 15pp.

PFMC. 2014a. Groundfish Management Team (GMT) Report on Proposed Discard Mortality for Cowcod, Canary, and Yelloweye Rockfish Released Using Descending Devices in the Recreational Fishery. Supplemental GMT Report 2. March 2014. 3p.

PFMC. 2014b. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery. May 2014. Pacific Fishery Management Council, Portland, Oregon. 158p.

PFMC. 2014c. Pacific Coast Salmon Fishery Management Plan for Commercial and Recreational Salmon Fisheries off the Coasts of Washington, Oregon, and California as amended through Amendment 18. PFMC, Portland, Oregon. 90p.

PFMC. 2016. Coastal Pelagic Species Fishery Management Plan as amended through Amendment 15. February 2016. Pacific Fishery Management Council, Portland, Oregon. 49p.

PFMC. 2019. Decision Summary Document. April 2019 council Meeting Decision Summary Document. April 11-16, 2019. 8p.

PFMC. 2020a. Pacific Fishery Management Council Salmon Fishery Management Plan Impacts to Southern Resident Killer Whales. Risk Assessment. March 2020. SRKW Workgroup Report 1. 164p.

PFMC. 2020b. Pacific Fishery Management Council Salmon Fishery Management Plan Impacts to Southern Resident Killer Whales: Risk Assessment. Agenda Item E.2.a. SRKW

Workgroup Report 1 (electronic only). May 2020. 165p.

Phinney, C., and B. Patten. 2018. Chris Phinney, Puyallup Tribal Fisheries Department, and Bill Patten, Northwest Fisheries Commission personal communication with Susan Bishop, National Marine Fisheries Service regarding correction to model inputs for the Puyallup River treaty fishery. April 6, 2018.

Pitcher, K. W., P. F. Olesiuk, R. F. Brown, M. S. Lowry, S. J. Jeffries, J. L. Sease, W. L. Perryman, C. E. Stinchcomb, and L. F. Lowry. 2007. Abundance and distribution of the eastern North Pacific Steller sea lion (*Eumetopias jubatus*) population. Fishery Bulletin. 105(1): 102–115.

Pribyl, A. L., M. L. Kent, S. J. Parker, and C. B. Schreck. 2011. The response to forced decompression in six species of Pacific rockfish. Transactions of the American Fisheries Society. 140(2): 374-383.

Pribyl, A. L., C. B. Schreck, M. L. Kent, and S. J. Parker. 2009. The differential response to decompression in three species of nearshore Pacific rockfish North American Journal of Fisheries Management. 29: 1479–1486.

PSAT. 2007. State of the Sound 2007 Report. Office of the Governor, State of Washington, Olympia Washington. May 2007. 96p.

PSC. 2020. Treaty between the government of Canada and the government of the United States of America concerning Pacific salmon.

PSIT, and WDFW. 2004. Puget Sound Chinook Salmon Hatcheries Comprehensive Chinook Salmon Management Plan. March 31, 2004. Washington Department of Fish and Wildlife and Puget Sound Treaty Tribes. 154p.

PSIT, and WDFW. 2010a. Comprehensive Management Plan for Puget Sound Chinook: Harvest Management Component. April 12. 2010. Puget Sound Indian Tribes and the Washington Department of Fish and Wildlife. 237p.

PSIT, and WDFW. 2010b. Draft Puget Sound Steelhead Harvest Management Plan. Lacey, Washington.

PSIT, and WDFW. 2010c. Puget Sound Steelhead Harvest Management Plan. Available from Washington Department of Fish and Wildlife, Olympia, Washington. January 7, 2010. 224p.

PSIT, and WDFW. 2017a. Comprehensive Management Plan for Puget Sound Chinook: Harvest Management Component. December 1, 2017.

PSIT, and WDFW. 2017b. Draft Comprehensive Management Plan for Puget Sound Chinook: Harvest Management Component. December 1, 2017. Puget Sound Indian Tribes and the Washington Department of Fish and Wildlife. 338p.

PSSTRT. 2013. Viability Criteria for Puget Sound Steelhead. Final Review Draft. April 2013. 372p.

Puget Sound Partnership. 2018. The 2018-2022 Action Agenda for Puget Sound. December 2018. 295p.

Puget Sound Steelhead Technical Recovery Team. 2011. Identifying Historical Populations of Steelhead within the Puget Sound Distinct Population Segment. 31 October 2011 Review Draft. NMFS NWFSC, Seattle, Washington. 110p.

Ralston, S. 1998. The status of federally managed rockfish on the U.S. West Coast. Pages 6-16 in M Yoklavich, editor. Marine harvest refugia for West Coast rockfish: a workshop. NOAA Technical Memorandum NMFS NOAA-TM-NMFS-SWFSC-255.

Ralston, S. 2002. West Coast groundfish harvest policy. North American Journal of Fisheries Management. 22(1): 249-250.

Raverty, S., J. S. Leger, D. P. Noren, K. B. Huntington, D. S. Rotstein, F. M. D. Gulland, J. K. B. Ford, M. B. Hanson, D. M. Lambourn, J. Huggins, M. A. Delaney, L. Spaven, T. Rowles, L. Barre, P. Cottrell, G. Ellis, T. Goldstein, K. Terio, D. Duffield, J. Rice, and J. K. Gaydos. 2020. Pathology Findings and Correlation with Body Condition Index in Stranded Killer Whales (Orcinus orca) in the Northeastern Pacific and Hawaii from 2004 to 2013. PloS One. 15(12): 1-31.

Reddy, M. L., J. S. Reif, A. Bachand, and S. H. Ridgway. 2001. Opportunities for using Navy marine mammals to explore associations between organochlorine contaminants and unfavorable effects on reproduction. The Science of the Total Environment. 274(1-3): 171-182.

