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*

Action Agency: National Marine Fisheries Service

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 Proposed or Designated Critical Habitat?**	**Is Action Likely To Destroy or Adversely Modify Critical Habitat?**
Southern Resident Killer Whale (*Orcinus orca*)	Endangered	Yes	No	Yes	No

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

Issued By:

For

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

Date: *April 21, 2021*

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List of Acronyms

ACOE	ARMY CORP OF ENGINEERS
BC	BRITISH COLUMBIA
BIA	BUREAU OF INDIAN AFFAIRS
CA	CALIFORNIA
CFR	FEDERAL CODE OF REGULATIONS
CO	CENTRAL OREGON
dB	DECIBELS
DDT	DICHLORODIPHENYLTRICHLOROETHANE
DFO	DEPARMENT OF FISHERIES AND OCEANS CANADA
DNA	DEOXYRIBONUCLEIC ACID
DPER	DAILY PREY ENERGY REQUIREMENT
DPS	DISTINCT POPULATION SEGMENT
DTAG	DIGITAL ACOUSTIC RECORDING TAG
EAR	ECOLOGICAL ACOUSTIC RECORDER
EFH	ESSENTIAL FISH HABITAT
ESA	ENDANGERED SPECIES ACT
ESU	EVOLUTIONARILY SIGNIFICANT UNIT
EEP	EXEMPTED FISHING PERMIT
EEZ	EXCLUSIVE ECONOMIC ZONE
FY	FISCAL YEAR
FMP	FISHERY MANAGEMENT PLAN
FRAM	FISHERY REGULATION ASSESSMENT MODEL
HPA	HYDRAULIC PROJECT APPROVAL
ITS	INCIDENTAL TAKE STATEMENT
KHZ	KILOHERTZ
KM	KILOMETER
KMZ	KLAMATH MANAGEMENT ZONE
KRFC	KLAMATH RIVER FALL CHINOOK
LCR	LOWER COLUMBIA RIVER
LOF	LIST OF FISHERIES
MCB	MID-COLUMBIA RIVER BRIGHTS
M/SI	MORTALITY AND SERIOUS INJURY
MI	MILES
MMAP	MARINE MAMMAL AUTHORIZATION PROGRAM
MMPA	MARINE MAMMAL PROTECTION ACT
MSA	MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT
NFWF	NATIONAL FISH AND WILDLIFE FOUNDATION
NMFS	NATIONAL MARINE FISHERIES SERVICE
NO	NORTH OREGON
NOAA	NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOF	NORTH OF FALCON
NRKW	NORTHERN RESIDENT KILLER WHALE
NWFSC	NORTHWEST FISHERY SCIENCE CENTER

OR	OREGON
PAH	POLYCYCLIC AROMATIC HYDROCARBON
PAL	PASSIVE AQUATIC LISTENER
PBF	PHYSIOLOCAL OR BIOLOGICAL FEATURES
PCB	POLYCHLORINATED BIPHENYL
PCE	PRIMARY CONSTITUENT ELEMENT
PFMC	PACIFIC FISHERY MANAGEMENT COUNCIL
PHOS	PROPORTION OF HATCHERY-ORIGIN FISH ON SPAWNING GROUND
PNI	PROPORTIONATE NATURAL INFLUENCE
PST	PACIFIC SALMON TREATY
RPA	REASONABLE AND PRUDENT ALTERNATIVE
RPM	REASONABLE AND PRUDENT MEASURE
SAFE	STOCK ASSESSMENT AND FISHERY EVALUATION
SCH	SPRING CREEK HATCHERY
SHB	STATE HOUSE BILL
SEAK	SOUTHEAST ALASKA
SF	SAN FRANCISCO
SOF	SOUT OF FALCON
SRFC	SACRAMENTO RIVER FALL CHINOOK
SRKW	SOUTHERN RESIDENT KILLER WHALE
SSC	SCIENTIFIC AND STATISTICAL COMMITTEE
STT	SALMON TECHNICAL TEAM
SWFSC	SOUTHWEST FISHERY SCIENCE CENTER
SWVCI	SOUTHWEST VANCOUVER ISLAND
UCR	UPPER COLUMBIA RIVER
URB	UP RIVER BRIGHT
VSP	VIABLE SALMON POPULATION
WA	WASHINGTON
WDFW	WASHINGTON DEPARTMENT OF FISH AND WILDLIFE
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 and conference opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402, as amended. The conference opinion concerning proposed critical habitat for Southern Resident killer whales does not take the place of a biological opinion under section 7(a)(2) of the ESA unless and until the conference opinion is adopted as a biological opinion when the proposed critical habitat designation becomes final. Adoption may occur if no significant changes to the action are made and no new information comes to light that would alter the contents, analyses, or conclusions of this opinion. As a result, this consultation will analyze effects on both designated and proposed critical habitat.

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 (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at the Protected Resources Division Seattle, WA office.

1.2. Consultation History

- NMFS consulted on the effects of the fisheries managed by NMFS and the Pacific Fishery Management Council (PFMC or Council) under the Pacific Coast Salmon Fishery Management Plan (FMP) ("Council salmon fisheries") under the ESA in 2009 (NMFS 2009) and concluded that the fisheries did not jeopardize the survival and recovery of the ESA-listed Southern Resident killer whales (SRKWs) (*Orcinus orca*) Distinct Population Segment (DPS). Since NMFS completed the 2009 consultation, a substantial amount of new information has become available on SRKW's status, diet, geographic distribution, and body condition and on their primary prey, Chinook salmon, such as stock abundance and distribution.

- In a letter to the Council dated March 6, 2019, NMFS announced we were re-initiating ESA consultation on the Council salmon fisheries and invited the Council to help reassess the effects of Council salmon fisheries on SRKWs (Agenda Item D.1.a, Supplemental NMFS Report 4, March 2019)

- On April 12, 2019, NMFS reinitiated consultation (NMFS 2019a) to consider the effects of Council-managed fisheries under the FMP on the SRKWs.

- Because the reinitiation could not be completed prior to the start of the 2019 Council-managed salmon fisheries, NMFS assessed the Council's alternative sets of management measures for the 2019 fisheries with respect to their potential effects on SRKWs and presented that assessment to the Council to inform its selection of a final recommended set of management measures (Agenda Item F.1.e, Supplemental NMFS Report 1, April 2019). NMFS considered the Council's recommended set of management measures in conjunction with its approval and implementation of those measures and concluded implementation of the measures would not likely jeopardize SRKWs, and did not represent an irreversible or irretrievable commitment of resources (NMFS 2019b).

  - NMFS' conclusion that the 2019 salmon fishery management measures were not likely to jeopardize SRKWs was based on the facts that (1) we did not anticipate relatively low coastwide Chinook salmon abundance coupled with relatively large percent reductions, and (2) we did not anticipate the Council fisheries to substantially reduce the availability of the vulnerable priority prey Chinook salmon stocks (i.e., relatively low abundance priority Chinook salmon stocks).

- In April 2019, the Council formed the ad-hoc SRKW workgroup (Workgroup) to reassess the effects of Council-area ocean salmon fisheries on the Chinook salmon prey base of SRKWs, and depending on the results, potentially recommend conservation measure(s) or management tool(s) that limit PFMC salmon fishery impacts to Chinook salmon prey availability.
- The Workgroup developed a draft risk assessment, which was presented to the Council in March 2020 (Agenda Items E.3.a, SRKW Workgroup Report 1 and Supplemental SRKW-WG Presentation 1, March 2020), however it did not complete its task of recommending any conservation measures or management tools in time for the 2020 preseason planning process. To address the 2020 fisheries, at the March 2020 Council meeting, NMFS described its process for the 2020 consultation and provided guidance for the Council's development of 2020 fishery management measures. Among other recommendations in its guidance, NMFS recommended using a low Chinook salmon abundance threshold as a trigger for considering changes to fishery management in order to increase the certainty that the fisheries would not further exacerbate the weakened status of the whales for the 2020/2021 fisheries season (Agenda Item E.5.b, Supplemental NMFS Report 1, March 2020).
- On April 29, 2020, NMFS issued a biological opinion on the implementation of the FMP in 2020 for SRKWs and their current and proposed critical habitat (NMFS 2020a). NMFS used the best available science and relied heavily on the Workgroup's draft risk assessment at the time and concluded the proposed action was likely to adversely affect but was not likely to jeopardize the continued existence of SRKWs. NMFS also concluded the action was likely to adversely affect the current or proposed critical habitat but not likely to destroy or adversely modify that habitat.
- The Workgroup met numerous times during the course of 2019 and 2020. All meetings were noticed in the Federal Register (FR) notices and open to the public. The Workgroup finalized its risk assessment to help inform the Council of potential impacts on SRKWs as a result of implementing the FMP (Agenda Item E.2.a, SRKW Workgroup Report 1, June 2020; referenced throughout the remainder of this opinion as PFMC 2020a). The drafts and final version of the risk assessment report were available for public comment and were commented on by the PFMC Salmon Advisory Subpanel, the Salmon Technical Team, and

the Scientific and Statistical Committee subcommittees[1]. In September 2020, the Workgroup provided a report (Agenda Item H.3.a, SRKW Workgroup Report 1, September 2020) that included a purpose and need statement, scope of action, and a draft range of management measure alternatives and recommendations for Council consideration. The Council adopted the range of management measure alternatives for public review and asked the Workgroup to provide additional information—which they did at the Council meeting in November 2020 (Agenda Item F.2.a, Workgroup Report 1; Agenda Item F.2.a, Workgroup Report 2; and Agenda Item F.2.a, Workgroup Report 3).

- In November 2020, NMFS provided an analytical document that described combinations of the management measure alternatives described in the Workgroup's September and November reports to the Council and assessed the effects of those alternatives on SRKWs and other resources (Agenda Item F.2.a, Supplemental NMFS Report 1, November 2020).
- The Council took final action in November 2020 and adopted Amendment 21 to address the effect of Council-area ocean salmon fisheries on the Chinook salmon prey base of SRKWs. Amendment 21 is described in the proposed action, refer to Section 1.1.3 Amendment 21.

1.3. Proposed Federal Action

Under the ESA, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). The proposed action is the authorization of the ocean salmon fishery in the west coast Exclusive Economic Zone (EEZ) (3 to 200 nautical miles off the coast of Washington, Oregon, and California) through approval of the fishery management plan (FMP) and promulgation of regulations implementing the plan, including approval and implementation of Amendment 21. NMFS has dual responsibilities as both the action agency that authorizes the fisheries under the Magnuson-Stevens Fishery Conservation and Management Act (MSA), and as the consulting agency under the authority of the ESA.

The ocean fisheries in the EEZ are recreational and commercial troll fisheries that use hook-and-line gear to catch salmon. Chinook salmon (*Oncorhynchus tshawytscha*), coho or silver salmon (*O. kisutch*), and pink salmon (*O. gorbuscha*) are the main species caught in Council-managed ocean salmon fisheries and they are the species for which the FMP includes fishery management objectives. Salmon of U.S. and Canadian origin and caught in the EEZ are managed under the FMP except for species that are managed by another management entity with primary jurisdiction (*i.e.,* sockeye and pink salmon by the Fraser River Panel of the Pacific Salmon Commission in the Fraser River Panel Area (U.S.) between 49°N latitude and 48°N latitude). Catches of other salmon species are inconsequential (low hundreds of fish or less each year) to very rare (PFMC 2016). The fisheries are mixed-stock fisheries, where fish encountered typically represent more than one stock[2] or ESU of Chinook or coho.

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[1] All public comments and subcommittee reports can be found in the PFMC briefing books on their website: https://www.pcouncil.org/category/briefing-book/

[2] The NS1 Guidelines provide a structure for classifying stocks in and around the fishery, and organizing stock complexes (PFMC 2016). As described in the FMP, individual stocks can also be formed into stock complexes for management and assessment purposes. Stock complexes are groups of stocks that are sufficiently similar in geographic distribution, life history, and vulnerabilities to the fishery such that the impacts of management actions on the stocks

The FMP sets the framework under which the Council develops recommended annual management measures governing the ocean salmon fisheries. The annual management measures apply to the period from mid-May of the current year through April-May of the following year[3]. Under the FMP, each salmon stock or stock complex is managed subject to a specified conservation objective. If one stock in the mix of stocks in the ocean in a given year is at an abundance that is compatible with relatively high fishing pressure, but another weaker stock requires a lower fishing pressure, then the ocean fishery is managed to target the limiting rate for the weaker stock. This leaves some of the harvestable fish from the stronger stock uncaught ("weak stock management"). Some stocks and stock complexes are managed to annual catch limits, which are set annually using harvest control rules described in the FMP. Others are managed under the Pacific Salmon Treaty with Canada, and have objectives related to that agreement. For ESA-listed salmon, the conservation objectives are referred to as consultation standards; these equate to levels of take (in some cases combined with additional management measures) that NMFS has determined through ESA section 7 consultation are not likely to jeopardize the continued existence of the species (refer to Table 1). The FMP requires the PFMC to set management recommendations that ensure the impacts of the fishery are consistent with all of these conservation objectives.

Table 1. NMFS ESA determinations regarding Evolutionarily Significant Units (ESUs) and DPSs affected by PFMC salmon directed fisheries and the duration of the 4(d) Limit determination or biological opinion (BO). (Only those decisions currently in effect are included.)

Date (Decision type)	Duration	Citation	Species Covered
March, 9 1996 (BO)	until reinitiated	NMFS 1996	Snake River spring/summer and fall Chinook, and sockeye
April 28, 1999 (BO)	until reinitiated	NMFS 1999	S. Oregon/N. California Coasts coho Central California Coast coho Oregon Coast coho
April 28, 2000 (BO)	until reinitiated	NMFS 2000	Central Valley Spring-run Chinook California Coastal Chinook
April 30, 2001 (BO)	until reinitiated	NMFS 2001a	Upper Willamette River Chinook Columbia River chum Ozette Lake sockeye Upper Columbia River spring-run Chinook Ten listed steelhead DPSs
September 14, 2001 (BO, 4(d) Limit)	until withdrawn	NMFS 2001b	Hood Canal summer-run chum
April 29, 2004 (BO)	until withdrawn	NMFS 2004	Puget Sound Chinook

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are similar (PFMC 2016). Stock complexes may be formed to facilitate management requirements. Each stock complex has one or more indicator stocks to establish annual harvest constraints based on status of those indicator stocks. A detailed listing of the individual stocks and stock complexes managed under the FMP are provided in Table 1-1 in PFMC 2016.

[3] At its September 2020 meeting, the Council adopted a final preferred alternative for Amendment 20 to the FMP. Amendment 20, if approved, would modify the preseason schedule for setting annual management measures, change a management area boundary, and bring language in several sections of the FMP up to date. Under Amendment 20, the effective date for the annual management measures would change from May 1 to May 16.

June 13, 2005 (BO)	until reinitiated	NMFS 2005	California Coastal Chinook
April 27, 2012 (BO)	until reinitiated	NMFS 2012c	Lower Columbia River Chinook
April 9, 2015 (BO)	until reinitiated	NMFS 2015c	Lower Columbia River coho
March 3, 2018 (BO)	until reinitiated	NMFS 2018e	Sacramento River winter-run Chinook

The PFMC salmon fisheries are managed consistent with the provisions of the PST, which also governs fisheries in southeast Alaska (SEAK), those off the coast of British Columbia, and fisheries in Puget Sound, the Columbia River and the Oregon Coast. Canadian and SEAK salmon fisheries impact salmon stocks from the states of Washington, Oregon, and Idaho as well as salmon originating in SEAK and Canadian waters. Fisheries off the U.S. West Coast and in inland waters 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.

The 2019 - 2028 PST Agreement includes reductions in harvest impacts for all Chinook fisheries within its scope and refines the management of coho salmon caught in these areas. 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 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 under the jurisdiction of the PFMC are reduced by up to 15% from the previous agreement (2009 through 2018). Although provisions of the updated Agreement are complex, they were specifically designed to reduce fishery impacts in all fisheries to respond to conservation concerns for a number of U.S. 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 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 implementation of 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 is being used in support of Puget Sound Critical Stock Conservation and Habitat Restoration and Protection, consistent with the funding initiative. The beneficial effects of these activities (i.e., increases in the abundance of Chinook salmon available as prey to SRKWs, hatchery conservation programs to support critical Puget Sound Chinook populations, and improved habitat conditions for those populations) are expected to begin in 3 – 5 years following implementation. Subsequent specific actions (i.e., hatchery production programs) will undergo separate consultations, tiered from the programmatic consultations (NMFS 2019e) to assess effects for site-specific actions. 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 PFMC salmon fisheries over the long term to SRKWs. Additional detail on the activities associated with the PST funding initiative are described in more detail in the Environmental Baseline.

For purposes of this opinion, we assume that funding for the conservation program for Puget Sound Chinook salmon and SRKW will continue largely as described in this and the previous opinion associated with domestic actions related to the 2019 PST Agreement (NMFS 2019e) and the program will be implemented during the duration of the new Chinook salmon regime under the 2019 PST Agreement. Although the benefits from reduction in harvest in SEAK and other fisheries resulting from the new 2019 PST Agreement (as described in NMFS 2019e) were immediately effective, it is important to note that the effects assumed in the analysis related to the funding initiative will not take place for at least three to five years following implementation. As projects are implemented (such as those described hatchery and habitat projects described above), it will take several years for fish from increased hatchery production to reach maturity in the oceans and become prey for the whales and it may take even longer before productivity improvements are realized from the habitat restoration projects. Although funding for the conservation program has been provided as anticipated for FY2020 and FY2021, we recognize that there is a degree of uncertainty regarding whether Congress will continue to provide the funding, in whole or in part, that was agreed to by the U.S. Section in a timely manner. In the event the required funding is 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 the proposed action that could result in effects on Puget Sound Chinook salmon and SRKWs not considered in this opinion. If so, reinitiation of consultation would therefore be required. See 50 CFR section 402.16(c). We expect this opinion and ITS to remain in place during the interim should reinitiation occur.

It is important to emphasize that, although the funding initiative is relevant to NMFS' consideration of the PFMC salmon fishery in this opinion, and it was relevant to NMFS' consideration in the SEAK salmon fishery (NMFS 2019e), it will likewise be an essential element of our review of future fisheries in Puget Sound as well. For example, a new 10 year Puget Sound Chinook Harvest Resource Management Plan, currently under development, will be subject to ESA evaluation regarding the effects on salmon and SRKWs. Fundamentally, all U.S fisheries may be affected by decisions made in the event that funding is not provided.

The Council develops fishery management measures annually to take account of annual abundance projections for the salmon stocks in the fishery, since abundance can vary significantly from one year to the next. At the beginning of the annual preseason planning process, the forecasts used for the various stocks used to set salmon fisheries for the coming fishing season become available and the Council uses them to develop alternative sets of management measures for further analysis and public review (see, e.g. PFMC 2020b). The

Council adopts its final management measures at its April meeting, based on analysis showing that all conservation objectives would be met given the abundance forecasts and proposed fisheries. These measures include descriptions of open fishing periods and locations for the annual ocean salmon fishery (see, e.g. PFMC 2020c).

The PFMC transmits its management measure recommendations to the Secretary of Commerce (Secretary), who promulgates the measures in a final rule if they are determined to be consistent with the MSA and other applicable law such as the ESA. NMFS takes inseason action to close fisheries when quotas are projected to be reached (50 CFR section 660.409(a)). NMFS may take inseason action to modify fishery management measures such as quotas, fishing dates, and bag limits after consultation with state fishery managers and the Council chair (50 CFR 660.409(b)). Inseason actions in this latter category must be consistent with the FMP's conservation objectives, treaty Indian fishing rights, and other applicable laws and FMP provisions.

While the FMP and implementing regulations apply only in the EEZ, salmon fisheries in state waters (0-3 miles off the coast, hereinafter referred to as "state ocean waters," does not include Puget Sound) are managed consistent with federal management. Quotas established in federal regulations include Chinook and coho catch in state ocean waters, and catch in those waters is included in modeling exercises to determine if the objectives in the FMP are projected to be met given the annual fishery management measures. The states have committed to coordinate with implementation of Amendment 21 as described below. In short, state management of salmon fisheries in state ocean waters is closely coordinated with and largely mirrors federal management. Even though state-managed fisheries would still occur, the specific management measures the states used as described in this opinion are caused by the proposed action.

A detailed description of the specific fishery marine areas and historical catch and effort data is found in the Review of Ocean Salmon Fisheries document available at each year's March PFMC meetings and also located on the PFMC website (e.g. Stock Assessment and Fishery Evaluation documents). Here we summarize the PFMC salmon fisheries season structure by spatial area (we relied heavily on PFMC 2020a for the summary below, see Figure 1). We follow with a summary description of the proposed Amendment 21.

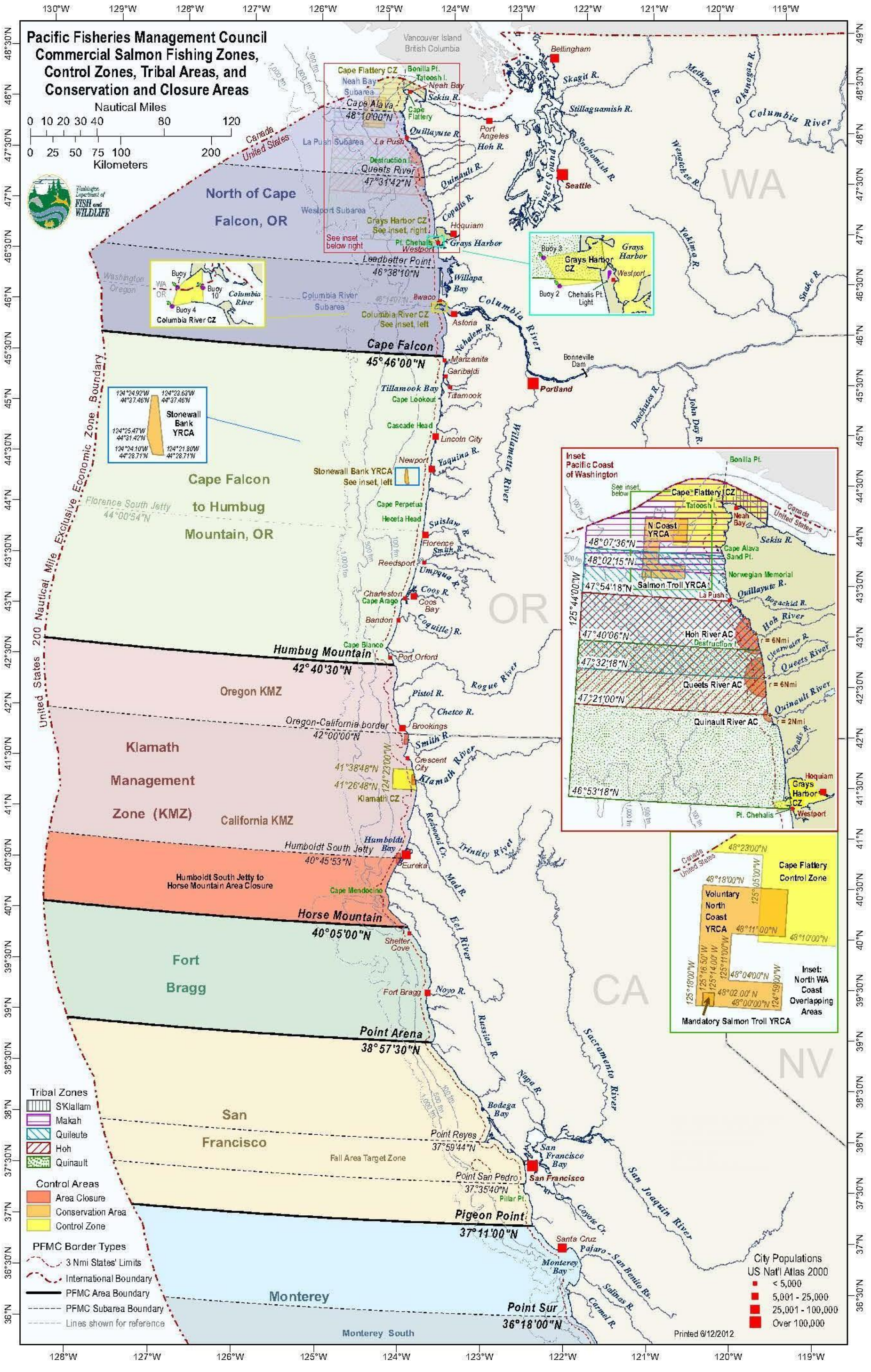

Figure 1. Map of Pacific Coast showing major salmon management areas and conservation zones. Map does not reflect the recent Council-adopted new southern boundary of the Klamath Management Zone at latitude 40°10'00" N. lat. (previously Horse Mt.). The Council moved the boundary north to 40°10'00" N. lat. under Amendment 20 to the Pacific Coast Salmon FMP, which was adopted by the Council in

September 2020.

1.3.1. North of Falcon (NOF) Salmon Fisheries

As described in Section 4.4 in PFMC (2020a), the NOF management area encompasses the Washington coast and the northern Oregon coast. Harvest allocation and seasons may vary among the four ocean subareas the Council uses, which include the Columbia River subarea - Leadbetter Point to Cape Falcon, OR (WDFW Marine Area 1), the Westport subarea - Queets River to Leadbetter Point, WA (WDFW Marine Area 2), the La Push subarea - Cape Alava to Queets River, WA (WDFW Marine Area 3), and the Neah Bay subarea - U.S./Canada Border to Cape Alava, WA (WDFW Marine Area 4) (refer to Figure 2 and Figure 2). In some years, the Council may adopt regulations specific to subareas of these areas to manage impacts to stay within FMP objectives.

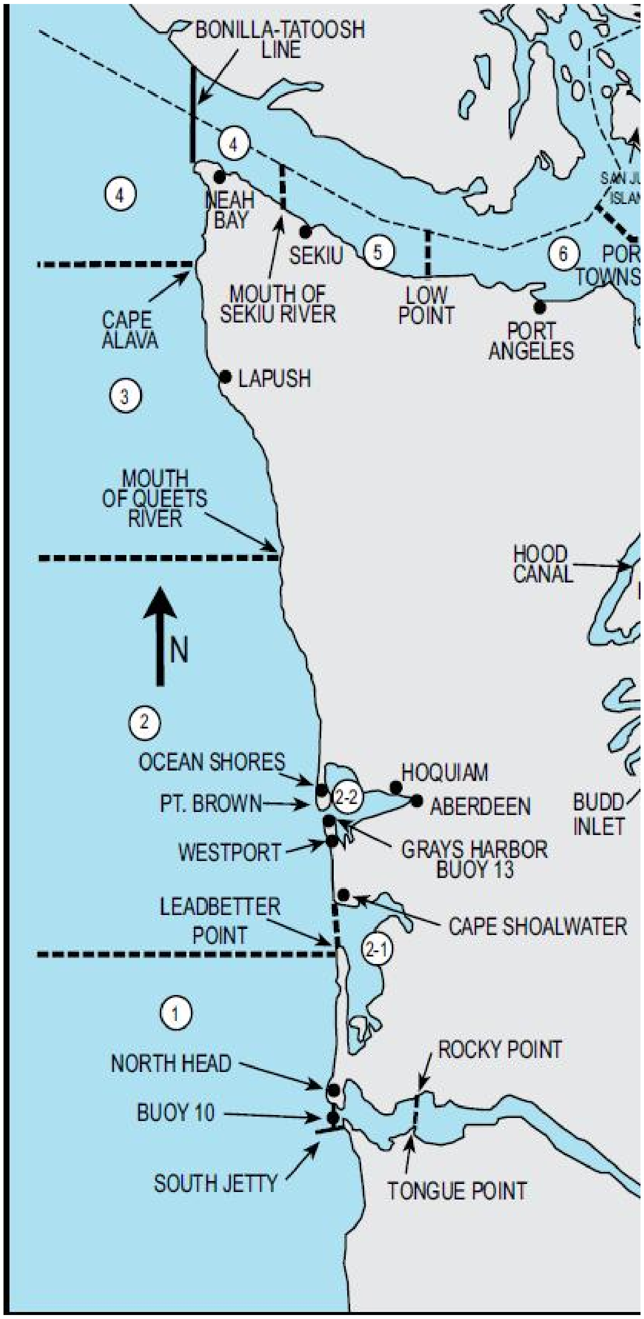

Figure 2. Coastal Washington Salmon Fishing Marine Areas (revised and reprinted from http://www.eregulations.com/washington/fishing/marine-area-rules-definitions/.