Redhorse, D. 2014. Acting Northwest Regional Director, Bureau of Indian Affairs. March 25, 2014. Letter to Will Stelle (Regional Administrator, NMFS West Coast Region) amending request for consultation dated March 7, 2014. On file with NMFS West Coast Region.

Reijnders, P. J. H. 1986. Reproductive failure in common seals feeding on fish from polluted coastal waters. Nature. 324(6096): 456-457.

Rice, C. A. 2007. Evaluating the Biological Condition of Puget Sound. Ph.D. University of Washington, School of Aquatic and Fisheries Sciences. 283p.

Richardson, W. J., J. C.R. Greene, C. I. Malme, and D. H. Thomson. 1995. Marine Mammals and Noise. Academic Press, San Diego, California.

Riera, A., J. F. Pilkington, J. K. B. Ford, E. H. Stredulinsky, and N. R. Chapman. 2019. Passive acoustic monitoring off Vancouver Island reveals extensive use by at-risk Resident killer whale (*Orcinus orca*) populations. Endangered Species Research. 39: 221-234. https://doi.org/10.3354/esr00966.

Ries, J. B., A. L. Cohen, and D. C. McCorkle. 2009. Marine calcifiers exhibit mixed responses to CO2-induced ocean acidification. Geology. 37(12): 1131-1134.

Robeck, T. R., K.J. Steinman, and J.K. O'Brien. 2016. Characterization and longitudinal monitoring of serum progestagens and estrogens during normal pregnancy in the killer whale (Orcinus orca). General and Comparative Endocrinology. 236: 83-97.

Rockwood, R. C., J. Calambokidis, and J. Jahncke. 2017a. High mortality of blue, humpback and fin whales from modeling of vessel collisions on the U.S. West Coast suggests population impacts and insufficient protection. PLoS One. 12(8): 1-24. https://www.ncbi.nlm.nih.gov/pubmed/28827838.

Rockwood, R. C., J. Calambokidis, and J. Jahncke. 2017b. High mortality of blue, humpback and fin whales from modeling of vessel collisions on the U.S. West Coast suggests population impacts and insufficient protection. PloS one. 12(8): e0183052.

Romano, T. A., M. J. Keogh, C. Kelly, P. Feng, L. Berk, C. E. Schlundt, D. A. Carder, and J. J. Finneran. 2003. Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences. 61: 1124–1134.

Rose, G. 2018. Gordon Rose, Northwest Indian Fisheries Commission, personal communication with Susan Bishop, National Marine Fisheries Service regarding fishing schedule and associated harvest rate information for Skokomish Chinook and coho fisheries. April 4, 2018.

Rosenthal, R. J., L. Haldorson, L. J. Field, V. Moran-O’Connell, M. G. LaRiviere, J. Underwood, and M. C. Murphy. 1982. Inshore and shallow offshore bottomfish resources in the southeastern Gulf of Alaska. Alaska Coastal Research and University of Alaska, Juneau.

Ross, P. S., G. M. Ellis, M. G. Ikonomou, L. G. Barrett-Lennard, and R. F. Addison. 2000. High PCB concentrations in free-ranging Pacific killer whales, *Orcinus orca*: Effects of age, sex and dietary preference. Marine Pollution Bulletin. 40(6): 504-515.

Ruckelshaus, M. H., K. P. Currens, R. R. Fuerstenberg, W. H. Graeber, K. Rawson, N. J. Sands, and J. B. Scott. 2002. Planning Ranges and Preliminary Guidelines for the Delisting and Recovery of the Puget Sound Chinook Salmon Evolutionarily Significant Unit. Puget Sound Technical Recovery Team, Northwest Fisheries Science Center. April 30, 2002. 20p.

Ruckelshaus, M. H., K. P. Currens, W. H. Graeber, R. R. Fuerstenberg, K. Rawson, N. J. Sands, and J. B. Scott. 2006. Independent Populations of Chinook Salmon in Puget Sound. July 2006. U.S. Dept. Commer., NOAA Technical Memorandum NMFS-NWFSC-78. 145p.

Ruggerone, G. T., A. M. Springer, L. D. Shaul, and G. B. van Vliet. 2019. Unprecedented biennial pattern of birth and mortality in an endangered apex predator, the southern resident killer whale, in the eastern North Pacific Ocean. Marine Ecology Progress Series. 608: 291-296.

Saez, L., D. Lawson, and M. DeAngelis. 2020. Large whale entanglements off the U.S. West Coast, from 1982-2017. NOAA Tech. Memo. NMFS-OPR-63. February 2020. 48p.

Saez, L., D. Lawson, M. DeAngelis, E. Petras, S. Wilkin, and C. Fahy. 2013. Understanding the co-occurrence of large whales and commercial fixed gear fisheries off the west coast of the United States. September 2013. NOAA Technical Memorandum NMFS, NOAA-TM-NMFS-SWR-044. NMFS, Long Beach, California. 103p.

Salden, D. R., L. M. Herman, M. Yamaguchi, and F. Sato. 1999. Multiple visits of individual humpback whales (*Megaptera novaeangliae*) between the Hawaiian and Japanese winter grounds. Canadian Journal of Zoology. 77(3): 504-508.

Sandell, T., A. Lindquist, P. Dionne, and D. Lowry. 2019. 2016 Washington State Herring Stock Status Report. Fish Program Technical Report No. FPT 19-07. WDFW. September 2019. 90p.

Sanga, R. 2015. US EPA Region 10 Sediment Cleanup Summary. Presentation at Sediment Management Annual Review Meeting (SMARM) 2015, May 6, Seattle, WA.