Stocks that constrain NOF fisheries (i.e., stocks that require lower fishing pressure in a given year in order to meet the applicable conservation objective) vary annually depending on relative stock abundance and allocation of allowable impacts between the ocean salmon fisheries and marine and freshwater fisheries within inland waters of Washington (PFMC 2020a). In recent years, fisheries have been structured to limit impacts on (a) ESA-listed Chinook salmon stocks from the Columbia River and Puget Sound, (b) non-listed Chinook stocks in California, (c) ESA-listed coho salmon from the Columbia River, (d) non-listed coho salmon stocks from the Washington Coast and Puget Sound; and (e) coho stocks from the Fraser River consistent with provisions of the PST Agreement.

North of Falcon Coastal Non-Tribal Commercial and Recreational Ocean Fisheries

As described in PFMC (2020a), Chinook and coho catch quotas are set preseason to manage these fisheries. Fisheries are planned based on allocations between recreational and commercial sectors and between subareas as established in the FMP (PFMC 2020a). The commercial non-tribal troll fishery in NOF waters is typically open for a Chinook-only season between May 1 and June 30 and an all-species season July 1-September 30. For the recreational fishery in NOF waters in previous years, season opening dates, closing dates and daily retention limits vary by year and by subarea. The goal for these fisheries described in the FMP is to provide coho salmon for an all-species recreational fishery from late June through early September and, if possible, a minimal Chinook-only fishery prior to the all-species season.

Because the July-September season operates with one quota for Chinook salmon and another quota for coho salmon, reaching one quota before the fishery catches the other would result in closure for the season. In-season management focuses on managing the fishery throughout the season to maximize attainment of the quota, respond to changes in catch distribution across management areas and sectors, and address safety concerns. To achieve these goals, occasionally quota is transferred inseason between subareas, sectors and/or species in a manner that does not change the overall impacts on the affected stocks ("impact neutral"). Impact neutrality is assessed for limiting stocks (identified annually at the end of the preseason process) and requires that based on modeling, total fishery impacts to these stocks with an in-season action are equal to or less than originally planned for in that specific year.

Management boundaries and control zones (areas that may be closed) are used to manage the fishery; many of these can be changed from year to year to achieve management goals, others are defined in the FMP and are quite stable (PFMC 2016). Control zones that have been designated in recent years in NOF are the Cape Flattery Control (CFC) Zone[4], the Columbia River Control (CRC) Zone[5], and the Grays Harbor Control (GHC) Zone[6] (Figure 1). In general, control zones are closed to limit impacts on stocks of concern passing through those areas or staging before

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[4] The area from Cape Flattery (48º23'00" N. lat.) to the northern boundary of the U.S. EEZ; and the area from Cape Flattery south to Cape Alava (48º10'00" N. lat.) and east of 125º05'00" W. long. (as described in annual management measures).

[5] An area at the Columbia River mouth, bounded on the west by a line running northeast/southwest between the red lighted Buoy #4 (46°13'35" N. lat., 124°06'50" W. long.) and the green lighted Buoy #7 (46°15'09' N. lat., 124°06'16" W. long.); on the east, by the Buoy #10 line which bears north/south at 357° true from the south jetty at 46°14'00" N. lat.,124°03'07" W. long. to its intersection with the north jetty; on the north, by a line running northeast/southwest between the green lighted Buoy #7 to the tip of the north jetty (46°15'48" N. lat., 124°05'20" W. long.), and then along the north jetty to the point of intersection with the Buoy #10 line; and, on the south, by a line running northwest/southeast between the red lighted Buoy #4 and tip of the south jetty (46°14'03" N. lat., 124°04'05" W. long.), and then along the south jetty to the point of intersection with the Buoy #10 line. (as described in 2020 annual management measures).

[6] The area defined by a line drawn from the Westport Lighthouse (46° 53'18" N. lat., 124° 07'01" W. long.) to Buoy #2 (46° 52'42" N. lat., 124°12'42" W. long.) to Buoy #3 (46° 55'00" N. lat., 124°14'48" W. long.) to the Grays Harbor north jetty (46° 55'36" N. lat., 124°10'51" W. long.) (as described in 2020 annual management measures).

entering a terminal area[7]. For example, the CRC has typically been used to eliminate fishing in an area thought to contain a high proportion of sublegal Chinook salmon. This control zone closure allows fish undisturbed access to the river (see Section 6.1 in PFMC 2016).

Washington Coast Treaty Ocean Troll Fishery

Treaty Indian tribes have a legal entitlement to take up to 50 percent of the harvestable surplus of fish which pass through their usual and accustomed fishing areas. Within Council waters, the Makah, Quileute, Hoh, and Quinault tribes exercise their treaty rights to harvest salmon in their respective usual and accustomed fishing areas off Washington (Marine Areas 2, 3, and 4; Figure 2). In addition, Makah, Lower Elwha Klallam, Jamestown S'Klallam, and Port Gamble S'Klallam tribes exercise their treaty rights to harvest salmon in their respective usual and accustomed fishing areas in Marine Area 4B, the entrance to the Strait of Juan de Fuca. Treaty (or tribal) troll quotas are set through the Council's annual pre-season process. During the May through September time period treaty-tribal salmon harvest in Area 4B is attributed to the treaty troll quotas (PFMC 2020a).

Similar to the non-tribal commercial troll fishery, the treaty troll fishery consists of a Chinook-only season between May 1 and June 30 and an all-species season July 1 – September 30. Chinook remaining from the May through June treaty troll quota may be transferred to the July through September quota on an impact-neutral basis for limiting stocks. Treaty tribes may apply in-season effort controls, such as days open per week, vessel landing limits, fishery closures, etc., when necessary to ensure tribal harvest does not exceed the Chinook or coho treaty troll quotas.

1.3.2. South of Falcon (SOF) to California Border Salmon Fisheries

Fishery management in the South of Falcon (SOF) area is generally based on fishery seasons rather than quotas in contrast to the NOF area.

Oregon Coast

This area includes the major management areas of Oregon (Cape Falcon to Humbug Mt.) and the Oregon portion of the Klamath Management Zone (KMZ; Humbug Mt. to the OR/CA border; Figure 1; PFMC 2020a).

As described in PFMC (2020a), in the Cape Falcon to Humbug Mt. area, the commercial season is typically open from mid-March/early-April through October, with various mid-season closures to reduce impacts on limiting stocks. The Oregon KMZ season typically opens in mid-March/early-April, with monthly quotas beginning in June. These quotas may run through September in some years, but late-summer/fall fisheries do not occur every year. Constraining Chinook salmon stocks for commercial troll fisheries in the Oregon areas are most often those originating in California rivers (e.g. Klamath River fall Chinook salmon and Sacramento River fall Chinook salmon), which are managed for escapement goals as specified in the Council's FMP. Coho retention has been prohibited in commercial troll fisheries SOF since 1993 with the exception of limited fisheries in 2007, 2009, and 2014.

In the Oregon Coast area (Cape Falcon to OR/CA border area, PFMC 2020a), the large majority

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[7] Portions of the existing and proposed control zones occur in state waters, 0-3 miles offshore, thus closures in those waters are implemented by the states.

of the catch and effort in the recreational salmon fishery is directed at coho salmon. Various coho salmon quota fisheries occur from June through the summer (depending on quota) and into September, overlapping with the ongoing recreational Chinook salmon season. The Oregon KMZ recreational fishery is usually open for Chinook salmon (with some years of limited summer coho salmon fishing in the Oregon KMZ), early-May through early-September, although mid-season closures are common.

California Coast

Commercial and recreational fisheries targeting Chinook salmon along the California coast are managed within four major catch/port areas (north to south, Figure 1): (1) the California portion of the Klamath Management Zone (CA-KMZ), which extends from the OR-CA border to Horse Mountain (to be changed to 40°10'00" N. lat. assuming approval of Amendment 20), (2) Fort Bragg (Horse Mountain to be changed to 40°10'00" N. lat. assuming approval Amendment 20 to Point Arena), (3) San Francisco (Point Arena to Pigeon Point), and (4) Monterey (Pigeon Point to the US-Mexico border). Within each area, fisheries are shaped annually to provide harvest opportunity and to achieve stock conservation objectives and annual catch limits defined in the salmon FMP. Retention of coho has been prohibited off California since 1996.

As described in PFMC (2020a), both commercial and recreational opportunity tend to be greatest in the Fort Bragg and San Francisco areas. To the south and north, protracted early (Monterey) or late (CA-KMZ) seasons or quotas (CA-KMZ troll) are often adopted to reduce impacts on ESA-listed Sacramento River Winter Run Chinook salmon and California Coastal Chinook. Management objectives for Sacramento Fall and Klamath River Fall Chinook stocks also often play a role in limiting opportunity in the SOF area; fishing in the Fort Bragg and CA-KMZ is most constrained by objectives for Klamath River Fall Chinook, or by California Coastal Chinook in years with high Klamath River Fall Chinook abundance. In a year with high Klamath River Fall Chinook or Sacramento River Fall Chinook abundance, commercial troll fisheries may be open from May 1 through the middle of October, with earlier or later seasons precluded by limits to protect Sacramento winter run Chinook south of Point Arena. Recreational fisheries may be open from the first Saturday in April through the second Sunday in November, again with earlier or later seasons constrained or shaped to limit impacts on Sacramento River winter run Chinook south of Point Arena. Commercial and recreational seasons in the Monterey management area are typically further restricted than the end dates in the Fort Bragg and CA-KMZ (October and November for commercial and recreational, respectively) due to limits on the projected impact rate allowable for Sacramento River winter run Chinook.

1.3.3. Amendment 21

The FMP framework for purposes of this consultation includes proposed Amendment 21, adopted by the Council at its November 2020 meeting. This proposed Amendment is intended to limit the effects that the fisheries have on SRKWs by way of reduced prey availability and accessibility in years when Chinook abundance in the NOF area is particularly low. As described above, the areas within the EEZ that are open to salmon fishing and the lengths of time the areas are open in any one year depends on salmon stock abundances relative to the conservation objectives and the spatial distribution of constraining stocks. Amendment 21 would add provisions to address the overall impact on availability of Chinook prey for SRKWs from PFMC fisheries, in addition to the existing measures to address impacts to specific salmon stocks.

The proposed Amendment would establish a threshold representing a low pre-fishing Chinook salmon abundance in the NOF area (including abundance in the EEZ and state ocean waters), below which the Council and states would implement specific management measures. The NOF abundance threshold is equal to the arithmetic mean of the seven lowest years of time step 1 (TS1) starting abundance from the Fishery Regulation and Assessment Model (FRAM) (1994 – 1996, 1998 – 2000 and 2007, updated for validated run size abundance estimates). Time step 1 is defined as the abundance of Chinook salmon in the NOF area starting on October 1 (time step[8] 1, TS1) before the PFMC salmon fisheries start (hereafter referred to as "TS1 projected abundance"). For the years used to set this threshold, SRKW status varied, with two relatively good status years (1994 and 2007) and the remaining five consecutive years with fair or poor SRKW status. The threshold based on these years is currently estimated at 966,000 Chinook salmon. 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. Proposed Amendment 21 includes a review schedule for possible updates to model parameters (e.g. if the models used by the Workgroup need to be recalibrated) if new science becomes available. The threshold would be updated accordingly using the same methodology (e.g. the arithmetic mean of the TS1 projected abundance in the seven years identified).

Each year, the preseason estimate of Chinook salmon abundance for TS1 for the upcoming fishing year would be compared to the threshold. The preseason estimate of TS1 projected abundance would be obtained by taking a weighted sum across modeled stocks of the stock-specific preseason projections of total ocean abundance on October 1. The weights are the estimated proportions of each stock's ocean abundance in the NOF area according to the time-invariant distribution estimates for that time period obtained from the Shelton et al. (2019) model, or according to the proxies identified in the final Workgroup report (PFMC 2020a) for stocks not included in Shelton et al. (2019) that do not have time-invariant distribution estimates. In years when the TS1 projected abundance falls below the threshold, the Council would implement the following:

1. Further limit NOF non-tribal Chinook salmon quotas– Non-tribal quota limits would be defined using a regression relationship between NOF TS1 projected abundance and non-tribal Chinook salmon quotas. This would ensure that fisheries in years of low abundance could not have disproportionately high removals from the aggregate abundance relative to other years in the data series.
2. Attain the NOF non-tribal commercial troll quota incrementally over time (spring/summer split) – NOF non-tribal commercial troll fisheries occur during spring/summer seasons with a specified split of quota, which is typically two-thirds of the quota allocation going to the May-June time period. Under this management response the proportion of the non-tribal commercial troll quota assigned to the spring time period

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[8] Time steps are seasonal breakpoints which fishery aggregates data for modeling purposes. See PFMC 2020a for further explanation.

(May through June) would be reduced to no more than 50 percent of the non-tribal commercial troll Chinook salmon quota.

3. Closure of NOF Area Control Zones – NMFS, the Council, and the states of Washington and Oregon, have periodically implemented closed areas or "control zones" in the NOF area over time including during the past five years (2016 – 2020). These closures have included: the Cape Flattery Control Zone[9] which has been closed to non-tribal commercial troll fisheries year-round, the Columbia River Control Zone which has been closed to non-tribal commercial troll and recreational fisheries year-round, and the Grays Harbor Control Zone which has been closed to non-tribal commercial troll and recreational fisheries beginning the second Monday in August through the remainder of the fishery (refer to Figure 1 for a map of major salmon management areas and conservation zones). Under this management measure, these closures would be automatically implemented, and in addition, spatial and/or temporal expansions to the closures would occur as described below:
    a. Columbia River Control (CRC) Zone[10] - the CRC would be closed to non-treaty commercial troll and recreational fisheries year-round inside from Buoy 10 out to the end of each Jetty (Buoy 4 to Buoy 7) similar to 2016 – 2020. The CRC Zone would be spatially expanded to extend to a line running northwest/southeast between Buoy 1 and Buoy 2 (refer to Figure 3) from January 1 - June 15.
    b. Grays Harbor Control Zone[11] – The closure of this area would be extended in time to include January 1 - June 15.
4. In Oregon coastal waters south of Cape Falcon:
    a. Delay opening Oregon SOF commercial troll (Cape Falcon to Humbug Mountain) until April 1;
    b. Close the Oregon Klamath Management Zone (KMZ) beginning October 1 through March 31 of the following year
5. Management responses in California coastal waters would include:

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[9] The area from Cape Flattery (48º23'00" N. lat.) to the northern boundary of the U.S. EEZ; and the area from Cape Flattery south to Cape Alava (48º10'00" N. lat.) and east of 125º05'00" W. long. (as described in 2020 annual management measures).

[10] An area bounded on the west by a line running northwest/southeast between green entrance lighted bell buoy #1 (46°13'24" N. lat., 124°11'00" W. long.) and red entrance lighted whistle buoy #2 (46°12'46" N. lat., 124°08'03" W. long.); on the east, by the Buoy #10 line which bears north/south at 357° true from the south jetty at 46°14'00" N. lat.,124°03'07" W. long. to its intersection with the north jetty; on the north, by a line running northeast/southwest from green entrance lighted bell buoy #1 to the green lighted Buoy #7 (46°15'09' N. lat., 124°06'16" W. long.) to the tip of the north jetty (46°15'48" N. lat., 124°05'20" W. long.), and then along the north jetty to the point of intersection with the Buoy #10 line; on the south, by a line running northeast/southwest from red entrance lighted whistle buoy #2 to the red lighted Buoy #4 (46°13'35" N. lat., 124°06'50" W. long.) to the tip of the south jetty (46°14'03" N. lat., 124°04'05" W. long.), and then along the south jetty to the point of intersection with the Buoy #10 line.

[11] The area defined by a line drawn from the Westport Lighthouse (46° 53'18" N. lat., 124° 07'01" W. long.) to Buoy #2 (46°12'46" N. lat., 124°08'03" W. long.) to Buoy #3 (46° 55'00" N. lat., 124°14'48" W. long.) to the Grays Harbor north jetty (46° 55'36" N. lat., 124°10'51" W. long.) (as described in 2020 annual management measures).

a. From October 1 through March 31 of the following year close the CA Monterey (Pigeon Point to U.S./Mexico border) and the CA KMZ, which extends from OR/CA border to Horse Mountain (40°10’00’’, as defined in Amendment 20, currently with NMFS for consideration of approval) fishing areas,

b. As in the past five years, the Klamath River Control Zone[12] would be closed to salmon fishing. In addition the closed area would be expanded to 6 miles beyond the northern and southern boundaries of the recently closed area and 12 miles seaward of the western boundary of the recently closed area. The State of California would also ensure closure of other California control zones[13] are in effect year-round (Smith, Eel, Klamath rivers).

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[12] The ocean area at the Klamath River mouth bounded on the north by 41°38'48" N. lat. (approximately 6 nautical miles north of the Klamath River mouth); on the west by 124°23'00" W. long. (approximately 12 nautical miles off shore); and on the south by 41°26'48" N. lat. (approximately 6 nautical miles south of the Klamath River mouth). (from 2020 annual management measures).

[13] California salmon closure zones includes: 1) the Smith River mouth bounded on the north by 41°59’36” N. lat. (approximately 3 nautical miles north of the Smith River mouth), on the west by 124°16’24” W. long. (approximately 3 nautical miles offshore), and on the south by 41°53’30” N. lat. (approximately 3 nautical miles south of the Smith River mouth); 2) in ocean waters at the Klamath River mouth; 3) in ocean waters at the Eel River mouth bounded on the north by 40°40’24” N. lat. (approximately 2 nautical miles north of the Eel River mouth), on the west by 124°21’24” W. long. (approximately 2 nautical miles offshore), and on the south by 40°36’24” N. lat. (approximately 2 nautical miles south of the Eel River mouth). The Klamath mouth closure that exists for the rest of the year is: No salmon may be taken at any time in ocean waters at the Klamath River mouth bounded on the north by 41°53’30” N. lat. (approximately 3 nautical miles north of the Klamath River mouth), on the west by 124°08’54” W. long. (approximately 3 nautical miles offshore), and on the south by 41°29’24” N. lat. (approximately 3 nautical miles south of the Klamath River mouth) (from https://wildlife.ca.gov/Fishing/Ocean/Regulations/Sport-Fishing/General-Ocean-Fishing-Regs).

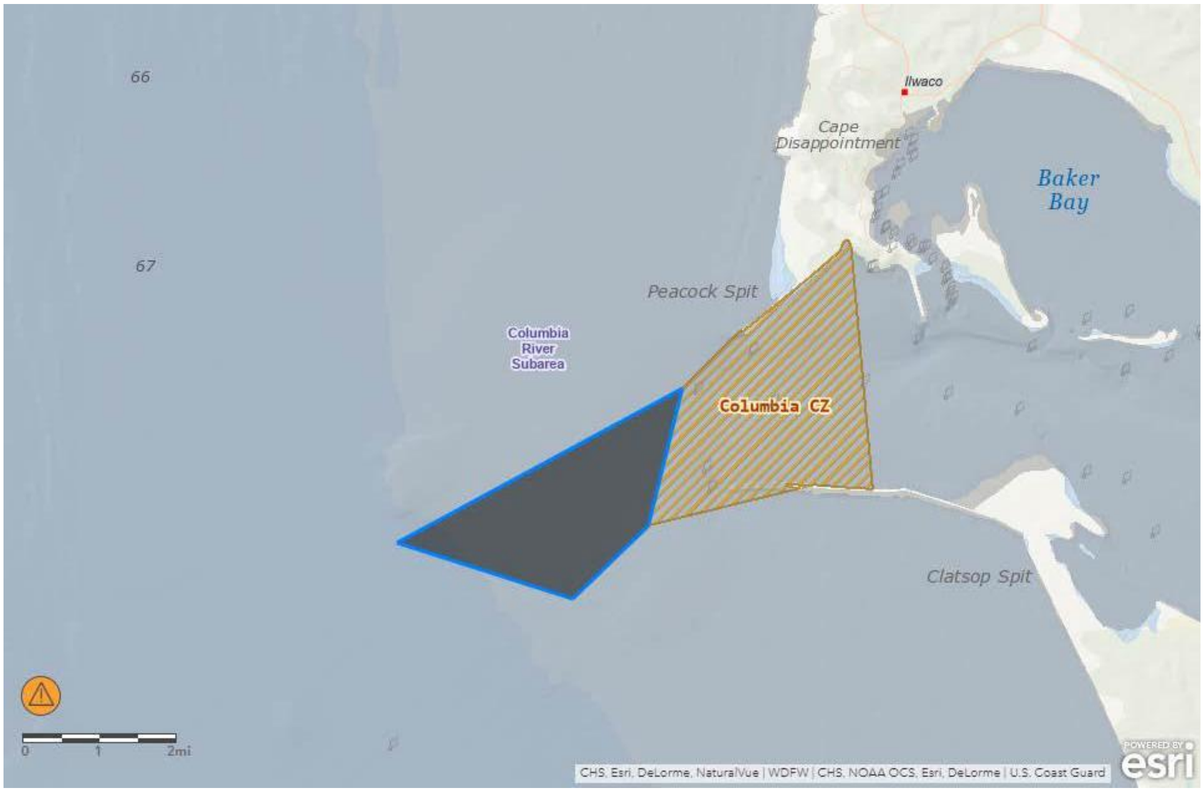

Figure 3.Detailed map of the Columbia River Control (CRZ) Zone and extension. The diagonally shaded area represents the previous Control zone, and the solid dark shaded area represents the new expanded area.

The control zones and geographic extensions identified above are located partially in the EEZ, and partially in state waters, 0-3 miles offshore. Under Amendment 21, in years when the abundance of Chinook is below the threshold described above, the portions of those control zones and extensions located in the EEZ would be closed through the annual management measures for the salmon fishery recommended by the Council and implemented by NMFS. During the Council discussion on November 16, 2020, the states indicated that in such low abundance years, they intend to implement closures in the portions of the control zones and extensions that occur in state waters.

We considered, under the ESA, whether or not the proposed federal action would cause any other activities and determined that the states' fishery management in state ocean waters, zero to three miles off the coast, and including closures in state waters as described above are such activities. As discussed above, the states typically manage their ocean fisheries to mirror federal management, thus federal and state management are linked in a causal connection. The states would implement the closures proposed in low abundance years consistent with and in response to the Council and NMFS' implementation of proposed Amendment 21.

2. ENDANGERED SPECIES ACT: BIOLOGICAL AND CONFERENCE 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, each Federal agency must ensure that its 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 provide an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

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 "jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably 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 402.02).

The designation of critical habitat for SRKWs uses the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (50 CFR 424.12) replaced 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 opinion, we use the term PBF to mean PCE or essential feature, as appropriate.

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 expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their habitat using an exposure-response approach.

- Evaluate cumulative effects.
- 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, suggest a reasonable and prudent alternative to the proposed action.

2.2. Rangewide Status of the Species and Critical Habitat

This opinion examines the status of SRKWs. 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, and listing decisions. 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' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of designated and proposed critical habitat, evaluates the conservation value of the various coastal and marine environments that make up the designated area, and discusses the function of the PBFs that are essential for the conservation of the species.

2.2.1. Status of Southern Resident Killer Whales (SRKWs)

The Southern Resident killer whale DPS, composed of J, K and L pods, was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). A 5-year review under the ESA completed in 2016 concluded that Southern Resident killer whales (SRKWs) should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2016a). NMFS considers SRKWs to be currently among nine of the most at-risk species as part of the Species in the Spotlight initiative[14] because of their endangered status, declining population trend, and they are high priority for recovery based on conflict with human activities and recovery programs in place to address threats. The population has relatively high mortality and low reproduction unlike other resident killer whale populations that have generally been increasing since the 1970s (Carretta et al. 2020).

The limiting factors described in the final recovery plan included reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS 2008a). This section summarizes the status of SRKW throughout their range and summarizes information taken largely from the recovery plan (NMFS 2008a), most recent 5-year review (NMFS 2016a), the PFMC SRKW Ad Hoc Workgroup's report (PFMC 2020a), as well as new data that became available more recently.

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

Abundance, Productivity, and Trends

Killer whales – including SRKWs - are a long-lived species and sexual maturity can occur at age 10 (review in NMFS 2008a). 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; Vélez-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). 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 4). 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 two new calves have been born following the census count. The previously published historical estimated abundance of Southern Resident killer whales is 140 animals (NMFS 2008a). 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.