Santora, J. A., N. J. Mantua, I. D. Schroeder, J. C. Field, E. L. Hazen, S. J. Bograd, W. J. Sydeman, B. K. Wells, J. Calambokidis, L. Saez, D. Lawson, and K. A. Forney. 2020. Habitat compression and ecosystem shifts as potential links between marine heatwave and record whale entanglements. Nature communications. 11(1): 1-12. https://www.ncbi.nlm.nih.gov/pubmed/31988285.

Sauk-Suiattle Indian Tribe, Swinomish Indian Tribal Community, Upper Skagit Indian Tribe, Skagit River System Cooperative, and WDFW. 2016. Skagit River Steelhead Fishery Resource Management Plan. November 18, 2016. 53p.

Sawchuk, J. H. 2012. Angling for insight: Examining the Recreational Community's Knowledge, Perceptions, Practices, and Preferences to Inform Rockfish Recovery Planning in Puget Sound, Washington. Master's Thesis, University of Washington, School of Marine and Environmental Affairs. 208p.

Sawchuk, J. H., A. H. Beaudreau, D. Tonnes, and D. Fluharty. 2015. Using stakeholder engagement to inform endangered species management and improve conservation. Marine Policy. 54: 98-107.

Schaefer, K. M. 1996. Spawning time, frequency, and batch fecundity of yellowfin tuna, *Thunnus albacares*, near Clipperton Atoll in the eastern Pacific Ocean. Fishery Bulletin. 94(1): 98-112.

Schroeder, D. M., and M. S. Love. 2002. Recreational fishing and marine fish populations in California. California Cooperative Oceanic Fisheries Investigations Report. 43: 182-190.

Schwacke, L. H., C. R. Smith, F. I. Townsend, R. S. Wells, L. B. Hart, B. C. Balmer, T. K. Collier, S. D. Guise, M. M. Fry, J. Louis J. Guillette, S. V. Lamb, S. M. Lane, W. E. McFee, N. J. Place, M. C. Tumlin, G. M. Ylitalo, E. S. Zolman, and T. K. Rowles. 2013. Health of common bottlenose dolphins (*Tursiops truncatus*) in Barataria Bay, Louisiana, following the Deepwater Horizon Oil spill. Environmental science & technology. 48(1): 93-103.

Schwacke, L. H., E. O. Voit, L. J. Hansen, R. S. Wells, G. B. Mitchum, A. A. Hohn, and P. A. Fair. 2002. Probabilistic risk assessment of reproductive effects of polychlorinated biphenyls on bottlenose dolphins (*Tursiops truncatus*) from the southeast United States coast. Environmental Toxicology and Chemistry. 21(12): 2752–2764.

Seely. 2017. Final 2017 Soundwatch Program Annual Contract Report. Soundwatch Public Outreach/Boater Education Program. The Whale Museum Contract No. RA-133F-12-CQ-0057. .

Seely, E. 2016. Final 2016 Soundwatch Program Annual Contract Report. Soundwatch Public Outreach/Boater Education Project. Contract No. RA-133F-12-CQ-0057. 55p.

Senigaglia, V., F. Christiansen, L. Bejder, D. Gendron, D. P. Noren, A. Schaffar, J. C. Smith, R. Williams, E. Martinez, K. Stockin, D. Lusseau, and D. Lundquist. 2016. Meta-analyses of whale-watching impact studies: comparisons of cetacean responses to disturbance. Marine Ecology Press Series. 542: 251–263.

Shaffer, J. A., D. C. Doty, R. M. Buckley, and J. E. West. 1995. Crustacean community composition and trophic use of the drift vegetation habitat by juvenile splitnose rockfish *Sebastes diploproa*. Marine Ecology Progress Series. 123: 13-21.

Shaw, B. 2015. Acting Northwest Regional Director, Bureau of Indian Affairs. May 1, 2015.

Letter to Will Stelle (Regional Administrator, NMFS West Coast Region) requesting consultation on revisions to the 2010 Puget Sound Chinook Harvest Management Plan for 2015-2016 Puget Sound fishing season. On file with NMFS West Coast Region, Sand Point office.

Shaw, B. 2016. Acting Northwest Regional Director, Bureau of Indian Affairs. April 2016. Letter to Will Stelle (Regional Administrator, NMFS West Coast Region) requesting consultation on for Puget Sound salmon fisheries based on co-manager agreed revisions to the 2010 Puget Sound Chinook Harvest Management Plan for 2016-2017 Chinook fisheries in Puget Sound. On file with NMFS West Coast Region, Sand Point office.

Shaw, B. 2018. Acting Northwest Regional Director, Bureau of Indian Affairs. April 16, 2018. Letter to Barry Thom (Regional Administrator, NMFS West Coast Region) requesting consultation on the 2018-2019 Puget Sound Chinook Harvest Plan. On file with NMFS West Coast Region, Sand Point office.

Shedd. 2019. 2018 Soundwatch Program Annual Contract Report. Soundwatch Public Outreach/Boater Education Program. The Whale Museum. Contract No. RA-133F-12-CQ-0057.

Shelton, A. O., W. H. Satterthwaite, E. J. Ward, B. E. Feist, and B. Burke. 2019. Using hierarchical models to estimate stock-specific and seasonal variation in ocean distribution, survivorship, and aggregate abundance of fall run Chinook salmon. Canadian Journal of Fisheries and Aquatic Sciences. 76(1): 95-108.

Shelton, A. O., G. H. Sullaway, E. J. Ward, B. E. Feist, K. A. Somers, V. J. Tuttle, J. T. Watson, and W. H. Satterthwaite. 2020. Redistribution of salmon populations in the northeast Pacific ocean in response to climate. Fish and Fisheries. 00:1 – 15. doi: 10.1111/faf.12530.

Shevchenko, V. I. 1975. The nature of the interrelationships between killer whales and other cetaceans. Morskie mlekopitayushchie, pp.173-175.

Skokomish Indian Tribe, and WDFW. 2010. Recovery Plan for Skokomish River Chinook Salmon. August 2010. 286p.

Skokomish Indian Tribe, and WDFW. 2017. Recovery Plan for Skokomish River Chinook Salmon 2017 Update. December 2017. 210p.

Smith, C. J., and B. Sele. 1995. Dungeness River Chinook Salmon Rebuilding Project *in* Techniques of Hydraulic Redd Sampling, Seining and Electroshocking. Pages 40-57, C.J. Smith and P. Wampler, editors. Progress report 1992-1993. Northwest Fishery Resource Bulletin, Project Report Series Number 3. Northwest Indian Fisheries Commission, Olympia, Washington.

Sogard, S. M., S. A. Berkeley, and R. Fisher. 2008. Maternal effects in rockfishes *Sebastes* spp.: a comparison among species. Marine Ecology Progress Series. 360: 227-236.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. G. Jr, D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals. 33(Number 4).

Speaks, S. 2017. Northwest Regional Director, Bureau of Indian Affairs. April 21, 2017. Letter to Barry Thom (Regional Administrator, NMFS West Coast Region) requesting consultation on for Puget Sound salmon fisheries based on co-manager agreed revisions to the 2010 Puget Sound Chinook Harvest Management Plan for 2017-2018 Chinook fisheries in Puget Sound. On file with NMFS West Coast Region, Sand Point office.

Spence, B. C., G. A. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An Ecosystem Approach to Salmonid Conservation. December 1996. TR-4501-96-6057. Corvallis, Oregon. 206p.

SSPS. 2005. Puget Sound Salmon Recovery Plan. Volumes I, II and III. Plan Adopted by the National Marine Fisheries Service (NMFS) January 19, 2007. Submitted by the Shared Strategy Development Committee. Shared Strategy for Puget Sound. Seattle, Washington. 503p.

SSPS. 2007. Puget Sound Salmon Recovery Plan. Volumes I, II and III. Plan Adopted by the National Marine Fisheries Service (NMFS) January 19, 2007. Submitted by the Shared Strategy Development Committee. Shared Strategy for Puget Sound. Seattle, Washington. 503p.

Stanley, R. D., M. McAllister, and P. Starr. 2012. Updated stock assessment for Bocaccio (*Sebastes paucispinis*) in British Columbia waters for 2012. Fisheries and Oceans Canada, Science.

Steiger, G. H., J. Calambokidis, J. M. Straley, L. M. Herman, S. Cerchio, D. R. Salden, J. Urbán-R., J. K. Jacobsen, O. v. Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, S. Uchida, J. K. B. Ford, P. L. d. Guevara-P., M. Yamaguchi, and J. Barlow. 2008. Geographic variation in killer whale attacks on humpback whales in the North Pacific: implications for predation pressure. Endangered Species Research. 4(3): 247-256.

Stevick, P. T., C. A. Carlson, and K. C. Balcomb. 1999. A note on migratory destinations of humpback whales from the eastern Caribbean. Journal of Cetacean Research and Management. 1(3): 251-254.

Stewart, J. D., J. W. Durban, H. Fearnbach, L. G. Barrett-Lennard, P. K. Casler, E. J. Ward, and

D. R. Dapp. In Press. Survival of the Fattest: Linking body condition to prey availability and survivorship of killer whales. Ecosphere.

Studebaker, R. S., K. N. Cox, and T. J. Mulligan. 2009. Recent and historical spatial distributions of juvenile rockfish species in rocky intertidal tide pools, with emphasis on black rockfish. Transactions of the American Fisheries Society. 138: 645–651.

Subramanian, A., S. Tanabe, R. Tatsukawa, S. Saito, and N. Miyazaki. 1987. Reduction in the testosterone levels by PCBs and DDE in Dall's porpoises of Northwestern North Pacific. Marine Pollution Bulletin. 18(12): 643-646.

Tagal, M., K. C. Massee, N. Ashton, R. Campbell, P. Pesha, and M. B. Rust. 2002. Larval development of yelloweye rockfish, Sebastes ruberrimus. National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center.

Thom, B. A. 2017. Letter to Herb Pollard (PFMC) from Barry Thom (NMFS) Summarizing NOAA's NMFS' Consultation Standards and Guidance Regarding the Potential Effects of the 2017 Season on ESA-Listed Salmonid Species. March 3, 2017. NMFS, Portland, Oregon. 14p.

Tolimieri, N., and P. S. Levin. 2005. The roles of fishing and climate in the population dynamics of bocaccio rockfish. Ecological Applications. 15(2): 458-468.

Towers, J. R., G. M. Ellis, and J. K. B. Ford. 2015. Photo-identification catalogue and status of the Northern Resident Killer Whale population in 2014. Canadian Technical Report of Fisheries and Aquatic Sciences 3139: iv + 75p.

Trites, A. W., and C. P. Donnelly. 2003. The decline of Steller sea lions *Eumetopias jubatus* in Alaska: a review of the nutritional stress hypothesis. Mammal review. 33(1): 3-28.

Trites, A. W., and D. A. S. Rosen. 2018. Availability of Prey for Southern Resident Killer Whales. Technical Workshop Proceedings. November 15–17, 2017. Marine Mammal Research Unit, Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, B.C. 64p.

Tsujii, K., T. Akamatsu, R. Okamoto, K. Mori, Y. Mitani, and N. Umeda. 2018. Change in singing behavior of humpback whales caused by shipping noise. PloS one. 13(10): e0204112.

Turner, B., and R. Reid. 2018. Pacific Salmon Commission transmittal letter. PST, Vancouver, B.C. August 23, 2018. 97p.