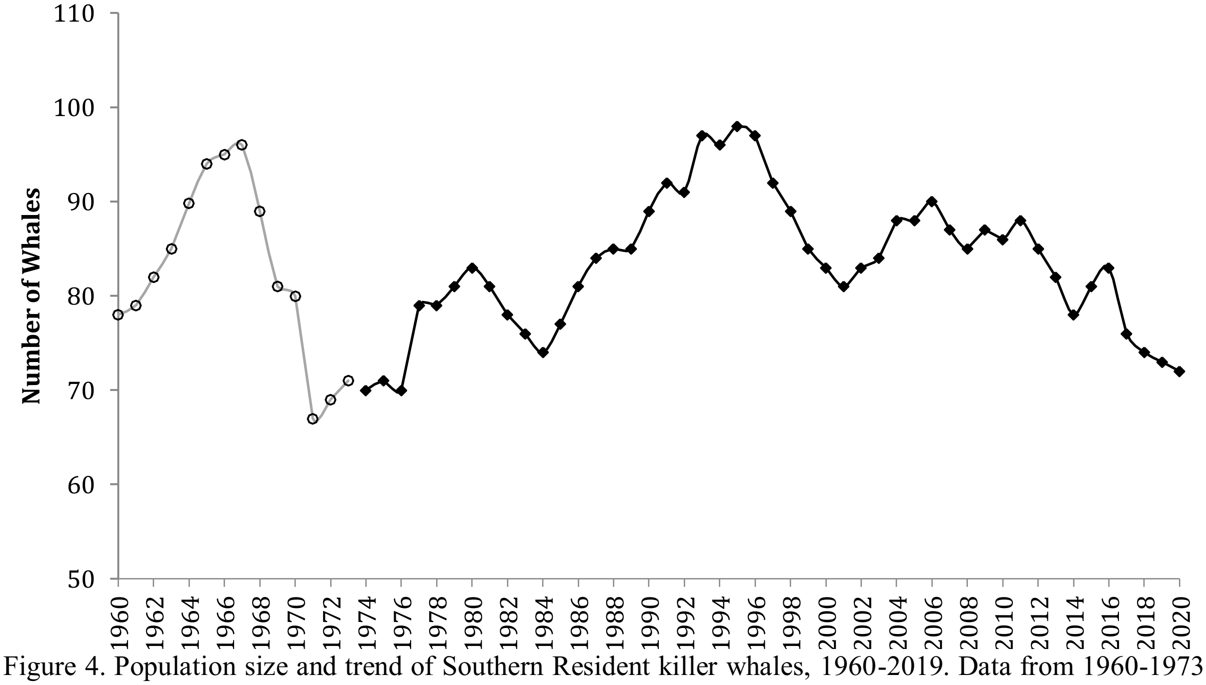

Figure 4. Population size and trend of Southern Resident killer whales, 1960-2019. Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of Olesiuk et al. (1990). Data from

1974-2020 (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 (2008a). 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. 2011; 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 to 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. 2004; Hilborn et al. 2012; Ward et al. 2013) and the most recent 5-year review (NMFS 2016a). The updated analysis[15] 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 scenarios with long-term demographic data or just the most recent years' project declines. Additional runs for this scenario 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

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[15] 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 2020a), the estimation model was switched to a generalized additive model (GAM), which allows for smoother over year effects (Ward 2019).

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 5).

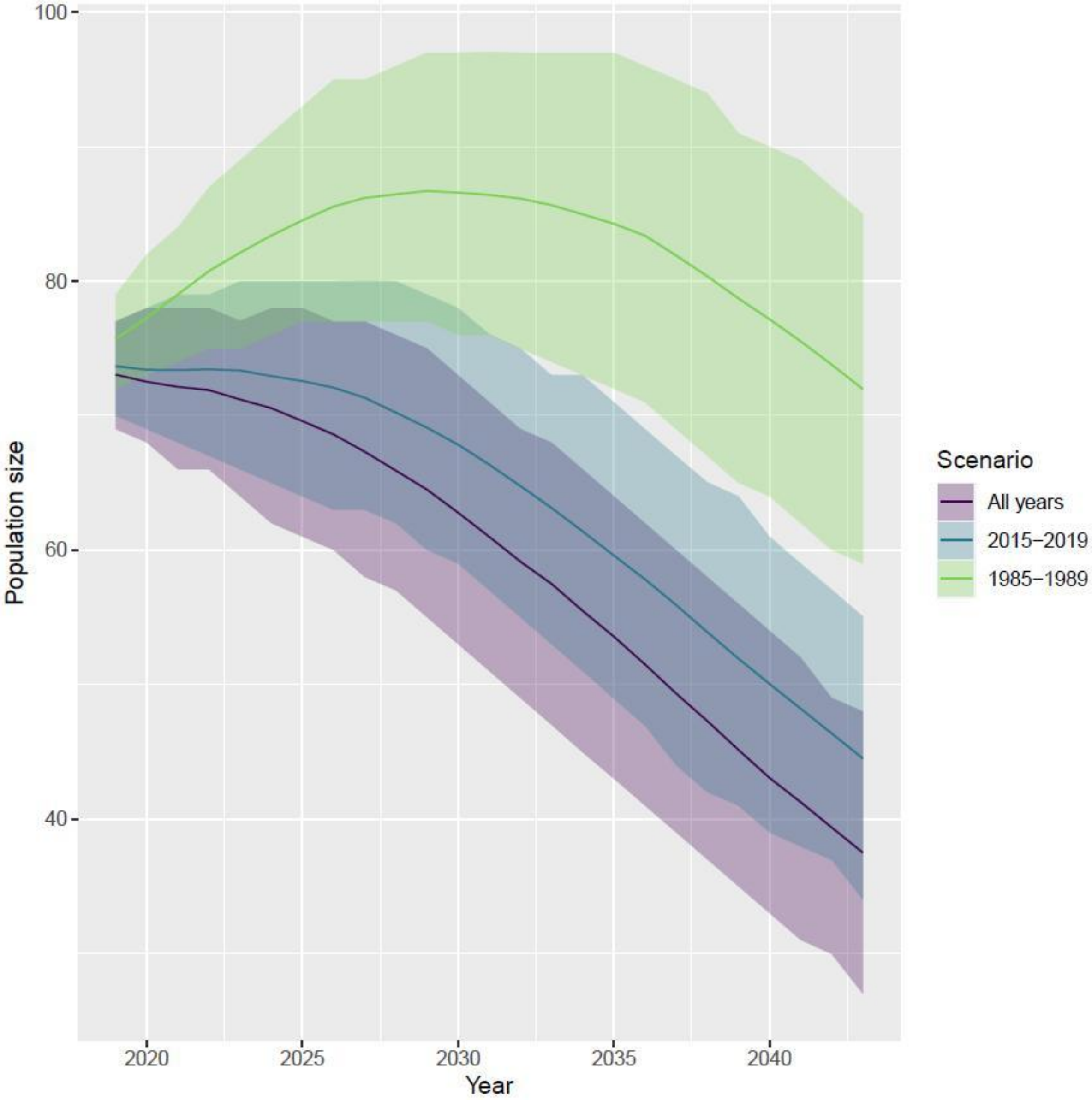

Figure 5. 25-year projections of the SRKW population, using NRKW age and stage data as prior distributions for the SRKW parameters, but not including priors on the year effects estimated from the NRKW population. The 3 scenarios run included (1) projections using demographic rates from the entire data 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 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, there have been contrasting changes by pod, with declines in L pod females and increases in J pod (Ward 2019, Figure 6). 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 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.

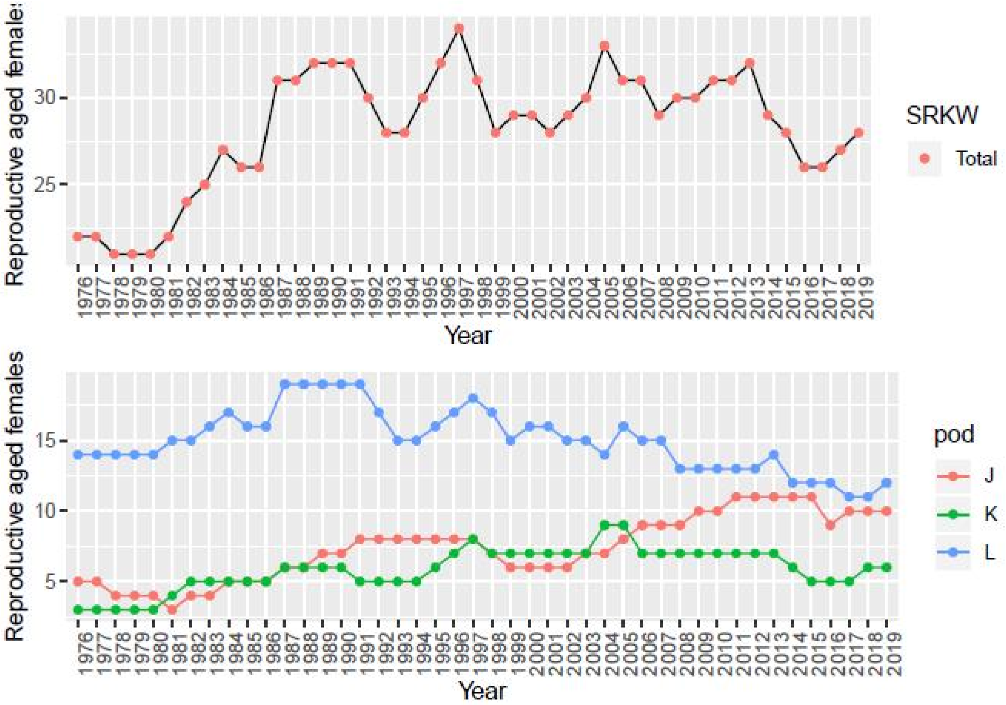

Figure 6. Time series of reproductive age females (10-42, inclusive) for Southern Residents by years since 1976 (reprinted from Ward 2019).

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 2008a; Hanson et al. 2013; Carretta et al. 2020; Ford et al. 2017; Figure 7). Southern Residents are highly mobile and can travel up to 86 miles (160 km) in a single day (Erickson 1978; Baird 2000), with seasonal movements likely tied to the migration of their primary prey, salmon. During the spring, summer, and fall months, the whales have typically spent a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford et al. 2000; Krahn et al. 2002; Hauser et al. 2007). During fall and early winter, SRWKs, and J pod in particular, expand their routine movements into Puget Sound, particularly J pod, likely to take advantage of chum, coho, and Chinook salmon runs (Osborne 1999; Hanson et al. 2010; Ford et al. 2016). Although seasonal movements are somewhat predictable, there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall, with late arrivals and fewer days present in recent years (Hanson and Emmons 2010; The Whale Museum, unpublished data).

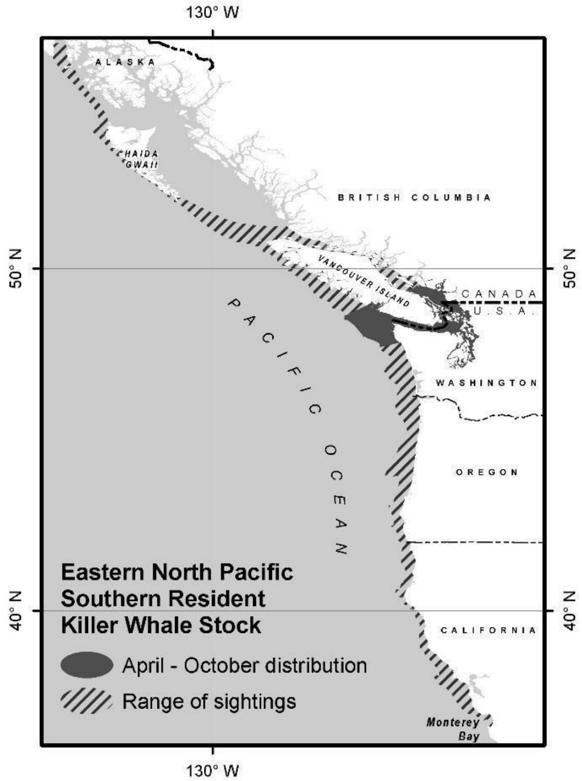

Figure 7. Geographic range of Southern Resident killer whales (reprinted from Carretta et al. 2020).

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 2019c).

As part of a collaborative effort between NWFSC, Cascadia Research Collective and the University of Alaska, satellite-linked tags were deployed on eight male SRKW (three tags on J pod members, two on K pod, and three on L pod) from 2012 to 2016 in Puget Sound or in the coastal waters of Washington and Oregon (Table 2). 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 2). 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 spent relatively little time in other coastal areas (Figure 8). 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 9) (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 8 and Figure 9).

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 2. 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

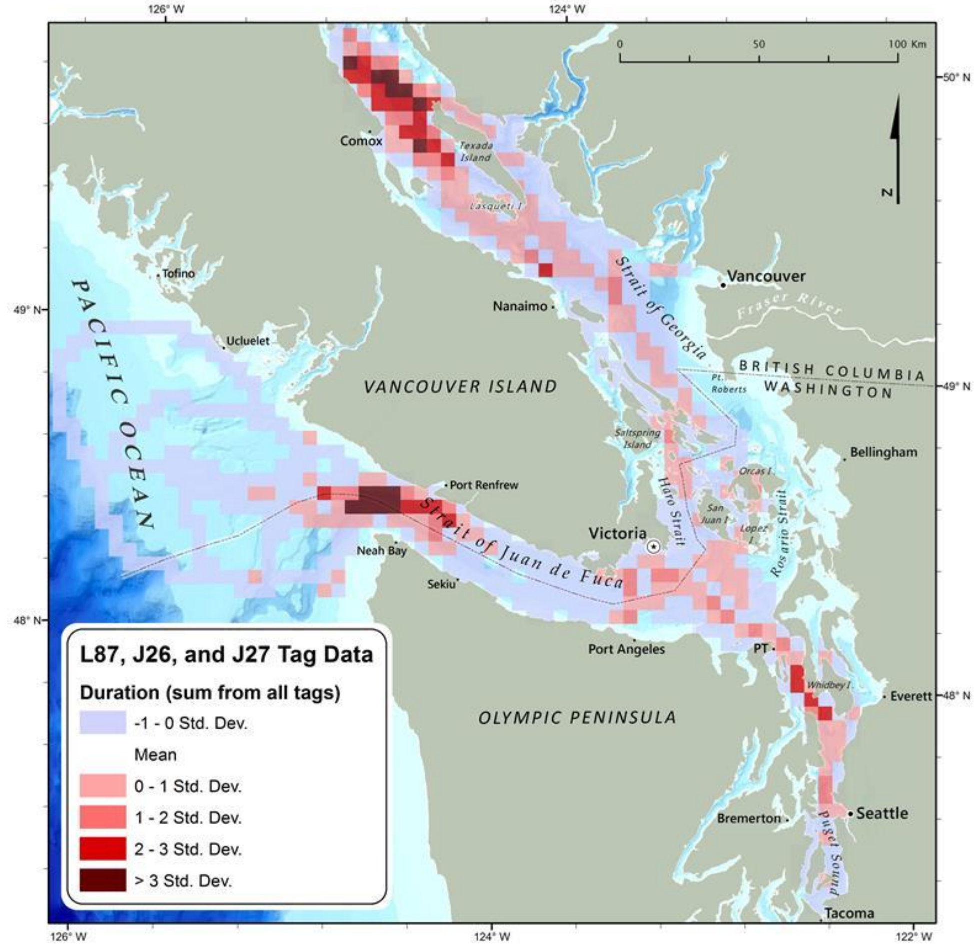

Figure 8. Duration of occurrence model output for J pod tag deployments (Hanson et al. 2017). "High use areas" or hot spots are illustrated by the 0 to > 3 standard deviation pixels.

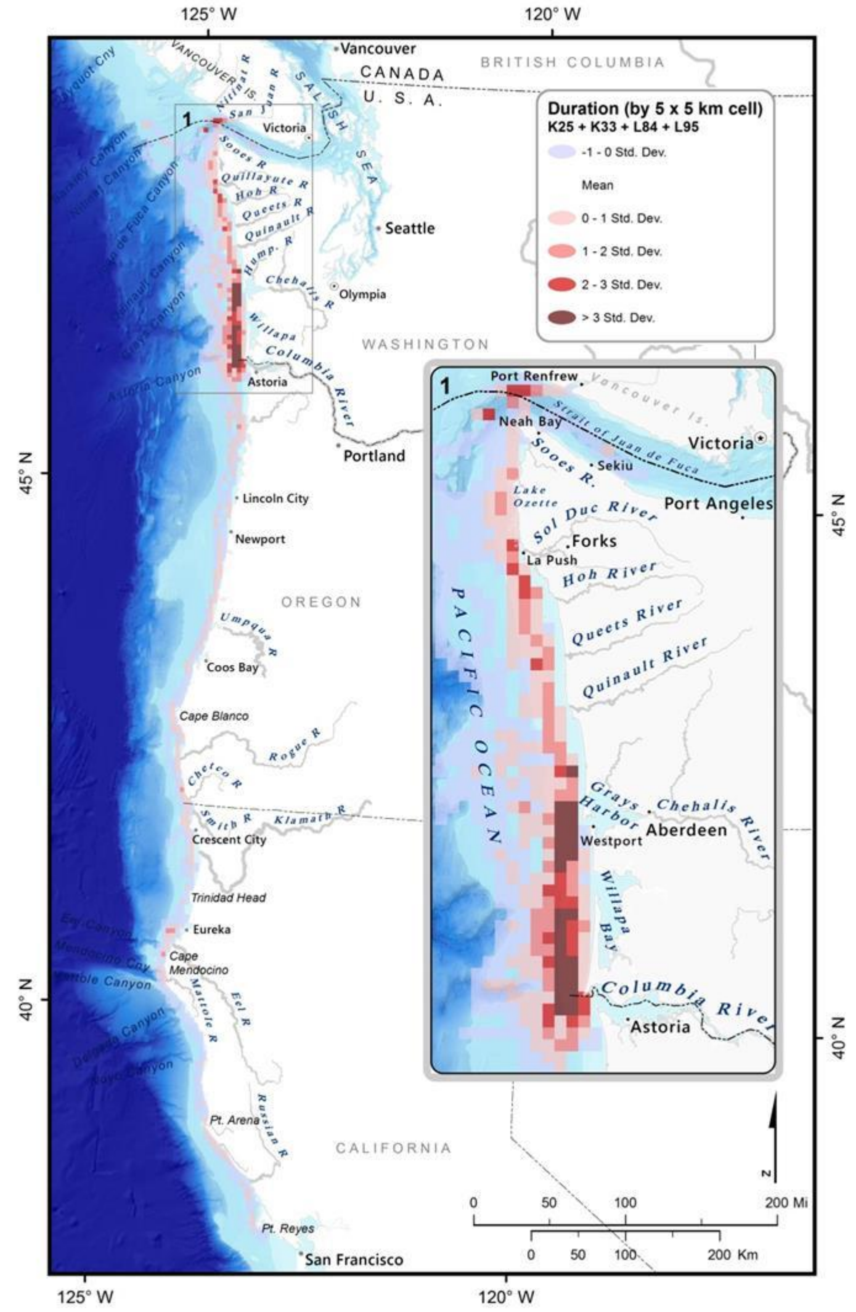

Figure 9. Duration of occurrence model for all unique K and L pod tag deployments (Hanson et al. 2017). “High use areas” or hot spots are illustrated by the 0 to > 3 standard deviation pixels.

Passive acoustic recorders were deployed off the coasts of California, Oregon and Washington in most years since 2006 to assess SRKW’s seasonal uses of these areas via the recording of stereotypic calls of the SRKW (Hanson et al. 2013; Emmons et al. 2019). Passive aquatic listeners (PALs) were originally deployed from 2006 – 2008. Since 2008, 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 11). From 2006 – 2011 specifically, passive acoustic listeners and recorders were deployed in areas thought to be used frequently by SRKWs based on previous sightings (Figure 10) (Hanson et al. 2013). The number of recorder sites off the Washington coast was increased from 7 to 17 in the fall of 2014 and locations (Figure 11) for the additional recorders 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 12), 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).

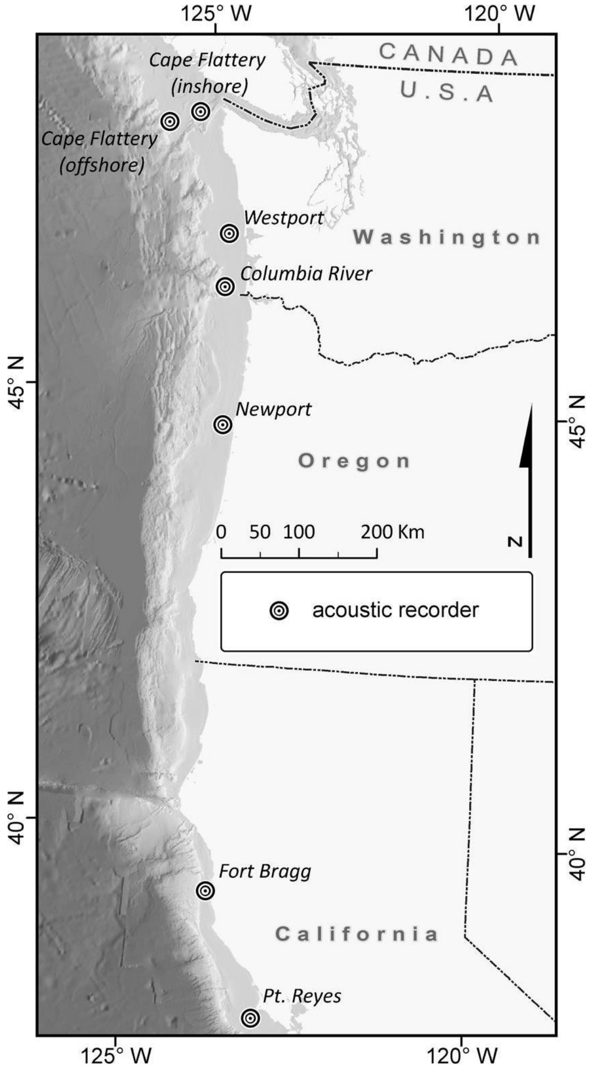

Figure 10. Deployment locations of acoustic recorders on the U.S. west coast from 2006 to 2011 (Hanson et al. 2013).

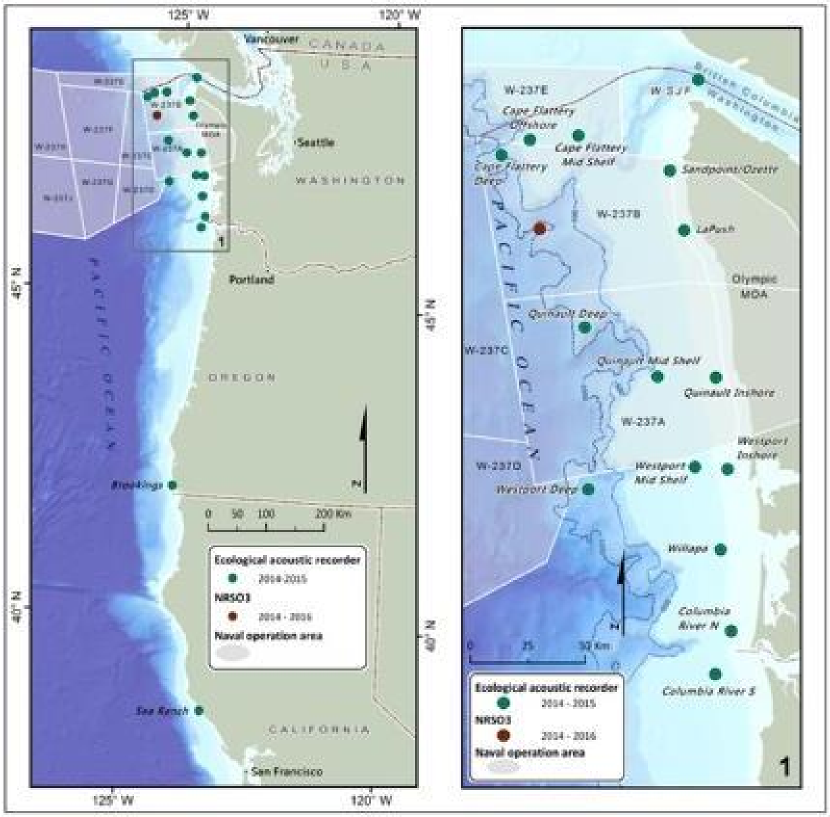

Figure 11. Locations of passive acoustic recorders deployed beginning in the fall of 2014 (Hanson et al. 2017).

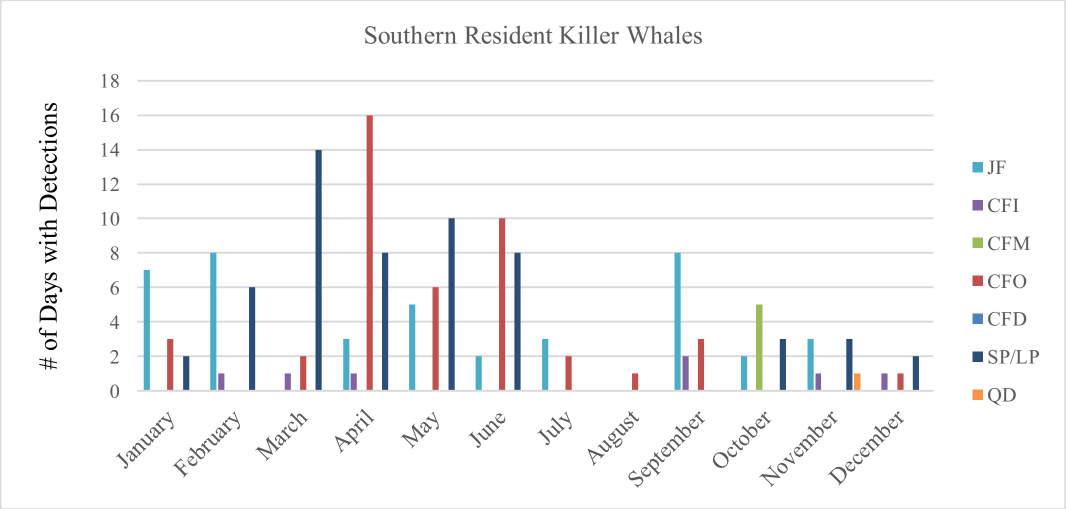

Figure 12. Counts of detections at each northern recorder site by month from 2014-2017 (Emmons et al. 2019). Areas include Juan de Fuca (JF); Cape Flattery Inshore (CFI); Cape Flattery Mid Shelf (CFM); Cape Flattery Offshelf (CFO); Cape Flattery Deep(CFD); Sand Point and La Push (SP/LP); and Quinault 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 13 (Riera et al. 2019). SRKW were detected on 163 days with 175 encounters (see Figure 14 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% 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 two 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).

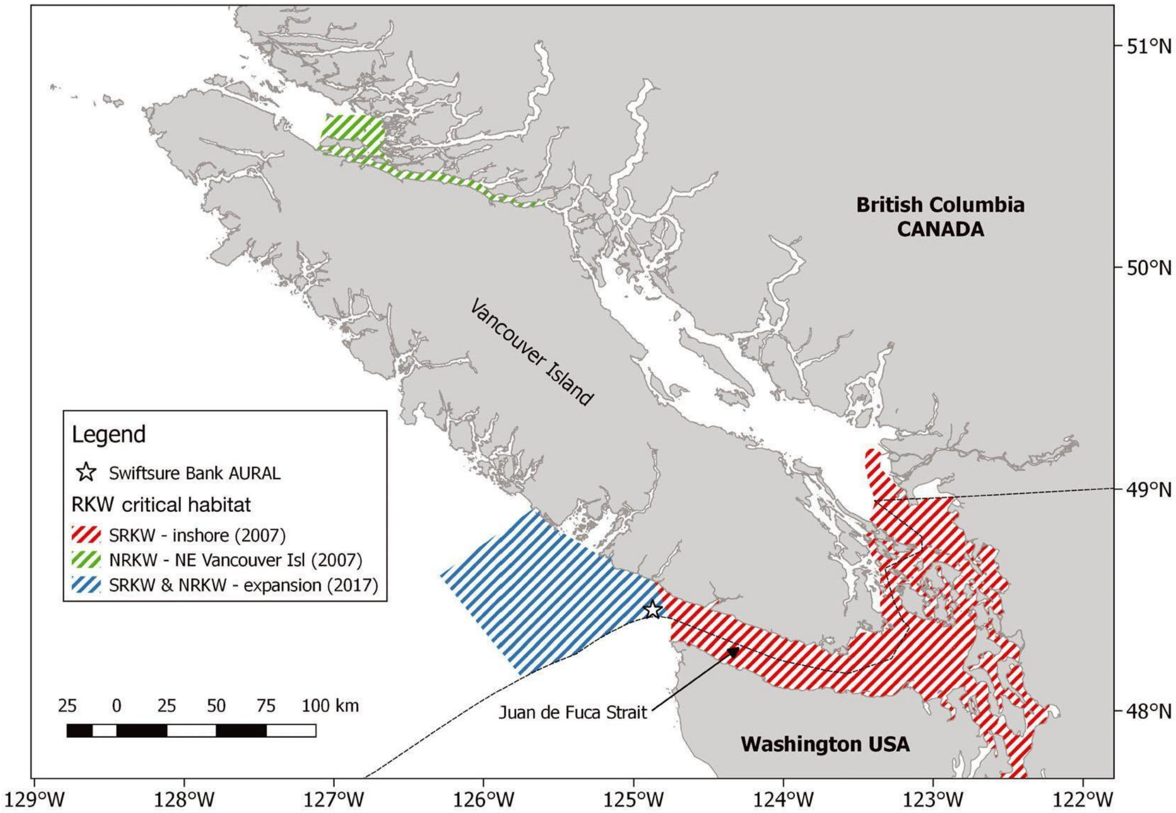

Figure 13. Swiftsure Bank study site off the coast of British Columbia, Canada in relation to the 2007 Northern Resident critical habitat (NE Vancouver Island) and 2007 Southern Resident killer whale critical habitat (inshore waters) and the 2017 Northern Resident and Southern Resident expansion of critical habitat (Riera et al. 2019).

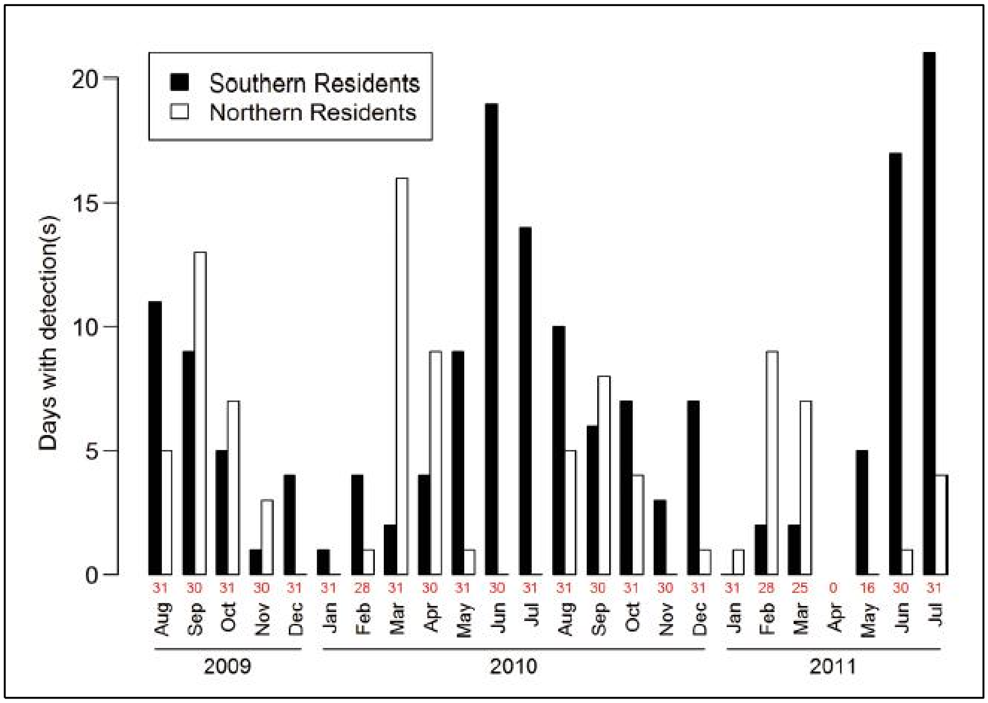

Figure 14. Number of days with acoustic detections of SRKWs at Swiftsure Bank from August 2009 – July 2011. Red numbers indicate days of effort (Riera et al. 2019).

Limiting Factors and Threats

Several factors identified in the final recovery plan for Southern Residents may be limiting recovery. The recovery plan identified three major threats including (1) quantity and quality of prey, (2) toxic chemicals that accumulate in top predators, and (3) impacts from sound and vessels. Oil spills and disease as well as the small population size are also risk factors. It is likely that multiple threats are acting together to impact the whales. Modeling exercises have attempted to identify which threats are most significant to survival and recovery (e.g. Lacy et al. 2017) and available data suggests that all of the threats are potential limiting factors (NMFS 2008a).

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. This work 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 species' large size, high fat and energy content, and year-round occurrence in the whales' geographic range. Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (kilocalorie/kilogram (kcal/kg)) (O'Neill et al. 2014). For example, in order for a killer whale to obtain the total energy value of one Chinook salmon, they would need to consume 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 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. 2017). In particular, southern Chinook salmon stocks ranging south from the Columbia River have been subject to the largest increases in predation, which the authors suggest may be potentially due to large subsidies of hatchery produced fish. Due to the Chinook salmon's northward migratory pathway and assumptions about their ocean residence, Chasco et al. (2017) 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. (2017) 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. 2017), 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 from fecal samples (Deagle et al. 2005). Recently, Ford et al. (2016) confirmed the importance of Chinook salmon to Southern Residents in the early to mid-summer months (May – August) using DNA sequencing from whale feces collected in inland waters of Washington and British Columbia. Salmon and steelhead made up to 98% of the inferred diet, of which almost 80% were Chinook salmon. Coho salmon and steelhead are also found in the diet inland waters of Washington and British Columbia in spring and fall months when Chinook salmon are less abundant. Specifically, coho salmon contribute to over 40% of the diet in September in inland waters, which is evidence of prey shifting at the end of summer towards coho salmon (Ford et al. 1998; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016). Less than 3% each of chum salmon, sockeye salmon, and steelhead were observed in fecal DNA samples collected in the summer months (May through September) in inland waters.

October – December

Prey remains and fecal samples collected in inland waters during October through December indicate Chinook and chum salmon are primary contributors of the whale's diet (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 15). 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 SRKW's in coastal areas.

As noted, most of the Chinook prey samples opportunistically collected in coastal waters were determined to have originated from the Columbia River basin, including Lower Columbia Spring, Middle Columbia Tule, and Upper Columbia Summer/Fall. In general, we would expect to find these stocks given the diet sample locations (Figure 15) 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).

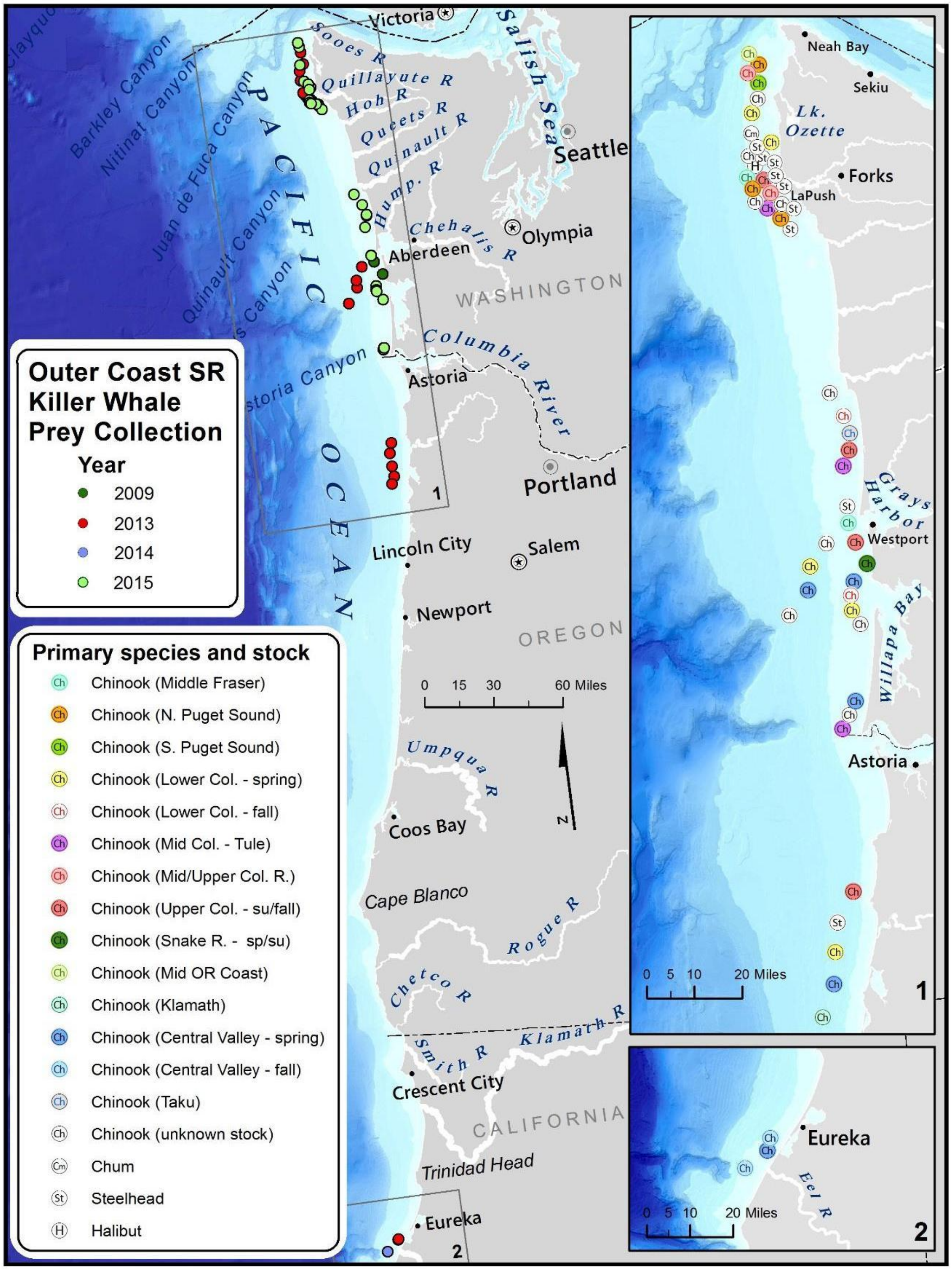

Figure 15. Location and species for scale/tissue samples collected from Southern Resident killer whale predation events in outer coastal waters (stock IDs are considered preliminary) (NMFS 2019c).

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 2008a). The release of hatchery fish has not been identified as a threat to the survival or persistence of Southern Residents and there is no evidence to suggest the whales prefer wild salmon over hatchery salmon. Increased Chinook abundance, including hatchery fish, benefit this endangered population of whales by enhancing prey availability to SRKWs and hatchery fish often contribute significantly to the salmon stocks consumed (Hanson et al. 2010). Currently, hatchery fish play a mitigation role of helping sustain Chinook salmon numbers while other, longer term, recovery actions for natural fish are underway. Although hatchery production has contributed some offset of the historical declines in the abundance of natural-origin salmon within the range of the whales, hatcheries also pose risks to natural-origin salmon populations (Nickelson et al. 1986; Ford 2002; Levin and Williams 2002; Naish et al. 2007).

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 (NMFS and WDFW 2018)[16]. 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 3 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.

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[16] 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 3. Summary of the priority Chinook salmon stocks for prioritizing recovery actions (adapted from NMFS and WDFW (2018)).

Priority	ESU/Stock Group	Run Type	Rivers or Stocks in Group
1	North Puget Sound	Fall	Nooksack, Elwha, Dungeness, Skagit, Stillaguamish, Snohomish, Nisqually, Puyallup, Green, Duwamish, Deschutes, Hood Canal Systems
	South Puget Sound		
2	Lower Columbia Strait of Georgia	Fall	Fall Tules and Fall Brights (Cowlitz, Kalama, Clackamas, Lewis, others), Lower Strait (Cowichan, Nanaimo), Upper Strait (Klinaklini, Wakeman, others), Fraser (Harrison)
3	Upper Columbia & Snake	Fall	Upriver Brights, Spring 1.3 (Upper Pitt, Birkenhead; Mid & Upper Fraser; North and South Thompson) and Spring 1.2 (Thompson, Louis Creek, Bessette Creak); Lewis, Cowlitz, Kalama, Big White Salmon
	Fraser	Spring	
	Lower Columbia	Spring	
4	Middle Columbia	Fall	Fall Brights
5	Snake River	Spring/summer	Snake, Salmon, Clearwater, Nooksack, Elwha, Dungeness, Skagit (Stillaguamish, Snohomish)
	Northern Puget Sound	Spring	
6	Washington Coast	Spring and Fall	Hoh, Queets, Quillayute, Grays Harbor
7	Central Valley	Spring	Sacramento and tributaries
8	Middle/Upper Columbia	Spring/Summer	Columbia, Yakima, Wenatchee, Methow, Okanagan
9	Fraser	Summer	Summer 0.3 (South Thompson, Lower Fraser, Shuswap, Adams, Little River, Maria Slough) and Summer 1.3 (Nechako, Chilko, Quesnel, Clearwater River)
10	Central Valley	Fall and late Fall	Sacramento, San Joaquin, Upper Klamath, and Trinity
	Klamath River	Fall and Spring	
11	Upper Willamette	Spring	Willamette
12	South Puget Sound	Spring	Nisqually, Puyallup, Green, Duwamish, Deschutes, Hood Canal systems
13	Central Valley	Winter	Sacramento and tributaries
14	North/Central Oregon (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 Southern Resident killer whales were observed from boats to have a pronounced "peanut-head"; and all but two subsequently died (Durban et al. 2009; Center for Whale Research unpublished data). None of the whales that died were subsequently recovered, and therefore definitive cause of death could not be identified. Both females and males across a range of ages were found in poor body condition.

Since 2008, NOAA's SWFSC (Southwest Fishery Science Center) have used aerial photogrammetry to assess the body condition and health of Southern Resident killer whales, initially in collaboration with the Center for Whale Research and, more recently, with the Vancouver Aquarium and SR^3. Aerial photogrammetry studies have provided finer resolution for detecting poor condition, even before it manifests in "peanut heads" that are observable from boats. Annual aerial surveys of the population from 2013-2017 (with exception of 2014) have detected declines in condition before the death of seven Southern Residents (L52 and J8 as reported in Fearnbach et al. (2018); J14, J2, J28, J54, and J52 as reported in Durban et al. (2017)), including five of the six most recent mortalities (Trites and Rosen 2018). These data have provided evidence of a general decline in Southern Resident killer whale body condition since 2008, and documented members of J pod being in poorer body condition in May compared to September of the previous year (at least in 2016 and 2017) (Trites and Rosen 2018). Other pods could not be reliably photographed in both seasonal periods. Furthermore, hormone analysis conducted by Ayres et al. (2012) from fecal samples collected in 2007-2009, suggested 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[17]. 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

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

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. 2020). 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.

A recent paper by Raverty et al. (2020) 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). 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% 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 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 killer whales physically mature at age 20 and the body stops growing (Noren 2011), we would expect adult male killer whales to have similar body lengths and 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 that were under 30 years of age that were measured in 2008 by the same photogrammetric technique were also shorter on average than older individuals also suggesting reduced growth (Fearnbach et al. 2011).

What appears to be constrained growth in both resident killer whale populations occurred in the 1990s - during a time when range-wide abundance of Chinook salmon in multiple subsequent years fell below the 1979 – 2003 average (Figure 16; 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 2008a). 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).

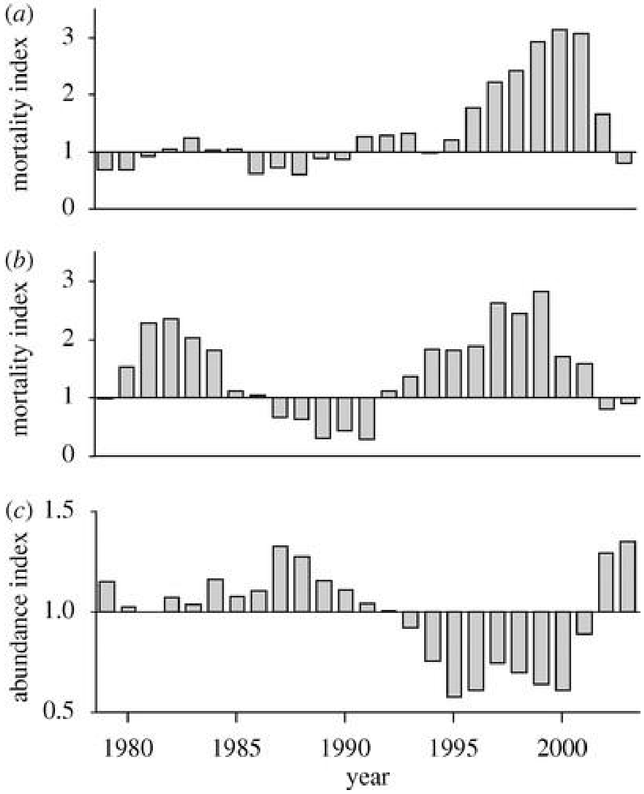

Figure 16. Annual mortality indices for a) Northern Resident and b) Southern Resident killer whales and c) abundance index of Chinook salmon from 1979 to 2003 (reprinted from Ford et al. 2010).

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 an extrinsic factors), the response to reduced prey abundance for example could include "group fissioning". However, this may not always be the case, especially if the benefit of "cooperative care" or food sharing outweighs the cost of the large group size. 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). Southern Residents are exposed to a mixture of pollutants, some of which may interact synergistically and enhance toxicity, influencing their health, and reproduction. Relatively high levels of these pollutants have been measured in blubber biopsy samples from Southern Residents compared to other resident killer whales in the North Pacific (Ross et al. 2000; Krahn et al. 2007; Krahn et al. 2009; Lawson et al. 2020). 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, 2016b).

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

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

Disturbance from Vessels and Sound

Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals. While in inland waters of Washington and British Columbia, Southern Resident killer whales are the principal target species for the commercial whale watch industry (Hoyt 2001; O'Connor et al. 2009) and encounter a variety of other vessels in their urban environment (e.g., recreational, fishing, ferries, military, shipping). Several main threats from vessels include direct vessel strikes, the masking of echolocation and communication signals by anthropogenic sound, and behavioral changes (NMFS 2008a). There is a growing body of evidence documenting effects from vessels on small cetaceans and other marine mammals (NMFS 2010a; NMFS 2016a; NMFS 2018a). 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. 2010, 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). Although, Ayres et al. (2012) examined glucocorticoid and thyroid hormone levels in fecal samples collected from SRKWs in inland waters and their results suggest the impacts from vessel traffic on hormone levels are lower than the impacts from reduced prey availability.

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

In the final rule implementing the federal regulations, NMFS committed to reviewing the vessel regulations to evaluate effectiveness, and also to study the impact of the regulations on the viability of the local whale watch industry. In December 2017, NMFS completed a technical memorandum evaluating the effectiveness of regulations adopted in 2011 to help protect endangered Southern Resident killer whales from the impacts of vessel traffic and noise (Ferrara et al. 2017). In the assessment, Ferrara et al. (2017) used five measures: education and outreach efforts, enforcement, vessel compliance, biological effectiveness, and economic impacts. For each measure, the trends and observations in the 5 years leading up to the regulations (2006-2010) were compared to the trends and observations in the 5 years following the regulations (2011-2015). The memo finds that some indicators suggested the regulations have benefited SRKWs by reducing impacts without causing economic harm to the commercial whale-watching industry or local communities, whereas some indicators suggested that vessel impacts continue and that some risks may have increased. The authors also find room for improvement in terms of increasing awareness and enforcement of the regulations, which would help improve compliance and further reduce biological impacts to the whales.

In 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; 10/24/2019).

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, Southern Resident killer whales are the most vulnerable marine mammal population to the risks imposed by an oil spill due to their small population size, strong site fidelity to areas with high oil spill risk, large group size, late reproductive maturity, low reproductive rate, and specialized diet, among other attributes (Jarvela-Rosenberger et al. 2017). Oil spills have occurred in the range of Southern Residents in the past, and there is potential for spills in the future. Oil can be discharged into the marine environment in any number of ways, including shipping accidents, refineries and associated production facilities, and pipelines. Despite many improvements in spill prevention since the late 1980s, much of the region inhabited by Southern Residents remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers.

Repeated ingestion of petroleum hydrocarbons by killer whales likely causes adverse effects; however, long-term consequences are poorly understood. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion and disease, pneumonia, liver disorders, neurological damage, adrenal toxicity, reduced reproductive rates, and changes in immune function (Geraci and Aubin 1990; Schwacke et al. 2013; Venn-Watson et al. 2015; de Guise et al. 2017; Kellar et al. 2017), potentially death and long-term effects on population viability (Matkin et al. 2008; Ziccardi et al. 2015). For example, 122 cetaceans stranded or were reported dead within 5 months following the Deepwater Horizon spill in the Gulf of Mexico (Ziccardi et al. 2015). An additional 785 cetaceans were found stranded from November 2010 to June 2013, which was declared an Unusual Mortality Event (Ziccardi et al. 2015). Previous Polycyclic Aromatic Hydrocarbon (PAH) exposure estimates suggested Southern Residents can be occasionally exposed to concerning levels (Lachmuth et al. 2011). More recently, Lundin et al. (2018) measured PAHs in whale fecal samples collected in inland waters of Washington between 2010 and 2013 and found low concentrations of the measured PAHs (<10 parts per billion (ppb), wet weight). However, PAHs were as high as 104 ppb in the first year of their study (2010) compared to the subsequent years. Although it is unclear the cause of this trend, higher levels were observed prior to the 2011 vessel regulations that increased the distance vessels could approach the whales. In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may adversely affect Southern Residents by reducing food availability.

Climate change and other ecosystem effects

The potential impacts of climate and oceanographic change on whales and other marine mammals would likely involve effects on habitat availability and food availability. Although few predictions of impacts on the Southern Residents have been made, it seems likely that any changes in weather and oceanographic conditions resulting in effects on salmon populations would have consequences for the whales. Southern Resident killer whales might shift their distribution in response to climate-related changes in their salmon prey. Persistent pollutant bioaccumulation may also change because of changes in the food web (e.g. Alava et al. 2018).

Climatic conditions affect salmonid abundance, productivity, spatial structure, and diversity through direct and indirect impacts at all life stages (e.g., Independent Scientific Advisory Board 2007, Lindley et al. 2007, Crozier et al. 2008; Moyle et al. 2013, Wainwright & Weitkamp 2013). Studies examining the effects of long-term climate change to salmon populations have identified a number of common mechanisms by which climate variation is likely to influence salmon sustainability. These include direct effects of temperature such as mortality from heat stress, changes in growth and development rates, and disease resistance. Changes in the flow regime (especially flooding and low flow events) also affect survival and behavior. Expected behavioral responses include shifts in seasonal timing of important life history events, such as the adult migration, spawn timing, fry emergence timing, and the juvenile migration. Indirect effects on salmon mortality, growth rates and movement behavior are also expected to follow from changes in the freshwater habitat structure and the invertebrate and vertebrate community, which governs food supply and predation risk (Independent Scientific Advisory Board 2007, Crozier et al. 2008).

In the marine ecosystem, salmon may be affected by warmer water temperatures, increased stratification of the water column, intensity and timing changes of coastal upwelling, loss of coastal habitat due to sea level rise, ocean acidification, and changes in water quality and freshwater inputs (Independent Scientific Advisory Board 2007, Mauger et al. 2015). Salmon marine migration patterns could be affected by climate-induced contraction of thermally suitable habitat. Abdul-Aziz et al. (2011) modeled changes in summer thermal ranges in the open ocean for Pacific salmon under multiple IPCC warming scenarios. For chum, pink, coho, sockeye and steelhead, they predicted contractions in suitable marine habitat of 30-50% by the 2080s, with an even larger contraction (86-88%) for Chinook salmon under the medium and high emissions scenarios. Northward range shifts are a climate response expected in many marine species, including salmon (Cheung et al. 2015). However, salmon populations are strongly differentiated in the northward extent of their ocean migration, and hence would likely respond individualistically to widespread changes in sea surface temperature.

Recent analysis ranked the vulnerability of West Coast salmon stocks to climate change and, of the top priority stocks for Southern Residents (NMFS 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). In general, Chinook salmon, coho, and sockeye runs were more vulnerable and this stemmed from exposure to higher ocean and river temperatures as well as exposure to changes in flow regimes (including in relation to snowpack, upwelling, sea level rise, and flooding). However, certain Chinook salmon runs do have higher ability to adapt and/or cope with climate change due to high life history diversity in juveniles and adults (including both subyearling and yearling smolts, multiple migration timings), but diversity may be lost with future climate change. Overall, chum and pink salmon were less vulnerable to climate change because they spend less time in fresh water than other salmonids, and certain steelhead runs had more moderate vulnerability than many Chinook and coho runs because of higher resilience (Crozier et al. 2019). Additionally, substantial declines in abundance due to climate change are predicted for Snake River spring/summer Chinook over the next 2-3 decades based on recent life-cycle modeling (NMFS 2020b; Zabel et al. 2020).

Furthermore, recent modeling research has shown variation in the impacts of marine warming on fall-run Chinook salmon distribution depending on stock, resulting in future regional declines or increases in salmon abundance. Shelton et al. (2020) used a Bayesian state-space model to model ocean distribution of fall-run Chinook salmon stocks in the Northeast Pacific, paired with data on sea surface temperature associated with each stock and future ocean climate predictions to predict future distribution of Chinook salmon related to changing sea surface temperature in 2030-2090. In warm years (compared to cool), modeled Klamath, Columbia River (upriver bright run, lower, middle), and Snake River stocks shifted further North, while California Central Valley stock shifted south. Notably, Columbia River and Snake River fall-run Chinook are in the top 10 priority stocks for SRKWs (NMFS and WDFW 2018). Predicted future shifts in distributions due to warming led to future increases in ocean salmon abundance off northern British Columbia and central California, minimal changes off Oregon, Southern British Columbia, and Alaska, and declines in abundance off Washington and northern California (Shelton et al. 2020).

In addition to long-term anthropogenic climate change, cyclic and year-to-year natural climate variability can also impact Southern Residents by way of impacts on their prey and this natural climate variability is likely heightened by climate change. For example, evidence suggests that marine survival among salmonids fluctuates in response to 20 to 30-year cycles of climatic conditions and ocean productivity. Naturally occurring climatic patterns, such as the Pacific Decadal Oscillation, El Niño and La Niña events, and North Pacific Gyre Oscillation, can cause changes in ocean productivity that can affect productivity and survival, of salmon (Mantua et al. 1997; Francis and Hengeveld 1998; Beamish et al. 1999; Hare et al. 1999; Benson and Trites 2002; Dalton et al. 2013, Kilduff et al. 2015), affecting the prey available to SRKWs. (Though relationships may be weakening, see Litzow et al. 2020). Prey species such as salmon are most likely to be affected through changes in food availability and oceanic survival (Benson and Trites 2002), with biological productivity increasing during cooler periods and decreasing during warmer periods (Hare et al. 1999; NMFS 2008a). Also, range extensions were documented in many species from southern California to Alaska during unusually warm water associated with "The Blob" in 2014 and 2015 (Bond et al. 2015; Di Lorenzo and Mantua 2016), and past strong El Niño events (Pearcy 2002; Fisher et al. 2015).