Turner, R. 2016. Letter from Robert Turner, ARA to David Troutt, Nisqually Tribal Natural Resources Director, regarding proposed Nisqually management approach for 2016.

March 7, 2016.

Tynan, T. 2010. Personal communication from Tim Tynan, Fishery Biologist, NMFS, Lacey, WA. April 13, 2010, with Susan Bishop, Fishery Biologist, NMFS NWR, regarding status of new Chinook supplementation programs in the South Forks of the Nooksack and Stillaguamish Rivers.

Unsworth, J., and M. Grayum. 2016. Directors, Washington Department of Fish and Wildlife and Northwest Indian Fisheries Commission. June 14, 2015. Letter to Bob Turner (Regional Assistant Administrator, NMFS West Coast Region, Sustainable Fisheries Division) describing harvest management objectives for Puget Sound Chinook for the 2016-2017 season. On file with NMFS West Coast Region, Sand Point office.

Unsworth, J., and J. Parker. 2017. Directors, Washington Department of Fish and Wildlife and Northwest Indian Fisheries Commission. April 21, 2017. Letter to Barry Thom (Regional Administrator, NMFS West Coast Region, Sustainable Fisheries Division) including a summary and enclosures that are the basis for the 2017-2018 Puget Sound Chinook Harvest Plan for Puget Sound Chinook. On file with NMFS West Coast Region, Sand Point office.

Van Cleve, F. B., G. Bargmann, M. Culver, and T. M. W. Group. 2009. Marine Protected Areas in Washington: Recommendations of the Marine Protected Areas Work Group to the Washington State Legislature. December 2009. WDFW, Olympia, Washington. 118p.

Veirs, S., V. Veirs, and J. D. Wood. 2016. Ship noise extends to frequencies used for echolocation by endangered killer whales. PeerJ. 4: 1-35.

Veldhoen, N., M. G. Ikonomou, C. Dubetz, N. MacPherson, T. Sampson, B. C. Kelly, and C. C. Helbing. 2010. Gene expression profiling and environmental contaminant assessment of migrating Pacific salmon in the Fraser River watershed of British Columbia. Aquatic Toxicology. 97(3): 212–225.

Velez-Espino, L. A., J. K. B. Ford, H. A. Araujo, G. Ellis, C. K. Parken, and R. Sharma. 2014. Relative importance of Chinook salmon abundance on resident killer whale population growth and viability. Aquatic Conservation: Marine and Freshwater Ecosystems. 25(6): 756-780.

Venn-Watson, S., K. M. Colegrove, J. Litz, M. Kinsel, K. Terio, J. Salik, S. Fire, R. Carmichael, C. Chevis, W. Hatchett, J. Pitchford, M. Tumlin, C. Field, S. Smith, R. Ewing, D. Fauquier, G. Lovewell, H. Whitehead, D. Rotstein, W. McFee, E. Fougeres, and T. Rowles. 2015. Adrenal gland and lung lesions in Gulf of Mexico common Bottlenose Dolphins (*Tursiops truncatus*) found dead following the Deepwater Horizon Oil Spill. PLOS ONE. 10(5): 1-23.

Viberg, H., A. Fredriksson, and P. Eriksson. 2003. Neonatal exposure to polybrominated diphenyl ether (PBDE-153) disrupts spontaneous behaviour, impairs learning and memory, and decreases hippocampal cholinergic receptors in adult mice. Toxicology and applied pharmacology. 192(2): 95-106.

Viberg, H., N. Johansson, A. Fredriksson, J. Eriksson, G. Marsh, and P. Eriksson. 2006. Neonatal exposure to higher brominated diphenyl ethers, hepta-, octa-, or nonabromodiphenyl ether, impairs spontaneous behavior and learning and memory functions of adult mice. Toxicological Sciences. 92(1): 211-218.

Vu, E. T., D. Risch, C. W. Clark, S. Gaylord, L. T. Hatch, M. A. Thompson, D. N. Wiley, and S. M. V. Parijs. 2012. Humpback whale song occurs extensively on feeding grounds in the western North Atlantic Ocean. Aquatic Biology. 14(2): 175-183.

Wade, P. R. 2017. Estimates of abundance and migratory destination for North Pacific humpback whales in both summer feeding areas and winter mating and calving areas revision of estimates in SC/66b/IA21. IWC Scientific Committee Report SC/A17/NP/11.

Wade, P. R., T. J. Quinn II, J. Barlow, C. S. Baker, A. M. Burdin, J. Calambokidis, P. J. Clapham, E. Falcone, J. K. B. Ford, C. M. Gabriele, R. Leduc, D. K. Mattila, L. Rojas-Bracho, J. Straley, B. L. Taylor, J. Urbán R., D. Weller, B. H. Witteveen, and M. Yamaguchi. 2016. Estimates of abundance and migratory destination for North Pacific humpback whales in both summer feeding areas and winter mating and calving areas. Paper SC/66b/IA21 submitted to the Scientific Committee of the International Whaling Commission, June 2016, Bled, Slovenia.

Wallace, J. R. 2007. Update to the status of yelloweye rockfish (*Sebastes ruberrimus*) off the U.S. West Coast in 2007, Pacific Fishery Management Council, Portland, Oregon. 71p.

Walters, C., and A. M. Parma. 1996. Fixed exploitation rate strategies for coping with effects of climate change. Canadian Journal of Fisheries and Aquatic Sciences. 53(1): 148-158.

Walters, C. J., and S. J. D. Martell. 2004. Fisheries Ecology and Management. Princeton University Press. November 7, 2004.

Ward, E. 2019. Southern Resident Killer Whale Population and Status Update. December 15, 2019. Internal memo. 12p.

Ward, E., and W. Satterthwaite. 2020. Power Analyses for Southern Resident Killer Whale Demographic Modeling. July 13, 2020. Internal memo.7p.

Ward, E. J., M. J. Ford, R. G. Kope, J. K. B. Ford, L. A. Velez-Espino, C. K. Parken, L. W. LaVoy, M. B. Hanson, and K. C. Balcomb. 2013. Estimating the Impacts of Chinook Salmon Abundance and Prey Removal by Ocean Fishing on Southern Resident Killer

Whale Population Dynamics. July 2013. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-123. 85p.

Ward, E. J., E. E. Holmes, and K. C. Balcomb. 2009. Quantifying the effects of prey abundance on killer whale reproduction. Journal of Applied Ecology. 46: 632-640.

Ward, L., P. Crain, B. Freymond, M. McHenry, D. Morrill, G. Pess, R. Peters, J. A. Shaffer, B. Winter, and B. Wunderlich. 2008. Elwha River Fish Restoration Plan. Developed Pursuant to the Elwha River Ecosystem and Fisheries Restoration Act, Public Law 102-495. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-90. 191p.

Wargo, L., and K. Hinton. 2016. Washington Review of Commercial Fisheries 2014-2015 Sardine and Mackerel and 2014 Anchovy. Published by Washington Department of Fish and Wildlife. Montesano, Washington. December 2016. 34p.

Warheit, K. I. 2014. Measuring reproductive interaction between hatchery-origin and Wild steelhead (*Oncorhynchus mykiss*) from northern Puget Sound populations potentially affected by segregated hatchery programs. November 10, 2014. Unpublished Final Report. WDFW, Olympia, Washington. 14p.

Warlick, A. J., G. M. Ylitalo, S. M. O'Neill, M. B. Hanson, C. Emmons, and E. J. Ward. 2020. Using Bayesian stable isotope mixing models and generalized additive models to resolve diet changes for fish-eating killer whales Orcinus orca. Marine Ecology Progress Series. 649: 189-199.

Warner, E. 2019. Email communication to Christina Iverson (NMFS) from Eric Warner (Muckleshoot) regarding MIT warm water test fishery monthly update for March and April 2019. June 7, 2019.

Washington, P. M. 1977. Recreationally Important Marine Fishes of Puget Sound, Washington. NMFS, Northwest and Alaska Fisheries Center, Seattle, Washington. May 1977. 128p.

Washington, P. M., R. Gowan, and D. H. Ito. 1978. A Biological Report on Eight Species of Rockfish (*Sebastes* spp.) from Puget Sound, Washington. NMFS, Northwest and Alaska Fisheries Center Processed Report, Seattle, Washington. April 1978. 63p.

Wasser, S. K., J. I. Lundin, K. Ayres, E. Seely, D. Giles, K. Balcomb, J. Hempelmann, K. Parsons, and R. Booth. 2017. Population growth is limited by nutritional impacts on pregnancy success in endangered Southern Resident killer whales (*Orcinus orca*). PLoS ONE. 12(6): 1-22.

WDFW. 2010. Draft narratives of Puget Sound Fisheries. Unpublished document, on file with the National Marine Fisheries Service, Sandpoint Way NE, Seattle, WA 98115.

WDFW. 2012. Application for an Individual Incidental Take Permit under the Endangered Species Act of 1973, March 2012. Prepared for the National Marine Fisheries Service by the Washington Department of Fish and Wildlife.

WDFW. 2014a. North/Middle Fork Nooksack native Chinook hatchery restoration program (Kendall Creek hatchery) HGMP. September 23, 2014. WDFW, Olympia, Washington. 46p.

WDFW. 2014b. Personal communication, via email to Dan Tonnes (NMFS) from Robert Pacunski (WDFW), regarding WDFW estimates of catch from recreational anglers in Puget Sound for 2003 – 2011, January 7, 2014.

WDFW. 2015. Personal communication, via email to Dan Tonnes (NMFS) from Eric Kraig (WDFW), regarding WDFW estimates of catch from recreational anglers in Puget Sound. March 17, 2015. Unpublished rockfish bycatch data, on file with the National Marine Fisheries Service, Sandpoint Way NE, Seattle, WA 98115.

WDFW. 2016. Personal communication, via email to Dan Tonnes (NMFS) from Eric Kraig (WDFW), regarding WDFW estimates of catch from recreational anglers in Puget Sound. March 8, 2016.

WDFW. 2017a. Draft conservation plan for reducing the impact of selected fisheries on ESA listed species in Puget Sound, with an emphasis on bocaccio and yelloweye rockfish. Prepared for the National Marine Fisheries Service by the Washington Department of Fish and Wildlife.

WDFW. 2017b. Personal communication, via email to Dan Tonnes (NMFS) from Eric Kraig (WDFW), regarding WDFW estimates of catch from recreational anglers in Puget Sound. March 8, 2017.

WDFW. 2018. Personal communication, via email to Dan Tonnes (NMFS) from Eric Kraig (WDFW), regarding WDFW estimates of catch from recreational anglers in Puget Sound. April 9, 2018.

WDFW. 2019a. Personal communication, via email to Dan Tonnes (NMFS) from Eric Kraig (WDFW), regarding WDFW estimates of catch from recreational anglers in Puget Sound. March 12, 2019.

WDFW. 2019b. Swinomish Indian Tribe, Upper Skagit Indian Tribe and Sauk-Suiattle Indian Tribe. 2018-2019 Wild Skagit Steelhead Management Season Post-Season Report. December 4, 2019. 6p.

WDFW. 2020a. Catch and Release Steelhead Will Not Open on Skagit, Sauk Rivers Amid Projected Low Returns. WDFW Press Release. January 14, 2020. 3p.