The frequency of these extreme climate conditions associated with El Niño events or "blobs" are predicted to increase in the future with climate change (greenhouse forcing) (Di Lorenzo and Mantua 2016) and therefore, it is likely that long-term anthropogenic climate change would interact with inter-annual climate variability. Multiple modeling studies have predicted increases in the frequency of extreme ENSO events and increased ENSO variability due to climate change

(Cai et al. 2014, 2015, 2018, Wang et al 2017). Modeled projections of future marine heat waves similar to the "blob" have predicted decreases in salmon biomass and distribution shifts for salmon, particularly sockeye, in the Northeast Pacific (Cheung and Frölicher 2020). Evidence suggests that early marine survival for juvenile salmon is a critical phase in their survival and development into adults. The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and a local scale, provides an indication of the role they play in salmon survival in the ocean.

2.2.2. Status of Proposed and Designated Critical Habitat

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

On September 19, 2019 NMFS proposed to revise the critical habitat designation for the SRKW DPS under the ESA by designating six new areas along the U.S. West Coast (84 FR 49214). Specific new areas proposed along the U.S. West Coast include 15,626.6 square miles (mi2) (40,472.7 square kilometers (km2)) of marine waters between the 6.1-meter (m) depth contour and the 200-m depth contour from the U.S. international border with Canada south to Point Sur, California (Figure 17). In the proposed rule (84 FR 49214), NMFS states that the "proposed areas are occupied and contain physical or biological features that are essential to the conservation of the species and that may require special management considerations or protection." The three physical or biological features essential to conservation in the 2006 designated critical habitat were also identified for the six new areas along the U.S. West Coast.

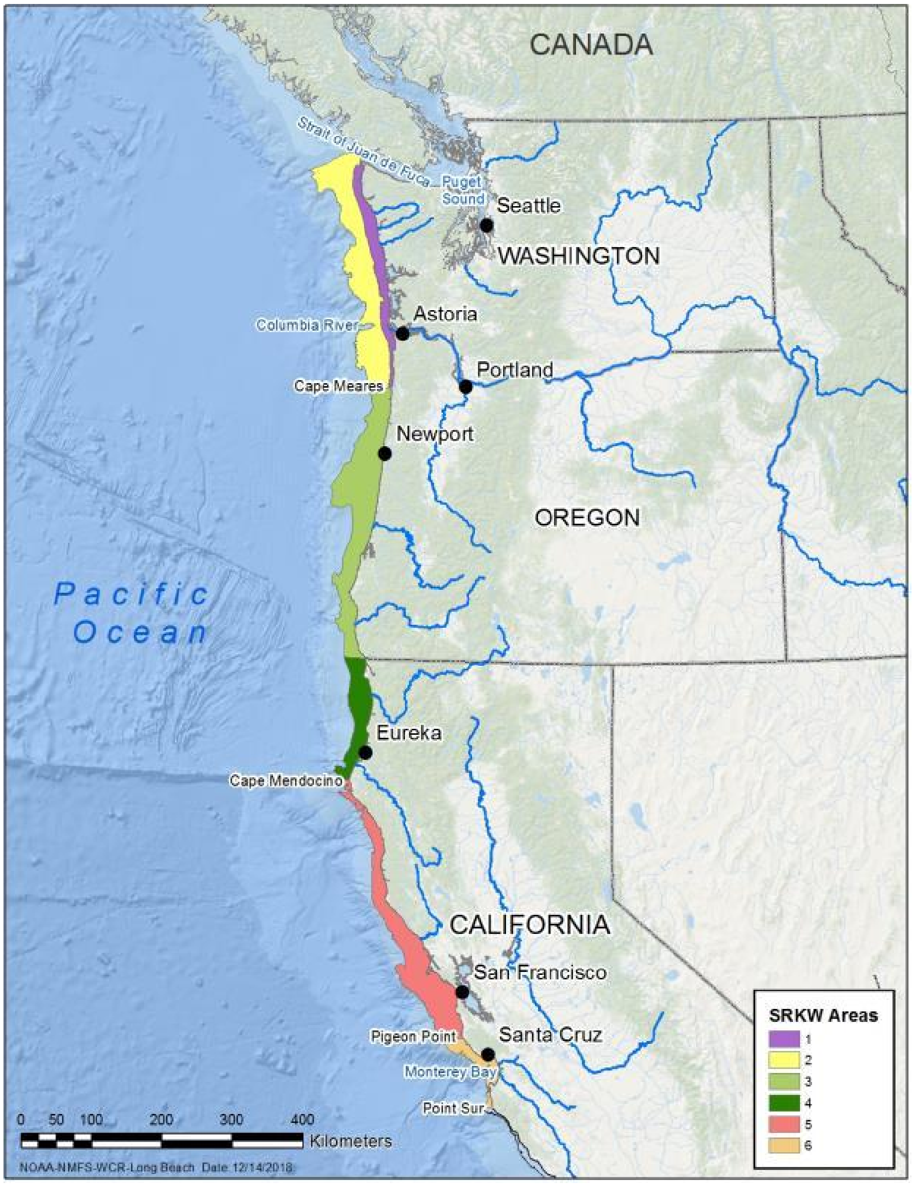

Figure 17. Specific areas containing essential habitat features (Figure 9 reproduced from NMFS 2019c).

Water Quality

Water quality supports SRKW's ability to forage, grow, and reproduce free from disease and impairment. Water quality is essential to the whales' conservation, given the whales' present contamination levels, small population numbers, increased extinction risk caused by any additional mortalities, and geographic range (and range of their primary prey) that includes highly populated and industrialized areas. Water quality is especially important in high-use areas where foraging behaviors occur and contaminants can enter the food chain. The absence of contaminants or other agents of a type and/or amount that would inhibit reproduction, impair immune function, result in mortalities, or otherwise impede the growth and recovery of the SRKW population is a habitat feature essential for the species' recovery. Water quality in Puget Sound, in general, is degraded as described in the Puget Sound Partnership 2018-2022 Action

Agenda and Comprehensive (Puget Sound Partnership 2018). For example, toxicants in Puget Sound persist and build up in marine organisms including SRKWs and their prey resources, despite bans in the 1970s of some harmful substances and cleanup efforts. Water quality varies in coastal waters from Washington to California. For example, as described in NMFS (2019), high levels of DDTs have been found in SRKWs, especially in K and L pods, which spend more time in California in the winter where DDTs still persist in the marine ecosystem (Sericano et al. 2014).

Exposure to oil spills also poses additional direct threats as well as longer term population level impacts; therefore, the absence of these chemicals is of the utmost importance to SRKW conservation and survival. Oil spills can also have long-lasting impacts on other habitat features. Oil spill risk exists throughout the SRKW's coastal and inland range. From 2002- 2016, the highest-volume crude oil spill occurred in 2008 off the California coast, releasing 463,848 gallons (Stephens 2017). In 2015 and 2016, crude oil spilled into the marine environment off the California coast totaled 141,680 gallons and 44,755, respectively; no crude oil spills were reported off the coasts of Oregon or Washington in these years (Stephens 2015, Stephens 2017). Non-crude oil spills into the marine environment also occurred off California, Oregon, and Washington in 2015 and 2016 (Stephens 2015, Stephens 2017).The Environmental Protection Agency and U.S. Coast Guard oversee the Oil Pollution Prevention regulations promulgated under the authority of the Federal Water Pollution Control Act. There is a Northwest Area Contingency Plan, developed by the Northwest Area Committee, which serves as the primary guidance document for oil spill response in Washington and Oregon. In 2017, the Washington State Department of Ecology published a new Spill Prevention, Preparedness, and Response Program Annual Report describing the Spills Program as well as the performance measures from 2007 – 2017 (WDOE 2017).

Prey Quantity, Quality, and Availability

Southern Resident killer whales are top predators that show a strong preference for salmonids in inland waters, particularly larger, older age class Chinook (age class of 3 years or older) (Ford and Ellis 2006, Hanson et al. 2010). Samples collected during observed feeding activities, as well as the timing and locations of killer whales' high use areas that coincide with Chinook salmon runs, suggest the whales' preference for Chinook extends to outer coastal habitat use as well (Hanson et al. 2017, Hanson et al. 2021). Quantitative analyses of diet from fecal samples indicate a high proportion of Chinook in the diet of whales feeding in waters off the coast but a greater diversity of species, which included substantial contributions of other salmon and also lingcod, halibut, and steelhead (Hanson et al. 2021). Habitat conditions should support the successful growth, recruitment, and sustainability of abundant prey to support the individual growth, reproduction, and development of Southern Residents.

Most wild salmon stocks throughout the whales' geographic range are at fractions of their historic levels. Beginning in the early 1990s, 28 ESUs and DPSs of salmon and steelhead in Washington, Oregon, Idaho, and California were listed as threatened or endangered under the ESA. Historically, overfishing, habitat losses, and hatchery practices were major causes of decline. Poor ocean conditions over the past two decades have reduced populations already weakened by the degradation and loss of freshwater and estuary habitat, fishing, hydropower system management, and hatchery practices.

In addition to sufficient quantity of prey, those fish need to be accessible and available to the whales. Depending on pod migratory behavior, availability of Chinook along the outer coast is likely limited at particular times of year (e.g. winter months) due to run timing of various Chinook stocks. Prey availability may also be low when the distribution of preferred adult Chinook is relatively less dense (spread out) prior to their aggregation when returning to their natal rivers. Prey availability may also be affected by competition from other predators including other resident killer whales, pinnipeds, and fisheries (Chasco et al. 2017).

Contaminants and pollution also affect the quality of SRKW prey in Puget Sound and in coastal waters of Washington, Oregon, and California. Contaminants enter marine waters and sediment from numerous sources, but are typically concentrated near areas of high human population and industrialization. Once in the environment these substances proceed up the food chain, accumulating in long-lived top predators like SRKWs. Chemical contamination of prey is a potential threat to SRKW critical habitat, despite the enactment of modern pollution controls in recent decades, which were successful in reducing, but not eliminating, the presence of many contaminants in the environment. The size of Chinook salmon is also an important aspect of prey quality (i.e., SRKWs primarily consume large Chinook) so changes in Chinook size may affect the quality of this component critical habitat.

Availability of prey to the whales may also be impacted by anthropogenic sound if it raises average background noise to a level that is expected to chronically or regularly reduce the effective zone of echolocation space for SRKW (Holt 2008, Veirs et al. 2016, Joy et al. 2019), and therefore could limit a whale’s ability to find/access the prey critical habitat feature. For example, ship noise was identified as a concern because of its potential to interfere with Southern Resident killer whale communication, foraging, and navigation (Veirs et al. 2016). In-water anthropogenic sound is generated by other sources beside vessels, including construction activities, and military operations, and may affect availability of prey to Southern Residents by interfering with hearing, echolocation, or communication depending on the intensity, persistence, timing, and location of certain sounds in the vicinity of the whales (see review in NMFS 2008a). Therefore, anthropogenic noise may affect the availability of prey to Southern Residents by reducing echolocation space used for foraging and communication between whales (including communication for prey sharing).

Southern Resident killer whales might shift their distribution in response to climate-related changes in their salmon prey, as discussed above in Section “Climate change and other ecosystem effects” and climate change may have impacts on the prey feature of critical habitat.

Passage

Southern Residents are highly mobile and use a variety of areas for foraging and other activities, as well as for traveling between these areas. Human activities can interfere with movements of the whales and impact their passage. Southern Residents 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. In particular, vessels may present both physical and/or acoustic obstacles to whale passage, with behavioral changes in the presence of both motorized and non-motorized vessels, 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 (2010a), Ferrara et al. (2017)).

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

The action area analyzed in this opinion includes the U.S. Pacific Coast Region Exclusive Economic Zone (EEZ) (i.e., 3-200 nautical miles off the West Coast states of California, Oregon, and Washington) (Figure 18), which is where the fisheries in the proposed action will occur. The action area also includes the coastal waters of the states of Washington, Oregon, and California (zero to three miles off the coast where salmon fishery management is coordinated with federal management), coastal waters of southwest Vancouver Island (SWVCI), Canada, and inland waters of Washington and British Columbia (Salish Sea) which are affected by the action (i.e., potential reduction in available prey that would have moved into these waters if it had not been caught by the PFMC fisheries).

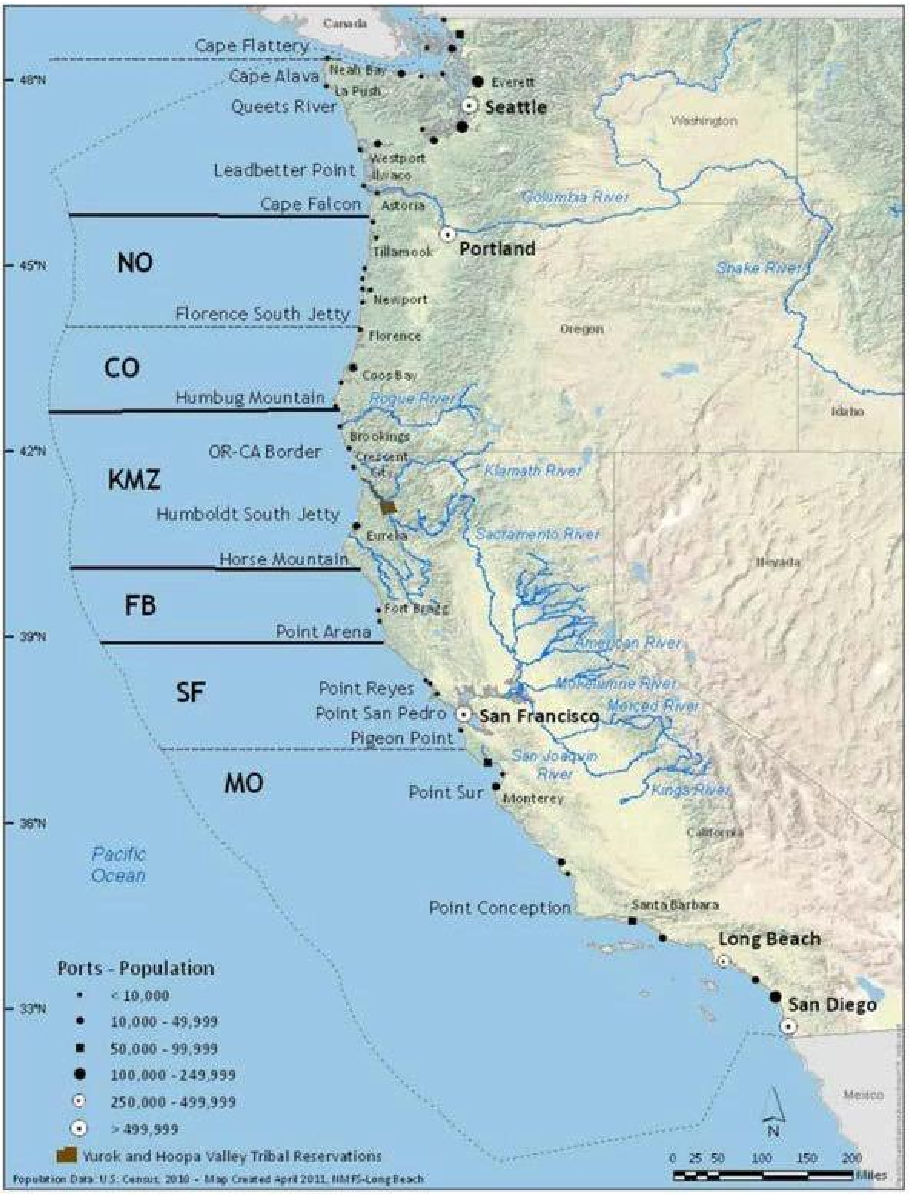

Figure 18. Map of major management boundaries in common use since 2000. North Oregon (NO), Central Oregon (CO), Klamath Management Zone (KMZ), Fort Bragg, San Francisco (SF) Monterey.

2.4. Environmental Baseline

The “environmental baseline” refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. 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 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

2.4.1. Status of treaty Indian fisheries and their relationship to the Environmental Baseline

NMFS recognizes the unique status of treaty Indian fisheries and their relation to the environmental baseline. Implementation of treaty Indian fishing rights involves, among other things, application of the sharing principles of various legal principles established through multiple cases affecting Council salmon fishery implementation (e.g., *United States v. Oregon (302 F. Supp. 899, D. Or. 1969); Unites States v. Washington (384 F. Supp. 312, W.D. Wash. 1974), and Parravano v. Masten, (70 F.3d 539, 9th Cir. 1995))*. Exploitation rate calculations, escapements, 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, status of other species intercepted, the allowable fisheries and the anticipated fishing effort.

Native Americans have lived along the western coast of the present-day United States for thousands of years. On the coast, native people lived at the mouths of the many rivers that spill into the Pacific Ocean. Generally a seafaring people, along the Washington Coast they also have hunted seals and whales. Along this coast, and further south, anthropological and archaeological evidence suggests that for more than 10,000 years Native Americans have fished for salmon and steelhead, as well as for other species for ceremonial, subsistence, and economic purposes (Campbell and Butler 2010). These people expressed their relationship to the fish and waters that sustained them in dance, song, ceremony, and social relationships. In the late 1800s, they ceded most of their ancient lands to the federal government as waves of settlers encroached west and forced treaties took their lands, rivers, and fishing rights.

While we do not have reliable catch data for Indian fisheries prior to the 1800's to include as a baseline level of native harvest, Native American fish harvest and consumption helped elucidate the reservation of the treaty fishing right during treaty negotiations in the mid-1850s. Salmon and steelhead from the ocean had spiritual and cultural significance for tribes, and the fish had economic importance as both a trade and food item. Tribes developed elaborate rituals to celebrate the return of the first fish. These first-salmon ceremonies were intended to ensure that abundant runs and good harvests would follow. The health of Native Americans was heavily reliant on these resources whose diets traditionally included certain quantities and qualities of fish (Harper and Deward E. Walker 2015).

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 Secretarial Order 3206, and other applicable laws and policies. 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.

The final recovery plan for SRKWs reviews and assesses the potential factors affecting their survival and recovery, and lays out a recovery program to address each of the threats (NMFS 2008a). As described in the Status of the Species (Section **Error! Reference source not found.**) the primary limiting factors identified include reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS 2008a). 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 primarily responsible for the status of SRKW. A number of other factors in addition to these three have been identified as potential threats to SRKW. 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 2008a; NMFS 2016a). Available data suggests that all the threats are potential limiting factors. Subsequent sections describe conditions in the Environmental Baseline resulting from the other primary threats. The majority of the factors that affect the whales' status throughout their geographic range, also affect the whales and critical habitat within the action area. As a result, most of the topics addressed in the species' status section and critical habitat status section are also relevant here and so we only briefly touch upon some of these topics in this section. Below, we briefly discuss climate change, prey availability, prey quality, vessels and noise, entrapment and entanglement in fishing gear, oil spills, and scientific research in the action area.

2.4.2. Climate Change

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. The effects of climate change described in the Status section would be expected to occur in the action area. Extensive climate change caused by the continuing buildup of human-produced atmospheric carbon dioxide and other greenhouse gases is predicted to have major environmental impacts in the action area during the 21st century and beyond. Warming trends in water and air temperatures are ongoing and are projected to disrupt the region's annual cycles of rain and snow, alter prevailing patterns of winds and ocean currents, and result in higher sea levels (Glick 2005, Snover et al. 2005). These changes, together with increased acidification of ocean waters, would likely have profound effects on marine productivity and food webs, including populations of salmon.

2.4.3. Prey Availability

Chinook salmon are the primary prey of SRKWs throughout their geographic range, which includes the action area. 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.

Here we provide a review of previous ESA Section 7(a)(2) consultations covering affects 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 SRKW in the action area.

2.4.2.1 ESA Section 7(a)(2) Consultations

Harvest Actions

Directed Salmon Fisheries

Directed salmon fisheries that intercept fish that would otherwise pass through the action area as available prey for SRKWs occur all along the Pacific Coast, from Alaska to California. In past harvest consultations including Puget Sound salmon fisheries—(NMFS 2010b; 2014a; 2015b; 2016b; 2017a; 2018b; 2019d, 2020c), Council-area salmon fisheries (NMFS 2008b; NMFS 2020a), the Columbia River salmon fisheries (NMFS 2008c; 2018c), salmon fisheries managed consistent with provisions of the Pacific Salmon Treaty (PST) (NMFS 2008d; NMFS 2019e)—we characterized the short-term and long-term effects that these salmon fisheries have on the SRKWs via prey reduction and 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 stocks over time by decreasing the number of fish that escape to spawn.

Fisheries off Alaska, Canada, Washington, and Oregon are managed under the Pacific Salmon Treaty. 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 2019d), NMFS estimated that the percent reductions of adult 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%[18] 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. 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 ESU-specific requirements for ESA-listed salmon ESUs and as a result typically 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 SRKW, and fisheries are managed consistent with the proposed actions and ITSs in these opinions. Puget Sound salmon fisheries are managed by the State of Washington and tribes with treaty fishing rights ("co-managers") under the purview of US v. Washington. Since 2014, when the most recent long-term management agreement expired, the co-managers have generally developed single-year management plans. NMFS has consulted on several federal actions related to these one year plans on Puget Sound Chinook, steelhead, and SRKWs on an annual basis since 2014. Other listed species affected by fisheries in the action area are covered by existing opinions as described in Table 1.

The 2009 biological opinion on the Pacific Coast Salmon Plan (NMFS 2009) for SRKWs 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. The PFMC ocean salmon fisheries would reduce prey availability for the whales in most areas and time periods but in some areas/times, the reduction led to negligible reductions in prey compared to with no harvest. During other periods and in other locations, the harvest would appreciably reduce available prey (>10% reduction), but the amount available to the whales after harvest would still be multiple times larger than the whales' energetic needs (available prey is larger than 60 times SRKW needs). 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 was likely to adversely affect but was not likely to jeopardize the continued existence of SRKWs (NMFS 2020a). NMFS also concluded the action was likely to adversely affect the current or proposed critical habitat but not likely to destroy or adversely modify that habitat. We considered whether the overall Chinook abundance in the action area for 2020 was above the levels observed in particularly low abundance years when there is a higher risk of low Chinook abundance negatively affecting whale health. Taking into account the most recent data on abundance and whale health, we anticipated that the abundance of Chinook salmon estimated for 2020 would be well above the low abundance threshold in the NOF area (972,000 adult Chinook) that we used as an interim measure pending the completion of the Workgroup's

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[18] 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. 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.

analysis taken together with the expected percent reduction in Chinook abundance from the 2020 fisheries would result in relatively low risk to whale health in 2020. Even though NMFS 2020 only addressed the 2020 fisheries, we also analyzed the effect of similar fisheries into the foreseeable future, and considered the long-term effects of the 2020 fisheries on the affected salmon stocks that are prey for SRKWs. NMFS concluded that the 2020 fisheries are not likely to impede the survival or recovery of the whales (NMFS 2020a).

Recent biological opinions considering the effects of Puget Sound salmon fisheries on SRKWs have similarly considered percent reductions in 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 federal actions related to the salmon fisheries in Puget Sound (NMFS 2020c), 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%[19] 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 2020). 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 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. In addition, additional management measures were implemented to reduce impacts of vessel and noise disturbance.

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. With the exception of the opinion on the recent *U.S. v. Oregon* Agreement, which covers salmon fisheries in the Columbia River basin (NMFS 2018c), the harvest biological opinions referenced above also conclude that the harvest actions were likely to adversely affect but were not likely to jeopardize the continued existence of SRKW. The *U.S. v. Oregon* action was determined to not likely adversely affect SRKWs because hatchery production included as part of that action offset the in-river harvest reductions (i.e., reductions occur after they are no longer available as prey), Columbia River salmon stocks are currently managed in line with recovery planning and the status of several stocks and ESUs have improved under the fishing regime, and hatchery programs are managed in ways to minimize effects to listed species (NMFS 2018c).

PFMC Groundfish Fisheries

The groundfish fisheries in the EEZ off the West Coast are managed by NMFS and the PFMC pursuant to the Pacific Coast Groundfish FMP. PFMC groundfish fisheries catch Chinook salmon as bycatch while conducting these fisheries (Table 4). Chinook salmon bycatch in the

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[19] 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.

groundfish fishery ranged from 3,068 to 15,319 from 2008 to 2015 and averaged 6,806 (NMFS 2017b). Bycatch consists of primarily subadult Chinook salmon taken annually in the groundfish fisheries, which are typically age 2 and 3 year old Chinook (NMFS 2017c) that are typically smaller than the preferred prey size of SRKW. Previous analysis indicated that latitude was an important factor in determining expected Chinook bycatch and associated stock composition (NMFS 2017b). Chinook bycatch was higher when fishing at more southerly latitudes (NMFS 2017c).

Table 4. Chinook salmon bycatch in groundfish fisheries from 2011 to 2018. Created from the 2019 West Coast Groundfish Observer Program (WCGOP) salmon report, some WCGOP sectors have been combined for interannual continuity and improved reader understanding. Whiting fishery sectors together take on average 90 percent of the total Chinook bycatch each year in groundfish fisheries.

Fishery	2011	2012	2013	2014	2015	2016	2017	2018
Sum at-sea whiting	3,989	4,209	3,739	6,695	1,806	3,051	3,771	5,524
Catcher Processor	2,693	1,928	1,758	3,785	1,545	2,684	3,051	2,951
Non-Tribal Mothership	1,296	2,281	1,981	2,910	261	367	720	2,573
Shorebased whiting	3,722	2,359	1,263	6,898	2,002	738	1,435	1,334
Fixed gear	11	69	115	25	45	19		18
Bottom trawl	187	319	323	977	1,018	375	244	350
Midwater rockfish	1	12	71	661	482	47	34	95
Total	**11,899**	**11,177**	**9,250**	**21,951**	**7,159**	**7,281**	**9,255**	**12,845**

Hatchery Production

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

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

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

In addition, there have been new initiatives to increase hatchery production to further enhance SRKW 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 hatchery production. These new initiatives are expected to result in the release of over 18 million additional hatchery-origin Chinook in 2021.

NMFS considered the effects of the funding for this additional production programmatically in the 2019 biological opinion on domestic actions associated with implementation of the new PST Agreement (NMFS 2019e) referenced above. In the programmatic assessment of the PST funding initiative (NMFS 2019e), we described our expectations for increased prey abundance for SRKWs through increases in the abundance of age 3-5 Chinook salmon in the times and areas most important to SRKWs. The expectations included increased abundance in inside areas (Puget Sound) in the summer and outside areas (coast) during the winter (Dygert et al. 2018) resulting in a minimum increase of adult fish abundance by 4-5 percent in both inside areas in the summer and coastal areas in the winter. Consultations on site-specific hatchery production increases have been completed on some of the increased hatchery production and are included in Table A.1.