WDFW. 2020b. Email Communication from Elezear (WDFW) B. McClure, P. Kairis and C. Ruff to NMFS staff. February 14, 2020. 5p.

WDFW. 2020c. Personal communication, via email to Dan Tonnes (NMFS) from Eric Kraig (WDFW), regarding WDFW estimates of catch from recreational anglers in Puget Sound. March 4, 2020.

WDFW. 2021. Final Part I Status and Trends Analysis of Adult Abundance Data. Prepared in Support of Governor's Salmon Recovery Office 2020 State Salmon in Watersheds Report. WDFW Authors: Thomas Buehrens and Neala Kendall. Sent to Erik Neatherlin and Jennifer Johnson (GSRO) from Laurie Peterson (WDFW) on January 13, 2021. 28p.

WDFW, and PSIT. 2018. 2016/2017 Puget Sound Steelhead Harvest Management Plan Report. Chris James (Northwest Indian Fisheries Commission) and Robert Leland (Washington Department of Fish and Wildlife (eds). February 12, 2018. 10p.

WDFW, and PSIT. 2019. Puget Sound Chinook Comprehensive Harvest Management Plan Annual Report Covering the 2018-2019 Fishing Season. October 2019. Olympia, Washington. 79p.

WDFW, and PSTIT. 2009. Puget Sound Chinook Comprehensive Harvest Management Plan Annual Report Covering the 2008-2009 Fishing Season. May 11, 2009. Olympia, Washington. 136p.

WDFW, and PSTIT. 2011. Puget Sound Chinook Comprehensive Harvest Management Plan Annual Report Covering the 2010-2011 Fishing Season. August 1, 2011. Olympia, Washington. 125p.

WDFW, and PSTIT. 2012. Puget Sound Chinook Comprehensive Harvest Management Plan Annual Report Covering the 2011-2012 Fishing Season. October 3, 2012. Olympia, Washington. 125p.

WDFW, and PSTIT. 2013. Puget Sound Chinook Comprehensive Harvest Management Plan Annual Report Covering the 2012-2013 Fishing Season. Revised August 13, 2013. Olympia, Washington. 114p.

WDFW, and PSTIT. 2014. Puget Sound Chinook Comprehensive Harvest Management Plan Annual Report Covering the 2013-2014 Fishing Season. June 2014. Olympia, Washington. 78p.

WDFW, and PSTIT. 2015. Puget Sound Chinook Comprehensive Harvest Management Plan Annual Report Covering the 2014-2015 Fishing Season. December 2015 Revision. Olympia, Washington. 126p.

WDFW, and PSTIT. 2016a. 2014/2015 Puget Sound Steelhead Harvest Management Plan Report. Chris James (Northwest Indian Fisheries Commission) and Robert Leland (Washington Department of Fish and Wildlife (eds). March 2016. 10p.

WDFW, and PSTIT. 2016b. Puget Sound Chinook Comprehensive Harvest Management Plan Annual Report Covering the 2015-2016 Fishing Season. November 2016. Olympia, Washington. 122p.

WDFW, and PSTIT. 2017a. 2015/2016 Puget Sound Steelhead Harvest Management Plan Report. Chris James (Northwest Indian Fisheries Commission) and Robert Leland (Washington Department of Fish and Wildlife (eds). March 2017. 10p.

WDFW, and PSTIT. 2017b. Puget Sound Chinook Comprehensive Harvest Management Plan Annual Report Covering the 2016-2017 Fishing Season. September 2017. Olympia, Washington. 140p.

WDFW, and PSTIT. 2018. 2017-2018 Wild Skagit Steelhead Management Season Post-Season Report. November 29, 2018. 6p.

WDFW, and PSTIT. 2019. 2017/2018 Puget Sound Steelhead Harvest Management Report. January 25, 2019. 13p.

WDFW, and PSTIT. 2020. 2018/2019 Puget Sound Steelhead Harvest Management Report. February 19, 2020. 13p.

WDFW, and PSTIT. 2021. 2019/2020 Puget Sound Steelhead Harvest Management Report. February 10, 2021. 13p.

WDFW, Swinomish Indian Tribe, Upper Skagit Indian Tribe, and Sauk-Suiattle Inidian Tribe. 2021. 2019-2020 Wild Skagit Steelhead Management Season Post-Season Report. January 7, 2021. Final version updated January 28, 2021. 6p.

WDOE. 2017. Spill Prevention, Preparedness, and Response Program. 2017-2019 Program Plan. Publication 17-08-018. 29p.

Weilgart, L. S. 2007. The impacts of anthropogenic ocean noise on cetaceans and implications for management. Canadiann Journal of Zoology. 85(11): 1091-1116.

Weis, L. J. 2004. The effects of San Juan County, Washington, marine protected areas on larval rockfish production. A thesis submitted in partial fulfillment ofthe requirements for the degree of Master of Science, University of Washington.

Weitkamp, L. A. 2010. Marine distributions of Chinook salmon from the west coast of North

America determined by coded wire tag recoveries. American Fisheries Society. 139(1): 147-170.

West, J., S. O'Neill, G. Lippert, and S. Quinnell. 2001. Toxic Contaminants in Marine and Anadromous Fishes from Puget Sound, Washington: Results of the Puget Sound Ambient Monitoring Program Fish Component, 1989-1999. WDFW, Olympia, Washington. August 2001. 311p. Available at: http://dfw.wa.gov/publications/01026/wdfw01026.pdf.

Wiles, G. J. 2004. Washington State Status Report for the Killer Whale. March 2004. WDFW, Olympia, Washington. 120p.

Williams, G. D., P. S. Levin, and W. A. Palsson. 2010a. Rockfish in Puget Sound: An ecological history of exploitation. Marine Policy. 34(5): 1010–1020.