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 2020d) 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 may benefit from an increase in high priority prey stocks. Separate analyses of the long-term effects of hatchery production on listed salmon and steelhead have been completed for many of these hatchery programs (Table A.1). 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.

Habitat Actions

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 reasonable and prudent alternatives. In addition, the environmental baseline is influenced by many actions that pre-date the salmonid listings and that have substantially degraded salmon habitat and lowered natural production of ESA-listed Chinook salmon. In fact, Chinook salmon currently available to the whales are still below their pre-ESA listing levels, largely due to these past activities that pre-date the salmon listings. Since the SRKWs were listed, federal agencies have also consulted on impacts to the whales from actions affecting salmon by way of habitat modification.

In addition to the funding for increased hatchery production described above, the programmatic consultation on the funding initiative for U.S. domestic actions associated with the new PST Agreement (NMFS 2019e) assessed the effects of funding habitat restorations projects that would 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. 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 (NMFS 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 under consideration for the initiative would include riverine, lacustrine, wetland, estuarine and marine restoration activities designed to maintain, enhance, and restore aquatic functions as well as projects specifically designed to recover listed fishes. These projects would be reviewed for consistency with the Habitat Restoration Program 4(d) Rule, Limit 8 design constraints specified in NMFS biological opinion (NMFS 2006). These constraints are expected to limit the adverse effects of constructing the projects to ESA listed fish. NMFS will ensure projects have ESA and NEPA coverage before they can utilize federal funds.

A number of hydropower projects affect habitat for salmon that occur as adults in the action area. NMFS has consulted on several hydropower operations in Washington. For example, in 2014, NMFS finalized its biological opinion on the operation and maintenance of the Mud Mountain Dam project (NMFS 2014b). NMFS also recently consulted on the Howard Hanson Dam, Operations, and Maintenance (NMFS 2019f). These opinions concluded that the proposed actions would jeopardize the continued existence of Puget Sound Chinook salmon, Puget Sound steelhead, and SRKWs and would adversely modify or destroy their designated critical habitats. 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).

NMFS has also consulted on the Central Valley Project and State Water Project associated with the California WaterFix Project in the Central Valley Delta (NMFS 2017e) which included construction, maintenance, and operations of new facilities, operation of existing facilities, and operation of new and existing conversation programs, monitoring, and adaptive management. The opinion found that the project was not likely to jeopardize the continued existence of listed species that may be affected, specifically Sacramento River winter-run Chinook, Central Valley spring-run Chinook, Central Valley steelhead, the Southern North American green sturgeon DPS, or SRKW, and would also not destroy or adversely modify critical habitat for these populations with critical habitat in the action area.

NMFS has also previously consulted on the effects of flood insurance on SRKWs. NMFS' biological opinion on the National Flood Insurance Program in Washington State-Puget Sound region concluded that the action was likely to jeopardize the continued existence of the Puget Sound Chinook salmon ESU, and that the potential extinction of this ESU in the long-term jeopardized the continued existence of SRKWs (NMFS 2008e). For these consultations, RPAs were identified in order to avoid jeopardy and not adversely modify or destroy designated critical habitat (NMFS 2008e; 2014b; 2019f).

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 2012a). 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 2012a).

More recently, NMFS finalized its biological opinion on the Klamath Project Operations from April 1, 2019 through March 31, 2024 and found that action was not likely to jeopardize the continued existence of SRKWs (NMFS 2019g). While the analysis indicated that the Operations will generally continue to reduce Chinook salmon productivity in the Klamath River, additional measures were included in the proposed action that are expected to lower disease risk conditions and ultimately improve overall juvenile fall-run Chinook salmon survival.

On November 9, 2020, NMFS issued a biological opinion (NMFS 2020f) 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.

Our jeopardy and adverse modification findings for PS Chinook salmon and SRKWs were based on the following considerations: (1) PS Chinook salmon populations are far from meeting recovery goals and trends in abundance and productivity are mostly negative, (2) nearshore habitat quality is insufficient to support conservation of this ESU, (3) SRKW prey is at a fraction of historical levels (4) under the current environmental baseline, nearshore habitat in Puget Sound cannot support the biological requirements of PS Chinook salmon, (5) the condition of the environmental baseline is such that additional impacts on the quality of nearshore habitat is likely to impair the ability of that habitat to support conservation of these species, (6) the proposed action would further reduce the quality of nearshore habitat in Puget Sound.

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.

2.4.2.2 Assessing Baseline Prey Availability

We assessed Chinook salmon abundance in the action area in the absence of the proposed action (i.e., pre-fishing) by referring to the approach described in the PFMC SRKW Ad Hoc Workgroup Report (PFMC 2020a). Here, we briefly describe the method the Workgroup developed to estimate the starting abundance (without the proposed action) of Chinook salmon (age 3 and older) available for fishery management years 1992 – 2016 within the action area during October – April. Here we make the assumption that the range of abundances experienced since 1992 is likely representative of the range of abundances we expect to see in future years and that 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. As mentioned above, the goal of this funding initiative was a 4-5% increase in available prey in both inside areas in the summer and coastal areas in the winter, but these assumptions were not included in the Workgroup's prey availability assessment.

Coastwide adult abundance estimates for most Chinook salmon stocks were generated using the most recent version of the Chinook Fishery Regulation Assessment Model (FRAM) (MEW 2008) post-season runs (Round 6.2 of base period calibration; 10.29.2018[20]). There are several stocks[21] that are known to occur in the action area, but the Council either does not currently use models to account for these stocks, or a model is available but the stock's contribution as potential prey was considered insubstantial (refer to Appendix A in PFMC (2020a) for the rationale for excluding particular stocks). There are also several stocks that are currently modeled external to FRAM that were also considered and included in the abundance estimates due to the likely spatial-temporal overlap of these stocks with SRKWs and relatively large abundances of these stocks. These include Sacramento Fall, Klamath Fall, and Rogue Fall stocks along with Upper Columbia Spring/Snake River Spring-Summer stocks. The Sacramento River Fall stock tends to dominate ocean abundances in much of California (Satterthwaite et al. 2015), and Sacramento Fall, Klamath Fall, and Rogue Fall can make up a large proportion of the ocean abundance off northern California and southern/central Oregon (Bellinger et al. 2015).

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[20] FRAM gets updated periodically. Round 6.2 was the best available version at the time of the analysis.

[21] Sacramento Winter Chinook salmon, Central Valley Spring Chinook salmon, components of the Central Valley Fall Chinook stock complex (San Joaquin Fall and Sacramento Late-Fall Chinook salmon), Klamath River Spring Chinook salmon, California Coastal Chinook salmon, Smith River Chinook salmon, Rogue River Spring Chinook salmon, and other Southern Oregon Chinook salmon stocks outside the Rogue River (PFMC 2020a).

Rangewide ocean abundances were distributed among spatial boxes (e.g., waters off California and Oregon as well as North of Falcon (NOF), southwest Vancouver Island and the Salish Sea; see PFMC 2020a for the full descriptions of the areas) based on estimates of the proportion of each stock found in each area each season. 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 (2020a) and shown in Table 5.

Estimated Chinook salmon abundances aggregated in the various spatial areas prior to Council fishing (i.e., no proposed action) during the first time step in October – April during 1992 – 2016 are provided in Figure 19. These starting abundances are prior to natural mortality estimates or fishery mortality estimates. The starting abundances are based on time step 1 because the Workgroup agreed this was the most appropriate initial abundance estimate for the purpose of estimating reductions in area-specific abundance attributable to Council-area directed fishery removals. To determine the effects of the fisheries, fishery mortalities over the season by FRAM time step (October – April; May – June; July – September) are subtracted from the starting abundance in time step 1 (see Effects section). The estimated abundances include the FRAM stocks identified in Table 5 and the non-FRAM stocks that are estimated external to FRAM that are considered because of the spatial-temporal overlap with SRKWs and their relatively large abundances (e.g. Sacramento Fall, Klamath Fall, and Rogue Fall stocks along with Upper Columbia Spring/Snake River spring-summer).

Table 5. Mapping Chinook salmon stocks used within the Shelton et al. model to the FRAM model stocks (replicated from PFMC 2020a).

Stock (Shelton)	Stocks (FRAM)
Central Oregon	Mid Oregon Coast
Lower Columbia	Columbia River Oregon and Washington Hatchery Tules, Lower Columbia River Wilds, Lower Columbia River Naturals, Columbia River Bonneville Pool Hatchery
Upper Columbia	Columbia River Upriver Summer, Columbia River Upriver Bright, and Snake River Fall
Northern Oregon	Oregon North Coast
Puget Sound	Nooksack/Samish, Skagit, Snohomish, Stillaguamish, Tulalip, Mid Puget Sound, University of Washington Accelerated, South Puget Sound, Hood Canal, Juan de Fuca Tributaries, Hoko
Southern Georgia Strait	Fraser Lates, Fraser Earlies, Lower Georgia Strait
Washington Coastal	Willapa Bay, Washington North Coast
West Coast Vancouver Island	West Coast Vancouver Island

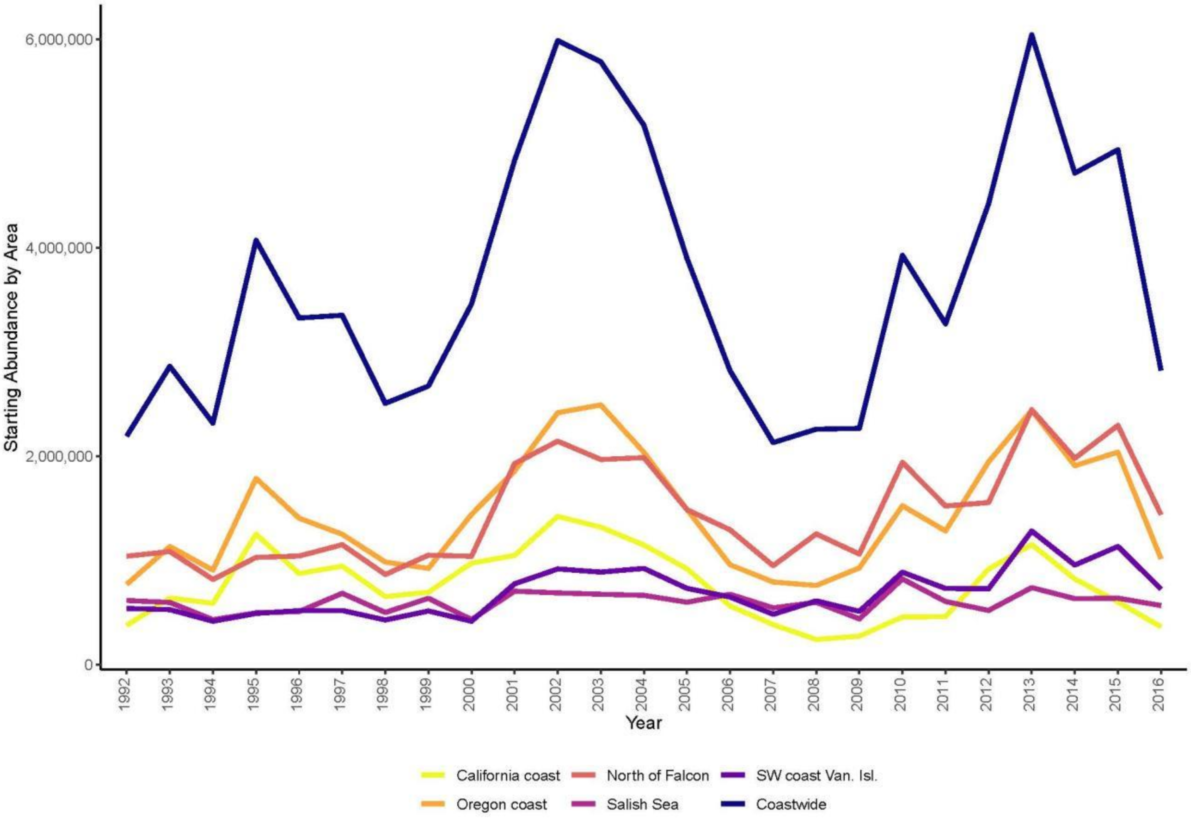

Figure 19. Starting abundances in October – April (FRAM time step 1) for "zero PFMC" fishing runs (PFMC 2020a, Appendix E) for each spatial area from 1992 – 2016.

To put these starting abundance estimates in Figure 19 in context, 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 coastwide (methodologies described in previous biological opinions; e.g. NMFS 2019d). 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. Based on dietary/energy needs and 2015 SRKW abundances, Chasco et al. (2017) also modeled SRKW prey requirements and found that in Salish Sea and U.S. West Coast coastal waters[22], the population requires approximately 393,109, adult Chinook salmon annually on average across model simulations, including 217,755 in the Salish Sea (discussed in more detail below). These estimates can vary

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

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.

In previous biological opinions (e.g. NMFS 2019d), 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. 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. In inland waters, forage ratios ranged from 17.57 to 29.77 in October – April, from 16.39 to 30.87 in May – June, and from 8.28 to 16.89 in July – September (see NMFS 2020c for further details). These estimated ratios suggest coastwide prey availability is substantially lower in the winter than summer relative to the metabolic needs of the whales, and inland water forage ratios suggest an opposite trend. The abundance estimates in Figure 19 are the number of adult Chinook salmon available to the whales at the beginning of the year, prior to natural mortality and fishery mortality. Therefore these are considered maximum estimates of prey available. Similar to other fishery models, the Workgroup 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).

Marine mammal consumption of Chinook salmon in coastal waters has likely increased over the last 40 years. Chasco et al. (2017) 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. (2017) 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 uncertainty. 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. (2017) calculated that when species occur in the coastal waters off the U.S. West Coast (not including occurrence and consumption in the Columbia River and Salish Sea; areas which were included in some of the previously referenced studies), Southern Residents would consume approximately 175,354 adult salmon (ocean ages 1-5), harbor seals ~163,676 salmon, California sea lions ~175,170 salmon, and Steller sea lions would consume approximately 253,997 adult salmon. Again, these values represent a model scenario where there is a consistent abundance of salmon for consumption and they 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 SRKW. The estimate of Chinook abundance available to the whales in the beginning of the year in the action area (maximum estimates of prey available, Figure 19) in 2016 was roughly 3 million fish compared to an estimated annual consumption ranging from 211,000 to 393,109 depending on the size of the SRKW population (Chasco et al. 2017; Noren 2011; Williams et al. 2011). 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.

2.4.4. Prey Quality

Contaminants enter marine waters and sediments from numerous sources, but are typically concentrated near populated areas of high human activity and industrialization. Freshwater contamination is also a concern because it may contaminate salmon that are later consumed by the whales in marine habitats. Chinook salmon contain higher levels of some contaminants than other salmon species, however levels can vary considerably among populations. Mongillo et al. (2016) reported data for salmon populations along the west coast of North America, from Alaska to California and found the salmon's marine distribution was a large factor affecting persistent pollutant accumulation. They found higher concentrations of persistent pollutants in Chinook salmon populations that feed in close proximity to land-based sources of contaminants. There is some information available for contaminant levels of Chinook in inland waters (i.e., Krahn et al. 2007; O'Neill and West 2009; Veldhoen et al. 2010; Mongillo et al. 2016). Some of the highest levels of certain pollutants were observed in Chinook salmon from Puget Sound and the Harrison River (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 that 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). Nutritional stress, potentially due to periods of low prey availability or in combination with other factors, could cause SRKWs 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. 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. 2019). Smaller fish would have less caloric content (lower quality), so decreases in size of older Chinook salmon that are preferred by SRKW could lead to SRKW needing to consume more Chinook salmon than historically, in order to consume enough to match their caloric needs.

2.4.5. Vessels and Sound

Commercial shipping, cruise ships, and military, recreational and fishing vessels occur in the coastal range of SRKWs and additional whale watching, ferry operations, recreational and fishing vessel traffic occurs in their inland range. The density of traffic is lower in coastal waters compared to inland waters of the Salish Sea. Several studies in inland waters have linked interactions of vessels and Northern Residents and SRKW with short-term behavioral changes (see review in Ferrara et al. (2017), whereas there have been no studies that have examined interactions of vessels and SRKWs with behavioral changes in coastal waters. These studies that occurred in inland waters 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 coastal waters are most likely from large ships, tankers and tugs, whereas vessel sounds in inland waters also come from whale watch platforms, ferry operations 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 or reduces 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 SRKW communication, foraging, and navigation (Veirs et al. 2016). 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 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. 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. Similar studies have not occurred in the coastal waters of the action area so it is unclear to what extent these results are applicable. However, it suggests there may be some energetic cost where vessels and SRKWs may overlap.

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). Southern Resident killer whales 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). Given the differences in vessel density between coastal and inland waters, the two areas differ in bathymetry (e.g. inland waters is a semi-closed fjord), and there have been limited studies on SRKWs in coastal waters, it is unknown if SRKWs behave similarly in the presence of vessels in coastal waters as they do in inland waters.

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 in inland waters 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 2017)). The average number of vessels with the whales decreased in 2018 and 2019 due to decreased viewing effort on SRKWs by commercial whale watching vessels, with an average of 10 and 9 vessels with the whales at any given time, respectively (Shedd 2020). However, fishing vessels are also found in close proximity to the whales in inland waters and were responsible for 13% of the incidents inconsistent with the Be Whale Wise Guidelines or non-compliant with federal regulations in 2019 (Shedd 2020). These activities included entering a voluntary no-go zone or fishing within 200 yards of the whales. A number of recommendations to improve compliance with guidelines and regulations are being implemented in inland waters by a variety of partners to further reduce vessel disturbance (Ferrara et al. 2017).

Anthropogenic (human-generated) sound in the action area 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).

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.

2.4.6. Entrapment and Entanglement in Fishing Gear

Drowning from accidental entanglements in nets and longlines is a minor source of fishing related mortality in killer whales. One killer whale was reported interacting with a salmon gillnet in British Columbia in 1994, but did not get entangled (Guenther et al. 1995). Two killer whales have been recorded entangled in Dungeness crab commercial trap fishery gear off California (one in 2015 and one in 2016). 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 unnpubl. 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[23].

2.4.7. Oil Spills

As described in the Status of the Species section, SRKWs are vulnerable to the risks imposed by an oil spill. There is some level of risk from serious spills in the action area because of the heavy volume of shipping traffic and proximity to petroleum refining centers. The total volume of oil spills in inland waters of Washington 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

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

known pathways: contact, adhesion, inhalation, dermal contact, direct ingestion, and ingestion through contaminated prey (Jarvela-Rosenberger et al. 2017).

2.4.8. Scientific Research

Most of the scientific research conducted on SRKW in the action area occurs in inland waters of Washington State. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. Research activities are typically conducted between May and October in inland waters and can include aerial surveys, vessel surveys, close approaches, and documentation, and biological sampling. Most of the authorized takes would occur in inland waters, with a small portion in the coastal range of SRKWs. In light of the number of permits, associated takes, and research vessels and personnel present in the environment, repeated disturbance of individual killer whales is likely to occur in some instances. In recognition of the potential for disturbance and takes, NMFS took steps to limit repeated harassment and avoid unnecessary duplication of effort through conditions included in the permits requiring coordination among permit holders, such as restricting the number of research vessels within 200 yards of a SRKW at any given time. The cumulative effects of research activities were considered in a batched biological opinion for four research permits in 2012 (NMFS 2012b). The cumulative effects were also considered in the biological opinion on the renewal of the research permits (NMFS 2018d). The biological opinion concluded the cumulative impacts of the scientific research projects were likely to adversely affect but were not likely to jeopardize the continued existence of SRKWs.

2.5. Effects of the Action

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. Effects on Southern Resident Killer Whales

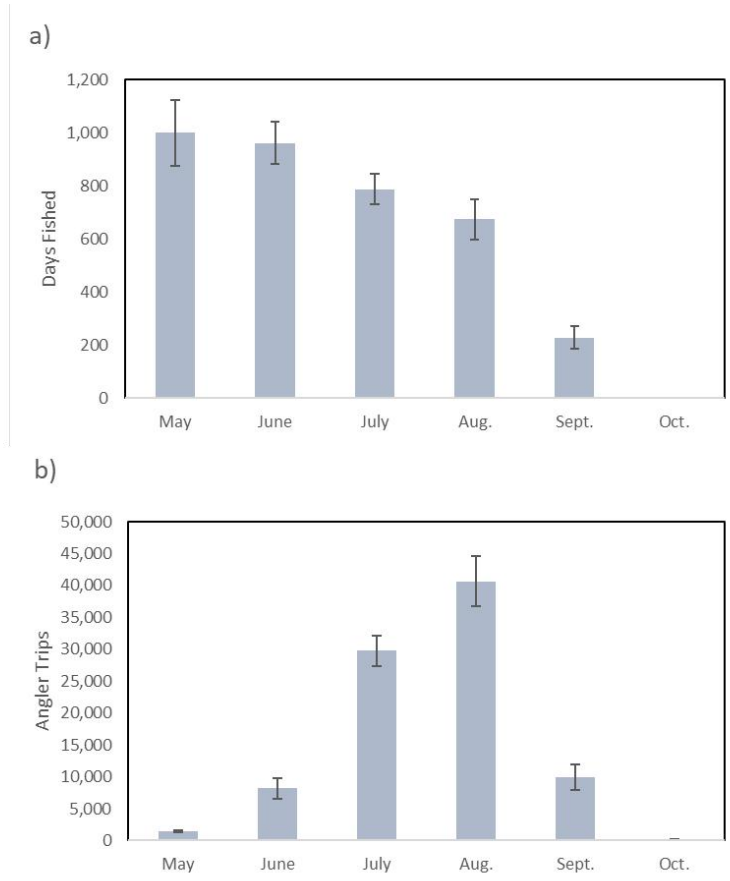
Fisheries conducted under the proposed action may affect SRKWs through interactions with vessels and gear and by reducing prey availability. This section evaluates the effects of the proposed action on the Southern Resident killer whale DPS. NMFS has incorporated analyses from the Pacific Fishery Management Council Salmon Fishery Management Plan Impacts to Southern Resident Killer Whales Risk Assessment (PFMC 2020a) into this biological opinion to help analyze the effects on prey availability from PFMC fisheries.

We first describe the temporal and spatial overlap of the fisheries with SRKWs to provide a context for assessing the action's effects on SRKWs. Seasonal timing and general locations of the fisheries are included in the description of the proposed action. Temporal and spatial data for SRKWs includes multiple data sets based on opportunistic sightings, acoustic detections, and satellite tag deployments which are considered together to provide the most comprehensive picture of SRKW movements. Second, we discuss the potential for vessel and gear interactions including potential SRKW responses to potential interactions. Next we assess the effects on SRKWs from the reduction of prey by (1) providing a background description on the relationship between Chinook salmon abundance and SRKW demographics, (2) analyzing the short-term (annual) effects, and lastly (3) analyzing the long-term effects from the PFMC fisheries.

Spatial/Temporal Overlap of the PFMC Salmon Fisheries with SRKWs

Overlap of Council ocean salmon fisheries in the NOF area with SRKWs

For the most recent ten-year period where data are available (2009-2018), the average NOF commercial troll fishing effort (total Treaty tribal and non-tribal) measured in days fished per month were highest in May (999 days fished[24]) which then decreased through the remaining season (Figure 20a). For the recreational fishery in the NOF area, season opening dates, closing dates and daily retention limits vary by year and by subarea (PFMC 2020a). The average number of angler trips from 2009 to 2018 were highest in August (40,636 trips) and lowest in May (1,460 trips) and October (234 trips) (Figure 20b; PFMC 2020d). We expect the general level of fisheries effort in future years to be similar to that observed during this recent time period (2009 – 2018) given the combination of generally more constraining salmon harvest control rules, conservation objectives, and Pacific Salmon Treaty obligations (PFMC 2020a).



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[24] Fishing days is the summation of the number of days each commercial troll fishing vessel fished.

Figure 20. U.S./Canada border to Cape Falcon a) commercial troll salmon fishing effort in average days fished (total Treaty tribal and non-tribal) and b) recreational fishing effort in average angler trips during open seasons from 2009 to 2018 (data from Table A-24 and Table A-27, PFMC 2020d). In data in PFMC 2020d, "-"represent season closures and are not included in our calculations so values are averages in years and months when the fishery is operating. Error bars represent standard error. The solid gray bars represent an increased likelihood there may be an overlap of whales and fishing vessels. Because whales are present in NOF waters in all months, all bars are solid gray.

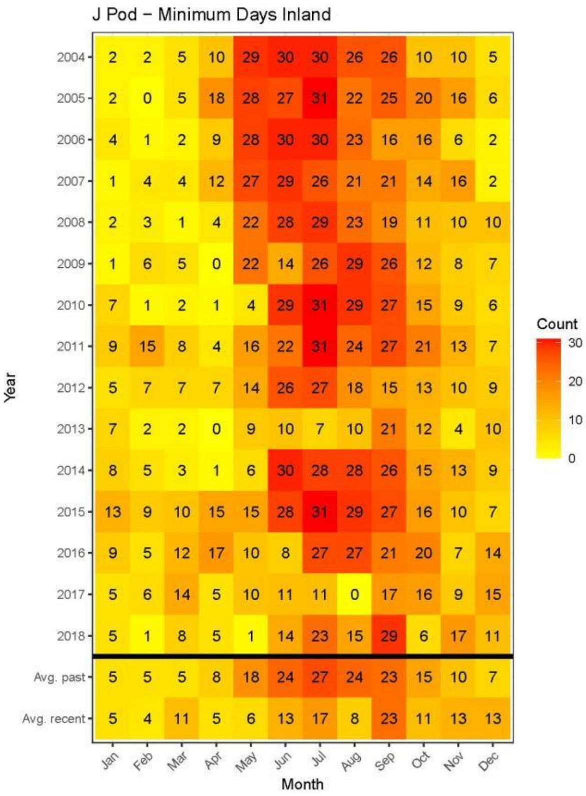
There have been 49 confirmed opportunistic sightings of SRKWs between 1986- 2016 off the coastal areas of Washington, Oregon, and California (NMFS 2019c). Twenty six of these 49 confirmed sightings occurred off Washington coast and six of the 26 occurred from May to September (refer to Table 2.2.a in PFMC 2020a). Satellite tagging efforts that were deployed from 2012-2016 between the months of December to May provide limited information on the overlap between whales and fisheries. However, the tagging effort showed K/L pods occurred almost exclusively on the continental shelf, primarily on the Washington coast, with a hot spot area between Grays Harbor and the Columbia River and off Westport with relative peak detections in spring months (Figure 9 and Figure 12; Hanson et al. 2017, 2018), whereas J pod remained primarily in the Salish Sea. Additionally, there were acoustic detections of SRKWs off Washington coast in all months of the year (Figure 11; refer to Table 2.2c in PFMC 2020a) and results of the acoustic detections suggest SRKWs may be present in Washington coastal waters at nearly any time of year, and in other coastal waters more often than previously believed (Hanson et al. 2017).

Given each method (opportunistic sightings, satellite tagging, and acoustic recordings) has its own limitations in terms of providing a clear understanding of the SRKW's spatial and temporal use in coastal waters throughout the year, Hanson et al. (2018) integrated the opportunistic sightings with output from a state-space movement model, which was fit to the locations from several satellite-tagged SRKWs, to fill in the detection gaps in the acoustic detections of this population in the coastal waters. The results from the annual predictive maps of the acoustic recorder detections indicate a pattern of distribution similar to years that whales were satellite tagged. While the winter monthly occurrence patterns appear to be similar to the annual patterns, there are some months that exhibit greater variation (Hanson et al. 2018).

As described in the status section, more is known on space use in the Salish Sea primarily during summer months. These data can inform us of when SRKWs are not in coastal waters. Although seasonal movements of SRKWs are generally predictable, there can be large inter-annual variability in the time spent in the Salish Sea from spring through fall and whales have been detected fewer days in recent years (Hanson and Emmons 2010; Whale Museum unpublished data). 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). In addition, in 2019, some members of L pod were not encountered 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).

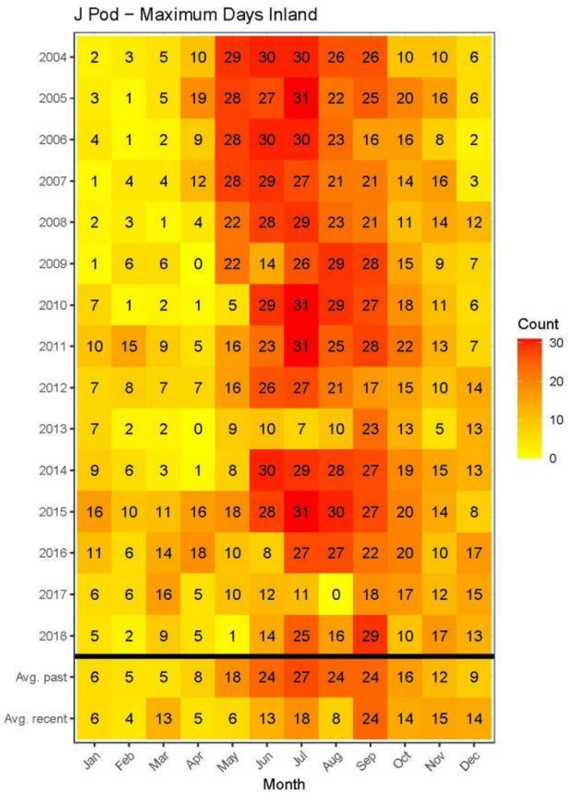
This occurrence in the Salish Sea is substantially different from patterns observed in previous years. We used the most recent available 15 years of data (2004 – 2018) from The Whale Museum as a reliable indicator of whale presence to estimate the number of days that members of specific pods spent in the Salish Sea (Figure 21). Figure 21 includes the minimum and maximum counts of days spent in the Salish Sea from 2004 – 2018 (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 21). For L pod, September 2017 and 2018 showed similar patterns to previous years, but was sighted in the Salish Sea substantially fewer days than average in July and August 2017 and 2018 (less than half the average of the previous years). Occurrence diverged in both years (2017-2018) for K pod, but especially in 2017 where they were only sighted 0-4 days in summer months and 20 or less days sighted in other months. In 2018, K pod was only sighted in 1 day in August. K and L pod were both sighted <10 days in July and August on average in 2017-2018. The year 2013 also showed fewer days in the Salish Sea in early summer months, but not to the extreme of more recent years. Altogether, this illustrates the variability in occurrence in the Salish Sea, especially in recent years. Even with fewer days in summer months recently, all pods are still encountered more frequently in the Salish Sea in summer months than in spring months (see Figure 21).

If we assume that when K and L pods are not encountered in the Salish Sea, they are likely in the coastal waters of the action area, then in some years there may be more potential for an overlap between PFMC fishing vessels and SRKWs. However, it is possible the whales are not in the Salish Sea or U.S. coastal waters of the action area and may occur in waters off southwest Vancouver Island given the limited data on SRKW presence in the coastal waters. They have been observed in both U.S. and Canadian coastal waters of the action area in recent years when not in the Salish Sea. Given the large inter-annual variability in the SRKWs seasonal distribution, we cannot predict the whales' movements in future years. Therefore, we take a conservative approach and assume that K and L pods will likely have more years where they spend less time in the Salish Sea (similar to what has been observed in recent years compared to most years before 2017), and more time in the U.S. coastal waters of the action area where the potential for overlap with the PFMC salmon fisheries may occur.



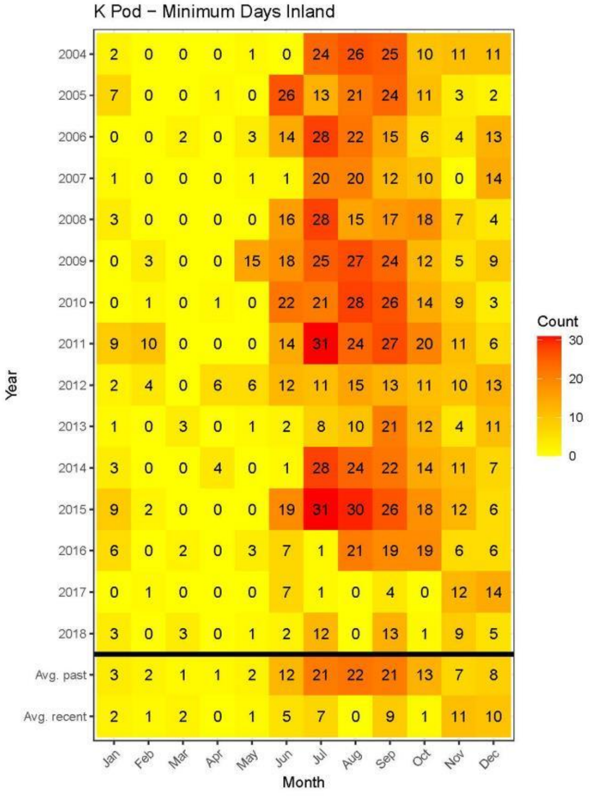
J Pod − Minimum Days Inland

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	2	2	5	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	21	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	6
2011	9	15	8	4	16	22	31	24	27	21	13	7
2012	5	7	7	7	14	26	27	18	15	13	10	9
2013	7	2	2	0	9	10	7	10	21	12	4	10
2014	8	5	3	1	6	30	28	28	26	15	13	9
2015	13	9	10	15	15	28	31	29	27	16	10	7
2016	9	5	12	17	10	8	27	27	21	20	7	14
2017	5	6	14	5	10	11	11	0	17	16	9	15
2018	5	1	8	5	1	14	23	15	29	6	17	11
Avg. past	5	5	5	8	18	24	27	24	23	15	10	7
Avg. recent	5	4	11	5	6	13	17	8	23	11	13	13



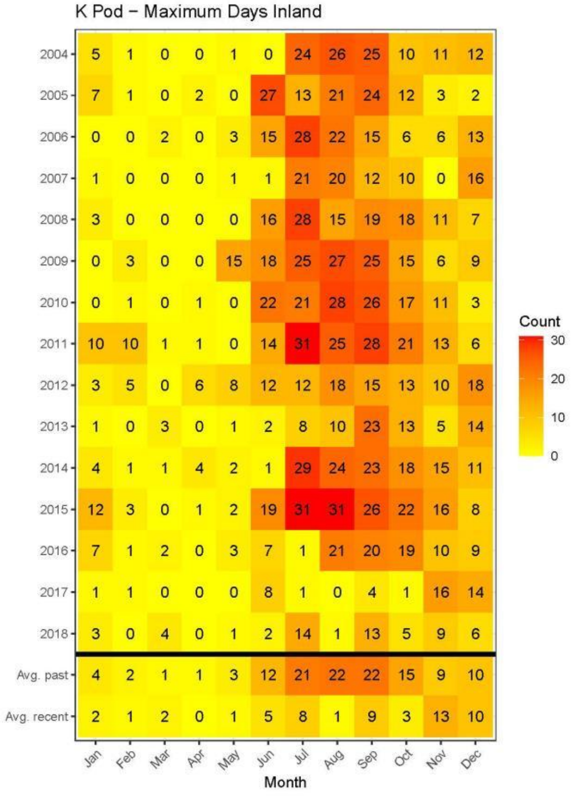
J Pod − Maximum Days Inland

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



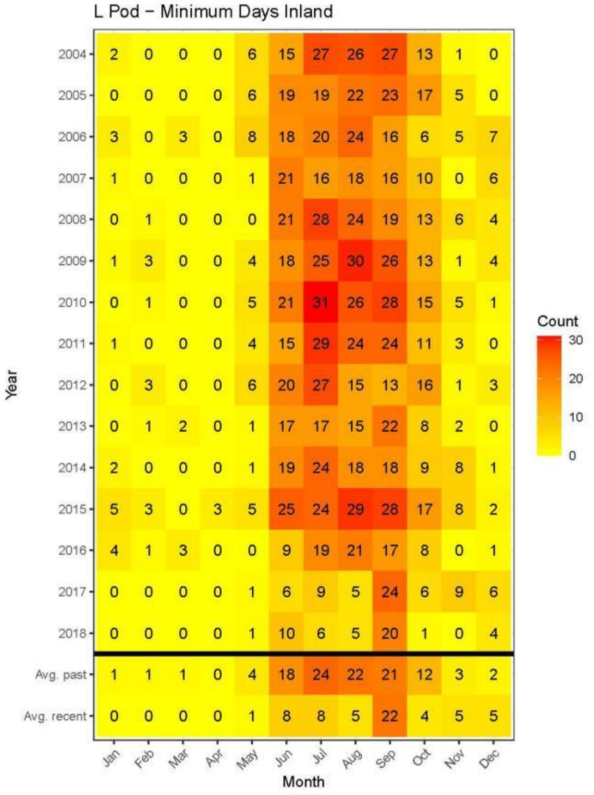
K Pod − Minimum Days Inland

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	2	0	0	0	1	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	14	28	22	15	6	4	13
2007	1	0	0	0	1	1	20	20	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	11	15	13	11	10	13
2013	1	0	3	0	1	2	8	10	21	12	4	11
2014	3	0	0	4	0	1	28	24	22	14	11	7
2015	9	2	0	0	0	19	31	30	26	18	12	6
2016	6	0	2	0	3	7	1	21	19	19	6	6
2017	0	1	0	0	0	7	1	0	4	0	12	14
2018	3	0	3	0	1	2	12	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	1	5	7	0	9	1	11	10



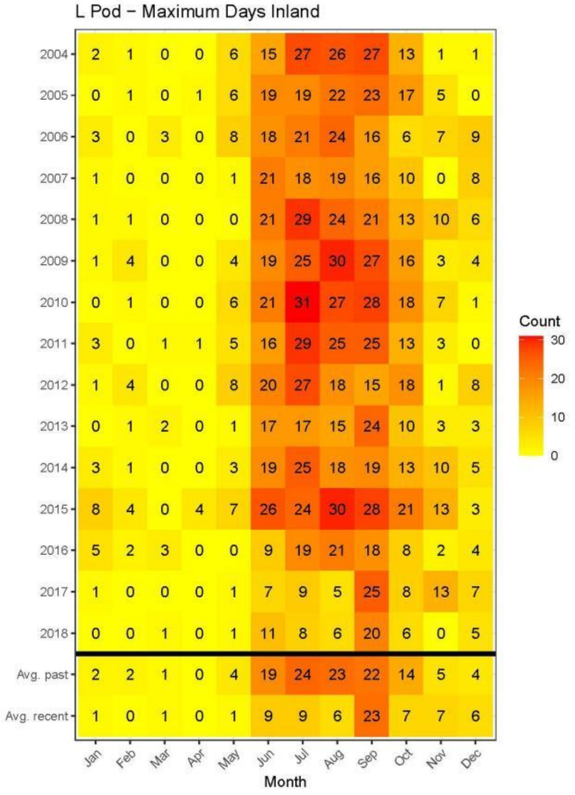
K Pod − Maximum Days Inland

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	5	1	0	0	1	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	15	28	22	15	6	6	13
2007	1	0	0	0	1	1	21	20	12	10	0	16
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	3	5	0	6	8	12	12	18	15	13	10	18
2013	1	0	3	0	1	2	8	10	23	13	5	14
2014	4	1	1	4	2	1	29	24	23	18	15	11
2015	12	3	0	1	2	19	31	31	26	22	16	8
2016	7	1	2	0	3	7	1	21	20	19	10	9
2017	1	1	0	0	0	8	1	0	4	1	16	14
2018	3	0	4	0	1	2	14	1	13	5	9	6
Avg. past	4	2	1	1	3	12	21	22	22	15	9	10
Avg. recent	2	1	2	0	1	5	8	1	9	3	13	10



L Pod − Minimum Days Inland

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



L Pod − Maximum Days Inland

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

Figure 21. 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, unpubl data). "Avg past" is average before 2017 and "Avg recent" is average in 2017-2018. Note that "inland" includes sightings off the West coast of Vancouver Island if nearshore because these are outside the action area and their movements could include heading north or turning into the Salish Sea without entering the action area, but likely staying nearshore as seen for the majority of SRKW detections (see Ford et al. 2017, Emmons et al. in press). 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.

Although we make a conservative assumption that when the whales are not in the Salish Sea, they are in U.S. coastal waters of the action area, we believe it is reasonable to assume that the whales could occur in the NOF area during the fishing season because the whales have been detected or observed in every month of the year in this area with peak detections in the spring (although potentially not in every year because there can be large inter-annual variability). It is also reasonable to assume that when SRKWs are in the NOF area during the fishing season (typically May through September), they may overlap with the fisheries given both are probably targeting the same salmon stocks that are available in this area. As discussed above, the commercial troll fishing effort is typically highest in May and declines over the season, therefore we assume a higher potential of overlap of the whales with commercial vessels early in the season. The recreational fishing effort is typically highest in August and therefore there may be a higher potential of direct overlap with the recreational vessels and whales in August, however, the overlap of whales and fishing vessels is less likely during late summer months than in the spring because the historical and more recent whale spatial use data suggest they are observed in the Salish Sea by August.

As described in the proposed action, under the FMP with proposed Amendment 21, 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. The effect of these actions would be to reduce overlap between the whales and fisheries in these low abundance years. In general, the quota restrictions and spatial/temporal control zone closures were designed to respond to SRKW seasonal movements and hot spot area use (areas of greater use) (e.g. the mouth of the Columbia River and Grays Harbor); PFMC 2020a, NMFS 2019c). Closures in these areas would reduce the likelihood of overlap. In addition, limiting the allocation of the non-tribal Chinook salmon troll quota in NOF waters caught in the spring time to no more than 50% would mean likely lower fishing effort in spring when the whales are more likely to be present, further reducing overlap.

In summary, results from opportunistic sightings, satellite tagging, and acoustic recorders suggest SRKWs may be present in Washington coastal waters at nearly any time of year (Hanson et al. 2017, NMFS 2019c; also see Section **Error! Reference source not found.**), although the available data are limited and there can be large inter-annual variability in the time spent and distribution in coastal waters. Therefore, there is the potential that SRKWs may overlap with the fisheries in any particular year. Although there is limited information on the exact locations of the fishing vessels and SRKWs when the whales are in coastal waters, and the vessels are likely spread out, we can assume that in years when the whales spend less time in the Salish Sea, there may be an increased likelihood of an overlap between vessels and whales in the U.S. coastal waters of the action area. Given that SRKWs have been observed less often in the Salish Sea in spring months compared to summer months, and peak acoustic detections in the NOF area have occurred in spring months (Figure 12; Figure 21), we assume the whales are more likely to be in the NOF area in spring months than in summer months and that is the most likely period when SRKWs and fisheries may co-occur or overlap. Lastly, because the extended spatial/temporal control zone closures consider the seasonal movements and hot spots of Southern Resident killer whales (e.g., off the mouth of the Columbia River and Grays Harbor; PFMC 2020a, NMFS 2019c), we expect in low Chinook salmon abundance years, the required management actions outlined in the proposed Amendment 21 would reduce overlap between the fisheries and the whales.

Overlap of Council ocean salmon fisheries off Oregon coast and SRKWs

For the most recent ten-year period where data are available (2009-2018), the highest average Oregon commercial troll salmon fishing effort (in days fished) occurred in May (1,180 days) followed by an average of 1,007 days in June (Figure 22a). In contrast, the highest average Oregon ocean recreational salmon fishing effort (in angler trips) occurred in August (22,726 trips) and July (19,942 trips) (Figure 22b). Similar to the NOF area, we expect the general level of fisheries effort in future years to be similar to the 2009-2018 time period given the combination of generally more constraining salmon harvest control rules, conservation objectives, and Pacific Salmon Treaty obligations (PFMC 2020a).

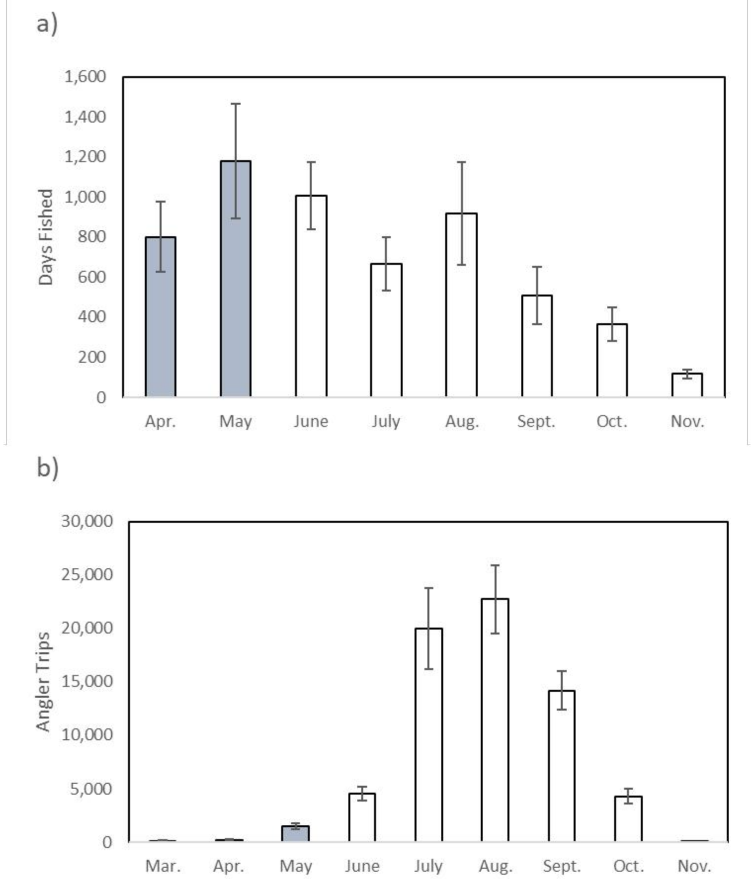


Figure 22. Oregon a) commercial troll salmon fishing effort in average days fished per month and b) ocean recreational salmon fishing effort in average number of angler trips per month in open seasons from 2009 – 2018 (data from Table

A-6 and Table A-9, PFMC 2020d). Error bars represent standard error; solid gray bars represent higher likelihood there may be an overlap of whales and vessels; white bars represent a lower likelihood that there may be an overlap of whales and vessels. Given the whales have not been detected or observed in Oregon waters in June through October, there is a lower likelihood of an overlap of whales and vessels even though the effort is relatively higher.

Based on opportunistic sightings, satellite tagging efforts, and acoustic detections, the whales are observed off the Oregon coast (see Section **Error! Reference source not found.**) and they may have some direct overlap with the fisheries. Specifically, of the 49 confirmed opportunistic sightings of SRKWs between 1986 and 2016, 8 were off the Oregon coast (south of Falcon to the California border; NMFS 2019c). Of these 8 sightings, 4 occurred in March and April and 4 occurred in January and February (refer to Table 2.2.a in PFMC 2020a). Satellite tagging efforts that were deployed from 2012-2016 between the months of December to May provide limited information on the overlap between whales and fisheries. The tagging effort showed K/L pods occurred off Oregon coast, but to a lesser extent than off the Washington coast (Figure 9; Hanson et al. 2017, 2018). Additionally, there were acoustic detections of SRKW off Oregon coast on the Newport hydrophone (Figure 10). Results indicate SRKW were detected off the Newport recorder in January, February, March, and May.

Although the whales' predictive use in any particular area is uncertain and the limited data seems to suggest considerable year-to-year variation, the current data suggest that an overlap of SRKWs with the fisheries may be more likely to occur from March through May when fisheries may be open and whales have been historically observed or detected in the area (illustrated in Figure 22 by the shaded bars). During this time, the commercial troll fishing effort is highest but the recreational fishing effort is lowest (Figure 22a, b; PFMC 2020d). Because the whales have not been detected or observed in the coastal waters of Oregon during June through October, the majority of duration of the commercial and recreational fishing seasons, there is a lower likelihood of overlap of whales with the fisheries in these months. Although there may be potential for overlap of the whales with recreational fisheries from March – May and in November, the recreational fishing effort is relatively low during these months and therefore likelihood of overlap is likely low. Furthermore, as described in the proposed action, under proposed Amendment 21, in years when the projected preseason abundance of Chinook salmon in NOF waters falls below the established low abundance threshold, multiple management actions will be implemented through annual regulations in areas South of Falcon, including in Oregon. These management measures are designed to respond to SRKW seasonal movements in Oregon coastal waters. The commercial troll fishery between Cape Falcon and the Oregon/California border would be delayed until April 1, and the KMZ in Oregon waters would close to commercial and recreational salmon fisheries from October 1 through March 31 of the following year. These actions would further reduce the potential for overlap between the whales and fisheries in these low abundance years.

In summary, results from opportunistic sightings, satellite tagging, and acoustic recorders suggest SRKWs may be more likely present in Oregon coastal waters in January through May than in other months of the year, although the available data are limited and there can be large inter-annual variability in the time spent and distribution in coastal waters. Although there is limited information on the exact locations of the fishing vessels and SRKWs when the whales are in the U.S. coastal waters of the action area, and the vessels are likely spread out, we can assume that in March through May when the whales have a higher likelihood of being in Oregon waters than in other months of the year, there may be an increased likelihood of an overlap between vessels and the whales. During these months, the commercial troll fishing effort is relatively high and recreational fishing effort is relatively low compared to other months of the year. Lastly, we expect in low Chinook salmon abundance years, the required management actions outlined in Amendment 21 would reduce overlap between the fisheries and the whales.

Overlap of Council ocean salmon fisheries off California coast and SRKWs

For the most recent ten-year period where data are available (2009-2018), the highest average California commercial troll salmon fishing effort (in days fished) occurred in May and July (approximately 2,500 days) followed by an average of 2,355 days in August (Figure 23a). The highest average California ocean recreational salmon fishing effort (in angler trips) occurred in July (27,410 trips) (Figure 23b). The whales are observed off the California coast (see Section **Error! Reference source not found.**), and may have some overlap with the fisheries. Similar to the NOF and Oregon coastal waters, we expect the general level of fisheries effort in future years to be similar to the 2009-2018 time period given the combination of generally more constraining salmon harvest control rules, conservation objectives, and Pacific Salmon Treaty obligations (PFMC 2020a).

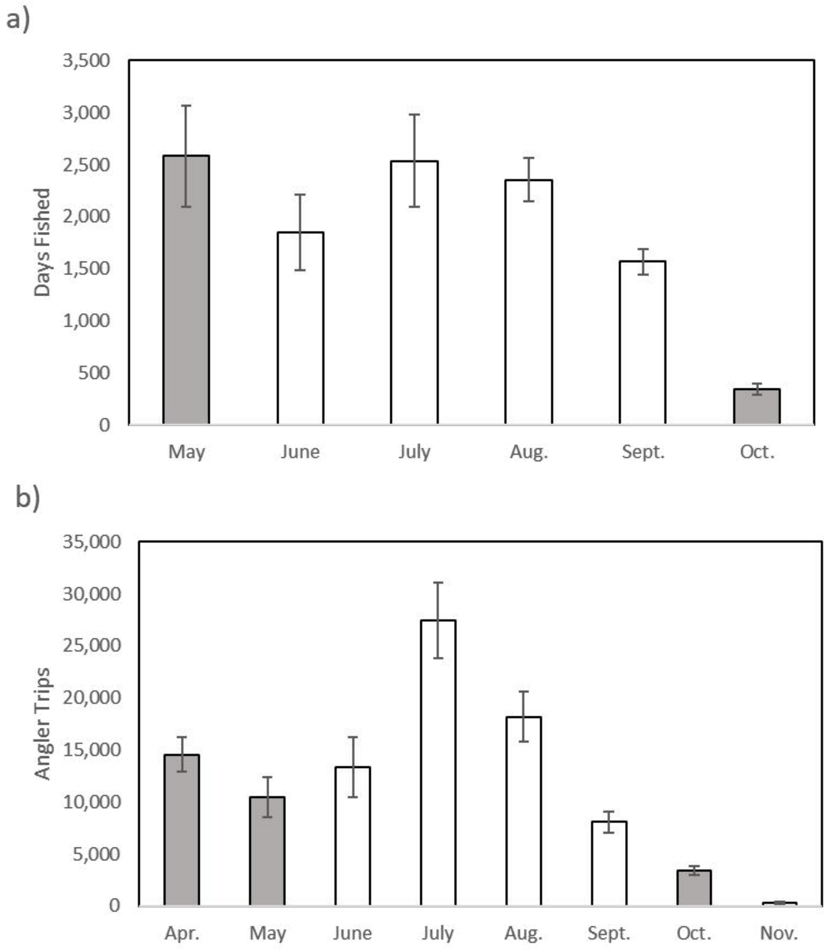


Figure 23. California a) commercial troll salmon fishing effort in average days fished per month and b) ocean recreational salmon fishing effort in average number of angler trips per month from 2009 – 2018 (data from Table A-

2 and Table A-4, PFMC 2020d). Error bars represent standard error; solid gray bars represent higher likelihood of overlap of whales and vessels; white bars represent a lower likelihood of overlap with the whales and vessels.

Of the 49 confirmed opportunistic sightings of SRKWs between 1986 and 2016, 15 were off the California coast (from the Oregon-California border to Point Sur, CA; NMFS 2019c). Of these 15 sightings, 13 occurred in January, February, and March, and 2 occurred in April and October (refer to Table 2.2.a in PFMC 2020a). Satellite tagging efforts that were deployed from 2012-2016 between the months of December to May provide limited information on the overlap between whales and fisheries. The tagging effort showed K/L pods occurred off California coast, but to a lesser extent than off the Washington coast (Figure 9; Hanson et al. 2017, 2018). Lastly, there were acoustic detections of SRKWs off California coast on the Fort Bragg and Point Reyes hydrophones (Figure 10). Results indicate SRKWs were detected off these recorders in January, February, May, and December (refer to Table 2.2.d in PFMC 2020a). Although limited, these data indicate the whales have been observed or detected in California waters at least once every year from 2005 to 2016, with the exception of 2010. These observations and detections occurred in winter months and early spring (between January through May, October, and December).