Williams, G. D., P. S. Levin, and W. A. Palsson. 2010b. Rockfish in Puget Sound: An ecological history of exploitation. Marine Policy. 34(5): 1010-1020.

Williams, R., E. Ashe, and D. Lusseau. 2010c. Killer whale activity budgets under no-boat, kayak-only and power-boat conditions. Contract via Herrera Consulting, Seattle, Washington.

Williams, R., M. Krkos, E. Ashe, T. A. Branch, S. Clark, P. S. Hammond, E. Hoyt, D. P. Noren, D. Rosen, and A. Winship. 2011. Competing Conservation Objectives for Predators and Prey: Estimating Killer Whale Prey Requirements for Chinook Salmon. PLoS ONE. 6(11): e26738.

Williams, R., D. Lusseauc, and P. S. Hammond. 2006. Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca*). Biological Conservation. 113: 301-311.

Winn, H. E., and N. E. Reichley. 1985. Humpback whale, *Megaptera novaeangliae* (Borowski, 1781). Pages 241-274 *in* S. H. Ridgway, and S. R. Harrison, editors. Handbook of marine mammals, volume 3: the Sirenians and Baleen Whales. Academic Press, London, England.

Wood, H. L., J. I. Spicer, and S. Widdicombe. 2008. Ocean acidification may increase calcification rates, but at cost Proceedings of the Royal Society B: Biological Sciences. 275(1644): 1767-1773.

Yamanaka, K., and L. C. Lacko. 2001. Inshore Rockfish (*Seb. ruberrimus, S. malinger, S. cauinus, S. melanops, S. nigrocinctus, and S. nebulosus*). Stock assessment for the west coast of Canada and recommendation for management. SSC 2000. 102p.

Yamanaka, K. L., and A. R. Kronlund. 1997. Inshore rockfish stock assessment for the west coast of Canada in 1996 and recommended yields for 1997. Can. Tech. Rep. Fish. Aquat. Sci. 2175.

Yamanaka, K. L., and G. Logan. 2010. Developing British Columbia's inshore rockfish conservation strategy. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science. 2(1): 28-46.

Ylitalo, G. M., J. E. Stein, T. Hom, L. L. Johnson, K. L. Tilbury, A. J. Hall, T. Rowles, D. Greig, L. J. Lowenstine, and F. M. D. Gulland. 2005. The role of organochlorines in cancer-associated mortality in California sea lions (*Zalophus californianus*). Marine Pollution Bulletin. 50: 30-39.

Zamon, J. E., T. J. Guy, K. Balcomb, and D. Ellifrit. 2007. Winter observations of Southern Resident Killer Whales *(Orcinus orca*) near the Columbia River plume during the 2005 spring Chinook salmon (*Oncorhynchus tshawytscha*) spawning migration. Northwestern Naturalist. 88(3): 193-198.

Ziccardi, M. H., S. M. Wilkin, T. K. Rowles, and S. Johnson. 2015. Pinniped and Cetacean Oil Spill Response Guidelines. U.S. Dept. of Commer., NOAA. December 2015. NOAA Technical Memorandum NMFS-OPR-52, 150p.

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[79]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[80]5 and a moderate to high likelihood that a majority of populations would achieve their

[79]4 Also referred to in previous opinions as the Upper Escapement Threshold.

[80]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 (≥ 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,[816] 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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[816] Equivalently, this could be termed "potential spawners" because it represents the number of fish that would return to spawn absent harvest-related mortality.

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

$R = (aSe^{-bS})(M^{c}e^{dF})$	[Ricker]
$R = (S/[bS + a])(M^{c}e^{dF})$	[Beverton-Holt]
$R = (\min[aS, b])(M^{c}e^{dF})$	[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.[82]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

[82]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

Appendix C

Table 2. Habitat Restoration Projects Funded with FY 2020 Pacific Salmon Treaty Implementation Funds

Project Name	Watershed	Project Sponsor
Dungeness Floodplain Restoration	Dungeness	Jamestown S'Klallam Tribe
Dosewallips Powerlines Acquisition & Design	Mid-Hood Canal	Mason County
Farmhouse Phase 4 Restoration	Nooksack	Nooksack Tribe
Middle Fork Nooksack Diversion Dam	Nooksack	American Rivers
Barnaby Reach Restoration	Skagit	Skagit System Cooperative
Hansen Creek Restoration	Skagit	Skagit System Cooperative
Reiner Acquisition	Snohomish	Tulalip Tribes
Gold Basin Habitat Restoration	Stillaguamish	Stillaguamish Tribe

Source: REPORT TO CONGRESS - 2018 RECERTIFICATION OF THE PACIFIC SALMON TREATY – SECOND BIANNUAL STATUS REPORT

Table 2. Habitat Restoration projects selected for FY21 PST funding.

Ranking	Project Sponsor	Project Name
1	Stillaguamish Tribe	Trafton Nursery Site Restoration
2	Stillaguamish Tribe	Anderson Family Farm (Cicero) Restoration and Design
3	Stillaguamish Tribe	Gold Basin Restoration
4	Nooksack Tribe	South Fork Nooksack Fish Camp Planning Area Design
5	Lummi Nation	South Fork Nooksack River Upper and Lower Fobes Reach Phase 2 Restoration
6	Skagit River System Cooperative	McGlinn Island Fish Passage Conceptual Design
7	Skagit River System Cooperative	Smokehouse Tidal Marsh Restoration (Final Design)
8	Tulalip Tribes	Snohomish Floodplain Acquisitions Phase I

9	Jamestown S'Klallam Tribe	Upper Dungeness Large Wood Restoration Phase 3

Source: REPORT TO CONGRESS - 2018 RECERTIFICATION OF THE PACIFIC SALMON TREATY – FY 2021 BIANNUAL STATUS REPORT