Although the whales' predictive use in any particular area is uncertain and the limited data seems to suggest considerable year-to-year variation, the spatial distribution data for the whales suggest an overlap with salmon fisheries may be more likely to occur in April, May, and October because the whales and the fisheries both occur off California during these months in some years. During these months of potential overlap (i.e., the fishing season is open and the whales have been observed or detected in the area), the average effort for commercial troll fishing is relatively high in May and relatively low in October and the average effort for recreational fishing is at average levels in April and May and relatively low in October (Figure 23a, b; PFMC 2020d). We assume the higher the fishing effort during months the whales may overlap with the fisheries, the higher the likelihood of the overlap.

As described in the proposed action, in years when the projected preseason pre-fishing abundance of Chinook salmon in the NOF area falls below the established low abundance threshold, multiple management actions will be implemented through annual regulations in SOF areas, including in California. These management measures are designed to respond to SRKW seasonal movements in California coastal waters. As in Oregon waters, the KMZ in California waters would close to commercial and recreational salmon fisheries from October 1 through March 31 of the following year. In addition, the commercial and recreational salmon fisheries in the Monterey management area would close from October 1 through March 31 of the following year. The Klamath River Control Zone would be closed to salmon fishing. In addition, the closed area would be expanded to 6 miles beyond the northern and southern boundaries of the recently closed area and 12 miles seaward of the western boundary of the recently closed area. The State of California would also ensure closure of other California control zones are in effect year-round (Smith, Eel, Klamath rivers). In summary, we expect in low Chinook salmon abundance years, the required management actions outlined in the proposed Amendment 21 would reduce overlap between the fisheries and the whales.

Vessel and Gear Interactions

There is some potential for direct interaction between SRKWs and salmon fishing vessels and gear in the U.S. coastal waters of the action area in some times and areas because of the spatial and temporal overlap between the whales' distribution and the distribution of the Council salmon fisheries as described above. Because K and L pods have more overlap with coastal fisheries, they are more likely to be affected by vessels and gear interactions than J pod, which generally has not been observed or detected in areas the PFMC fisheries occur. Assuming proposed Amendment 21 is approved, in low Chinook abundance years in the future, the proposed action would lower the potential for direct interactions with vessels and gear by reducing spatial and temporal overlap between the fisheries and SRKWs. There is no potential for direct effects on the SRKWs from vessels or gear when the whales occur in the Salish Sea or the coastal waters off SWVCI because the ocean salmon fisheries managed under the FMP do not occur in inland waters of Washington and British Columbia or the coastal waters of British Columbia. As described in the Status of the Species, SRKWs typically spend a substantial amount of time in the inland waterways of the Salish Sea during late spring, summer, and early fall. However, their seasonal movements are only somewhat predictable because there can be large inter-annual variability in arrival time and days present in inland waters (Figure 21). Late arrivals and fewer days present in inland waters have been observed in recent years.

In future fishing seasons, vessel traffic and fishing effort associated with the Council fisheries are not anticipated to be higher than past levels given the combination of generally more constraining salmon harvest control rules, conservation objectives, and Pacific Salmon Treaty obligations (PFMC 2020a).

As we do expect some overlap between vessel traffic and fishing effort and SRKWs, and thus potential interactions with the whales, this analysis considers how effects from vessel activities and gear interactions associated with the proposed fisheries may impact the fitness of SRKWs (e.g., reproduction, numbers, or their distribution). We first describe the potential interactions (e.g., vessel strike, gear interaction, vessel or acoustic disturbance) and then potential responses (e.g., mortality, serious injury, behavioral changes). 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 of SRKWs with commercial and recreational vessels could occur while vessels are fishing or while they are transiting to and from the fishing grounds. As described in the Status of the Species section, vessel strikes or any potential for gear interaction with marine mammals are rare, though a recent paper did determine cause of death was vessel strike for three stranded whales (one Southern Resident, one Northern Resident, and one transient whale, for 22 whales where a definitive cause of death could be determined from 2004 to 2013) (Raverty et al. 2020). 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 PFMC ocean 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)[25]. 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 (with the exception of tribal treaty fisheries, but tribes voluntarily report such interactions) participating in U.S. fisheries are required to report incidental marine mammal

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

injuries and mortalities. The current LOF classified the "CA/OR/WA salmon troll" fisheries as a Category III fishery (i.e., remote likelihood of/no known incidental mortality or serious injury of marine mammals) (85 FR 21079; April 16, 2020). Although vessel strikes and gear interactions 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 along the U.S. West Coast, particularly into and out of major ports. It is reasonable to expect that the Council salmon fisheries may result in more vessels in the general proximity to the whales than there would be if no fishing is authorized, and therefore based on the limited 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 fishing in the PFMC salmon fisheries if SRKWs were present nearby. There is a potential for SRKW/fishery vessel interaction during all months the fishery is occurring in the NOF area, with the highest likelihood occurring in the spring, and the highest likelihood for interaction in the beginning months of the season off Oregon and California (i.e., April and May) based on the limited data available. However, in years when Chinook abundance drops the low abundance threshold, exposure of SRKWs to vessels and noise from vessels would be reduced in general due to constraints on the fishery to protect Chinook salmon stocks and specifically in hot spot areas in the NOF (e.g. off the mouth of the Columbia River and Grays Harbor) during spring months (when the likelihood of overlap of fishing vessels and SRKWs is highest). Similarly, in the SOF area when abundance fell below the low abundance threshold, additional area/time closures which would be implemented under proposed Amendment 21 are anticipated to reduce the likelihood of spatial and temporal overlap of the whales and vessels, likely reducing exposure of SRKWs to vessels.

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 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). Increases in energetic costs because of behavioral disturbance and reduced foraging can both decrease individual whales' fitness and health (Dierauf and Gulland 2001; Trites and Donnelly 2003; 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 PFMC salmon fishing vessels 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. Fishing vessels participating in PFMC salmon fisheries are spread out over the large U.S. coastal portion of the action area. The greatest effects would be expected to occur in the NOF area where the potential for overlap of the whales and fisheries may be the greatest, compared to the SOF areas. Although vessel and acoustic disturbance are potential threats to SRKWs, their effect is likely limited as fishing vessels operate at slow speeds or in idle when actively fishing. When in transit, vessels would likely travel at faster speeds with potential to affect the whales' behavior; however, fishing vessels do not target whales, no interactions of ocean fishing vessels and SRKWs have been reported, and any disturbance that may occur would likely be transitory. Fishing vessels are subject to updated state regulations when transiting Washington State waters that protect SRKWs (see RCW 77.15.740) and otherwise subject to guidelines to avoid impacts to whales. NMFS and other partners have outreach programs in place to educate vessel operators, including the fishing community. For example, NMFS' annual Federal Regulations Reference Guide provides the current regulations and the www.bewhalewise.org website for reference to the guidelines on vessel approach distances to SRKWs and other marine life.

In summary, vessel strikes or any potential for gear interactions with SRKWs are rare in general and have never been observed in association with PFMC ocean salmon fisheries. Because we expect the general seasonal patterns of the fisheries and overlap of the fisheries with SRKWs to be similar to what occurred during 2009 – 2018, we also anticipate the direct interaction of SRKWs with fishing vessels and gear to be similar to what occurred during this recent time period under the proposed action. However, there remains some potential for the vessels to be close enough to the whales, either while fishing or transiting, to cause behavioral changes. If such interactions were to occur, they would more likely occur in the NOF area and would likely result in very minor or short-term changes to the whales' behavior or avoidance (as described above). These interactions would be less likely to occur in years when salmon abundance is below the low abundance threshold because the spatial and temporal overlap between the fishery and the whales would be further reduced due to additional fishery area/time closures in areas and times where SRKWs are most likely to be present. In both high and low Chinook salmon abundance conditions, 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. Therefore, we anticipate any interactions from vessels or gear attributed to the proposed action are not expected to result in take of SRKWs.

Effects on SRKWs from the Reduction of Prey Availability

We evaluated the potential effects of the Council salmon fishing on SRKWs based on the best scientific information about the whales' diet and distribution and the reduction in Chinook salmon caused by the Council salmon fishing. We relied on the PFMC SRKW Ad Hoc Workgroup report (PFMC 2020a) where appropriate. Similar to past biological opinions where we assessed the effects of the fisheries (NMFS 2009, NMFS 2019b, NMFS 2020c), our analysis of Council salmon fisheries focuses on effects to Chinook salmon availability because the best available information indicates that SRKWs prefer Chinook salmon (as described in Section **Error! Reference source not found.**) 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. We evaluated the potential short-term (or annual) effects as well as the long-term effects of changes in prey availability from the proposed action 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. We begin by summarizing what is known about the relationship between Chinook salmon abundance and SRKW status.

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 strengths 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) 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 southeast Alaska (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 abundance from 2000-2017 and only when the threats are considered together did the PVA model output 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. 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. Additional efforts to relate sample sizes, for SRKWs and other populations, and relate body condition and demographic rates, including reproduction, are ongoing.

More recently, the Workgroup also attempted to quantify the relationship between Chinook abundance and SRKW demographics (PFMC 2020a) and is discussed in the "*Quantifying Impacts from the PFMC Salmon Fisheries on SRKW demography*" subsection below following the description of the analytical approach to assessing effects. 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. The Workgroup's analysis that attempted to predict the potential SRKW demographic consequences given the predicted prey reductions attributed to the PFMC fisheries suggested that any effects of the fisheries on SRKW demographics were relatively small. Also, the results, combined with other information suggested, some areas of the U.S southern coastal waters may be more consistently more important than others.

Short-Term (Annual) Effects

Here we assess the short-term (or annual) effects of the proposed action on prey availability and considered information to help put those reductions in context. We analyzed the effects of prey reduction in several steps:

1) consider the Workgroup's estimated annual Chinook abundance reductions by spatial and temporal area attributed to the PFMC salmon fisheries for the fishery management years 1992 – 2016 (PFMC 2020a), and how the impacts from the proposed PFMC salmon fisheries compare to the past (1992 – 2016), (2) assess the Workgroup's effort to quantify the short-term effects from these annual prey reductions and the potential demographic consequences for the whales, (3) consider additional aspects of the actions that could have negative consequences, including the potential for localized prey depletions or disproportionally high removals of prey in relatively low Chinook salmon abundance years, and (4) consider increased risk during periods of low Chinook salmon abundance and the aspects of the action, including Amendment 21, that give us confidence that the negative effects will be limited or mitigated.

Annual Reductions in Prey Abundance

For this part of the analysis, we largely rely on the Workgroup's estimates of annual reductions of Chinook salmon abundance by spatial and temporal area attributed to the PFMC salmon fisheries for the fishery management years 1992 – 2016 (PFMC 2020a). 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. Understanding the annual reductions by spatial and temporal area is important because it is unlikely that SRKWs would encounter and consume all Chinook salmon stocks harvested by the PFMC salmon fisheries because the spatial and temporal distributions of whales and fish are not entirely overlapping; in other words there is a low probability that all the Chinook salmon vulnerable to the fisheries would be intercepted by SRKWs across their vast range in the absence of the proposed action. We can better understand the effects by evaluating prey reductions by season and area. We also consider how these annual reductions have changed over this retrospective time period as estimated by the Workgroup.

As described in the Environmental Baseline, the Workgroup estimated starting adult Chinook salmon abundance in seasonal time steps (October – April, May – June, July– September) and aggregated in various spatial areas (NOF, SWCVI, Salish Sea, Oregon coast (Cape Falcon, OR to Horse Mountain, CA), and the California coast (south of Horse Mountain), for the fishery management years 1992 – 2016 (PFMC 2020a). The Workgroup also estimated area-specific PFMC fishery removals using a two-step process. First, stock-specific reductions in abundance attributable to Council-area salmon fisheries were calculated across all fisheries within the action area for each modeled stock and each time step. This was to determine total stock abundance changes resulting from fishery removals. Then these reductions in abundance were apportioned across space based on the assumed distribution of each stock (based on the spatial model and assumptions), rather than attempting to account for where fishery removals actually occurred and subsequent movement of fish within and across time steps (refer to PFMC 2020a for further details on the Workgroup's estimates of removals of FRAM stocks and non-FRAM stocks).

In our short-term analysis, we assume that the range of overall abundances experienced from 1992 - 2016 is likely representative of the range of abundances we expect to see in future years. To take account of the possibility that abundances could drop below this range, we consider changing ocean conditions that may influence ocean survival and distribution of Chinook salmon and other Pacific salmon in our long-term analysis (see the subsection *Long-Term Effects from the PFMC Fisheries* below). Analyzing the effects of the proposed action relies on a review of past circumstances to develop an understanding of the likely influence of removals attributable to the salmon fisheries managed under the FMP on the environment in the future and also incorporates potential variability in other factors that influence salmon abundance. However, actual outcomes will depend on year-specific circumstances related to environmental conditions, individual salmon stock abundance, the combined abundances of stocks in particular fisheries, and how salmon fisheries are actually managed in response to these circumstances.

Due to weak stock management in Council salmon fisheries, a relatively large portion of the overall abundance goes unharvested. The proportion that goes unharvested has been increasing over the time period 1992 – 2016 (PFMC 2020a; Figure 24). For example, during the most recent decade (2007 to 2016), average Chinook salmon reductions coastwide (280,006 fish or a 7.0% reduction in prey) from the PFMC salmon fisheries were less than the average over the entire time period (552,888 fish or 14.9%) even though average coastwide Chinook salmon abundances in these two time periods were similar (3.6 million fish on average; Table 6). The average percent reduction of Chinook salmon abundance coastwide decreased by 53 percent (from 14.9% to 7.0%).

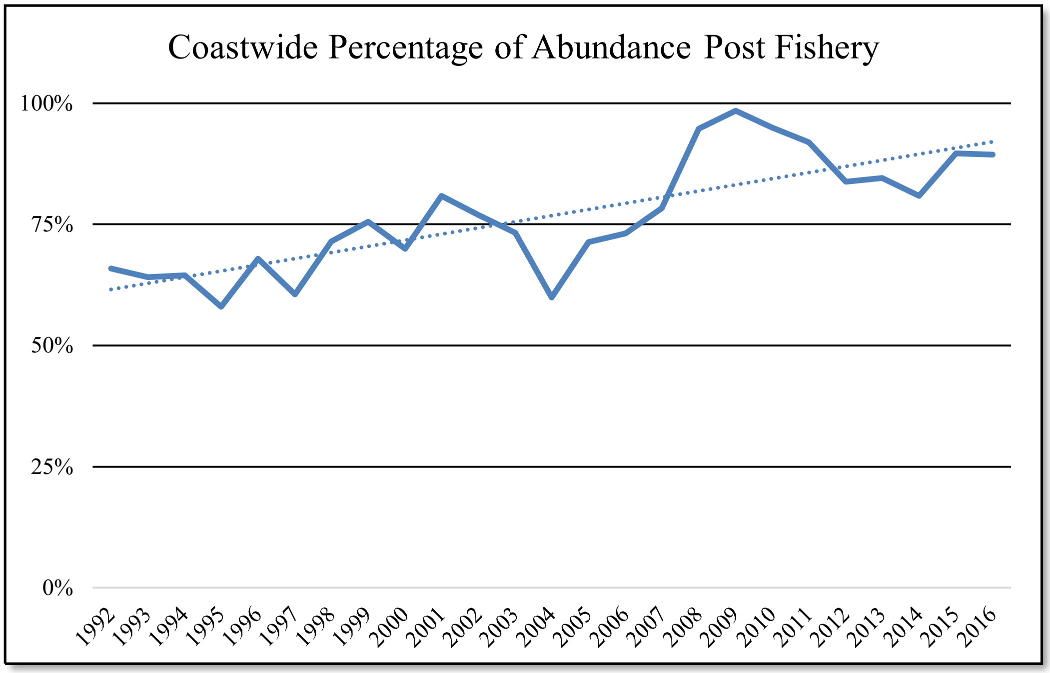

Figure 24. Coastwide (EEZ) 1992-2016 trend in percent of Chinook adult abundance remaining after PMFC ocean salmon fisheries from October through the following September (reproduced from PFMC 2020a).

Table 6. Annual starting abundance in Oct-April time step (PFMC 2020a, Appendix E) and fishery reduction in abundance (as percent reduction), which represents the percent difference between end of year abundances absent fishing and end of year abundances with PFMC fisheries that occurred for each spatial

area from 1992 – 2016 (PFMC 2020a, Appendix E).

Year	Coastwide EEZ	North of Falcon	Salish Sea	SW coast Van. Isl.	Oregon coast	California coast
1992	2,193,832 (18.6%)	1,041,932 (5.6%)	617,641 (2.2%)	541,157 (2.5%)	773,048 (17.2%)	378,852 (56.9%)
1993	2,862,854 (21.1%)	1,087,009 (5.2%)	598,158 (2.1%)	529,682 (2.4%)	1,134,747 (19.1%)	641,098 (51.9%)
1994	2,317,797 (22.9%)	819,183 (3.8%)	433,095 (0.5%)	418,484 (1.4%)	908,210 (18.7%)	590,405 (55.9%)
1995	4,071,145 (30.1%)	1,030,293 (7.7%)	499,241 (1.0%)	493,154 (2.9%)	1,787,381 (22.1%)	1,253,472 (60.0%)
1996	3,325,766 (23.0%)	1,043,645 (5.4%)	511,553 (1.0%)	519,938 (2.1%)	1,406,397 (20.3%)	875,724 (48.2%)
1997	3,351,693 (26.3%)	1,152,375 (5.4%)	686,152 (1.3%)	521,769 (2.4%)	1,252,483 (22.2%)	946,835 (57.2%)
1998	2,507,320 (19.1%)	866,538 (4.9%)	502,160 (1.5%)	430,246 (2.2%)	985,760 (15.3%)	655,023 (43.7%)
1999	2,673,606 (16.3%)	1,051,720 (3.7%)	638,259 (1.8%)	516,628 (1.8%)	925,410 (14.9%)	696,476 (37.2%)
2000	3,459,941 (19.6%)	1,041,262 (4.7%)	434,752 (1.3%)	418,416 (2.3%)	1,443,107 (16.4%)	975,571 (40.4%)
2001	4,838,052 (12.1%)	1,929,921 (4.6%)	707,099 (1.9%)	777,325 (2.3%)	1,858,529 (11.3%)	1,049,602 (27.4%)
2002	5,985,560 (15.1%)	2,144,581 (6.3%)	690,088 (2.7%)	919,884 (2.9%)	2,417,603 (12.8%)	1,423,376 (32.1%)
2003	5,781,691 (17.7%)	1,968,874 (7.3%)	677,273 (3.1%)	889,789 (3.4%)	2,492,455 (17.0%)	1,320,362 (34.2%)
2004	5,173,880 (25.7%)	1,986,923 (7.6%)	666,545 (3.0%)	924,845 (3.3%)	2,037,921 (26.3%)	1,149,036 (55.9%)
2005	3,898,795 (18.6%)	1,488,104 (7.3%)	600,655 (3.0%)	733,401 (3.1%)	1,489,504 (16.9%)	921,187 (39.7%)
2006	2,819,693 (15.9%)	1,294,450 (3.5%)	676,921 (1.6%)	651,164 (1.7%)	959,973 (16.8%)	565,271 (42.7%)
2007	2,131,210 (12.2%)	950,804 (3.1%)	546,430 (1.6%)	484,972 (1.7%)	794,726 (13.1%)	385,680 (32.5%)
2008	2,259,704 (2.9%)	1,255,132 (1.5%)	599,624 (1.1%)	613,707 (0.8%)	760,853 (4.8%)	243,719 (4.5%)

Year	Coastwide EEZ	North of Falcon	Salish Sea	SW coast Van. Isl.	Oregon coast	California coast
2009	2,267,670 (0.9%)	1,062,698 (1.2%)	441,122 (0.9%)	513,370 (0.6%)	929,713 (0.7%)	275,259 (0.4%)
2010	3,926,476 (3.1%)	1,941,645 (2.9%)	823,676 (1.8%)	888,483 (1.4%)	1,525,621 (2.9%)	459,210 (4.4%)
2011	3,269,850 (4.8%)	1,523,499 (2.7%)	607,633 (1.8%)	732,093 (1.3%)	1,284,170 (4.8%)	462,181 (11.4%)
2012	4,422,392 (10.2%)	1,556,212 (4.4%)	522,026 (3.0%)	729,967 (2.3%)	1,946,515 (9.3%)	919,665 (22.0%)
2013	6,040,198 (10.8%)	2,446,093 (3.8%)	741,030 (2.2%)	1,283,502 (1.5%)	2,440,226 (10.5%)	1,153,879 (26.2%)
2014	4,714,616 (12.2%)	1,981,173 (6.3%)	634,819 (3.0%)	957,234 (2.5%)	1,909,754 (11.4%)	823,689 (28.0%)
2015	4,939,468 (6.7%)	2,295,939 (4.3%)	639,674 (2.4%)	1,135,093 (1.7%)	2,039,608 (6.3%)	603,920 (17.1%)
2016	2,823,910 (6.0%)	1,441,061 (2.5%)	568,889 (1.4%)	727,196 (1.2%)	1,018,116 (6.0%)	364,733 (19.9%)
Time series average	3,682,285 (14.9%)	1,456,043 (4.6%)	602,581 (1.9%)	694,060 (2.1%)	1,460,873 (13.5%)	765,369 (34%)
Recent 10-Yr Average	3,679,549 (7.0%)	1,645,426 (3.3%)	612,492 (1.9%)	806,562 (1.5%)	1,464,930 (7.0%)	569,194 (16.6%)

Because the whales are observed in the NOF area in all seasons, they will likely be affected by reduced prey availability resulting from PFMC salmon fisheries in the area (PFMC 2020a). In general, PFMC fisheries are responsive to Chinook salmon abundance. For example, in years of low Chinook salmon abundance in the NOF area, the NOF quotas are set lower, whereas in years of high abundance, the quotas are generally set higher (see Figure 29 below and figures 3.1.a and 3.1.b in PFMC 2020e). The degree of higher or lower depends on the strength of individual Chinook stocks relative to each other and their conservation objectives. Pre-fisheries NOF Chinook salmon abundance estimates ranged from 819,183 to 2,446,093 Chinook salmon in 1992 – 2016 and generally increased over that time period (Table 6; PFMC 2020a). The most recent 10-year average in abundance was estimated slightly higher (1.7 million fish) than over the entire time series (1.5 million fish). Overall, reductions in Chinook salmon abundance NOF attributable to the PFMC fisheries was estimated to range from 1.2% to 7.7% or from 12,883 to 144,602 fish in 1992 - 2016 (Figure 25; Table 6). Although average Chinook salmon abundances NOF were slightly higher in the more recent 10 years when compared to the full time period, average annual reductions attributable to PFMC salmon fisheries (57,926 fish or a 3.3% reduction in prey) were 27 percent lower than the average from 1992 – 2016 (69,095 fish or a

4.5% reduction in prey). The Workgroup found that overall, the PFMC salmon fishery impacts on NOF Chinook salmon abundance are small relative to both annual variation in NOF Chinook abundance and the total abundance in a given year (Figure 25).

Although the PFMC salmon fisheries do not occur in the Salish Sea and in waters off the SWVCI, they reduce Chinook salmon abundance in these areas by harvesting the fish in other areas. Reductions in abundance in the Salish Sea attributable to PFMC salmon fisheries ranged from 0.5% to 3.1% during the entire retrospective time period (Table 6). Reductions in abundance off SWVCI attributable to PFMC salmon fisheries ranged from 0.6% to 3.4% during this same time period (Table 6).

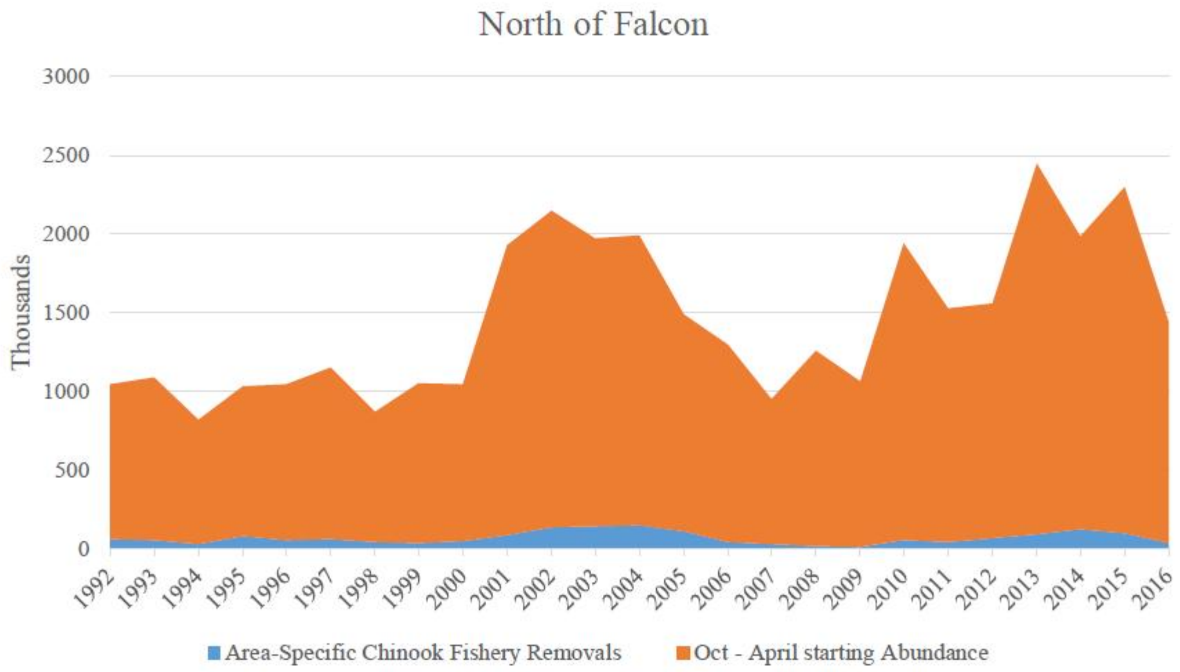

Figure 25. Annual NOF pre-fisheries adult Chinook salmon abundance and reductions attributable to PFMC fisheries (figure reprinted from PFMC 2020a).

As described above, SRKW presence in the SOF area is less frequent and may occur only in a season (winter/spring) during which there is a lower likelihood of a direct overlap of the fisheries and SRKWs compared to the NOF area. In Oregon's coastal waters (as defined by the Workgroup), pre-fisheries abundance estimates ranged from 760,853 to 2,492,455 Chinook salmon in 1992 – 2016 (Figure 26, Table 6; PFMC 2020a). During this time, percent reductions in Chinook salmon abundance in Oregon's coastal waters due to the PFMC salmon fisheries ranged from 0.7% to 26.3% or from 6,483 to 536,591 fish. The average abundance in the most recent 10 years of the time period was similar to the average abundance in the overall time period (approximately 1.5 million); however, the annual reduction in abundance attributable to PFMC salmon fisheries in the last 10 years of the time period (109,902 fish or a 7.0% reduction in prey) was almost half the average over the full time period (199,783 fish or a 13.5% reduction in prey).

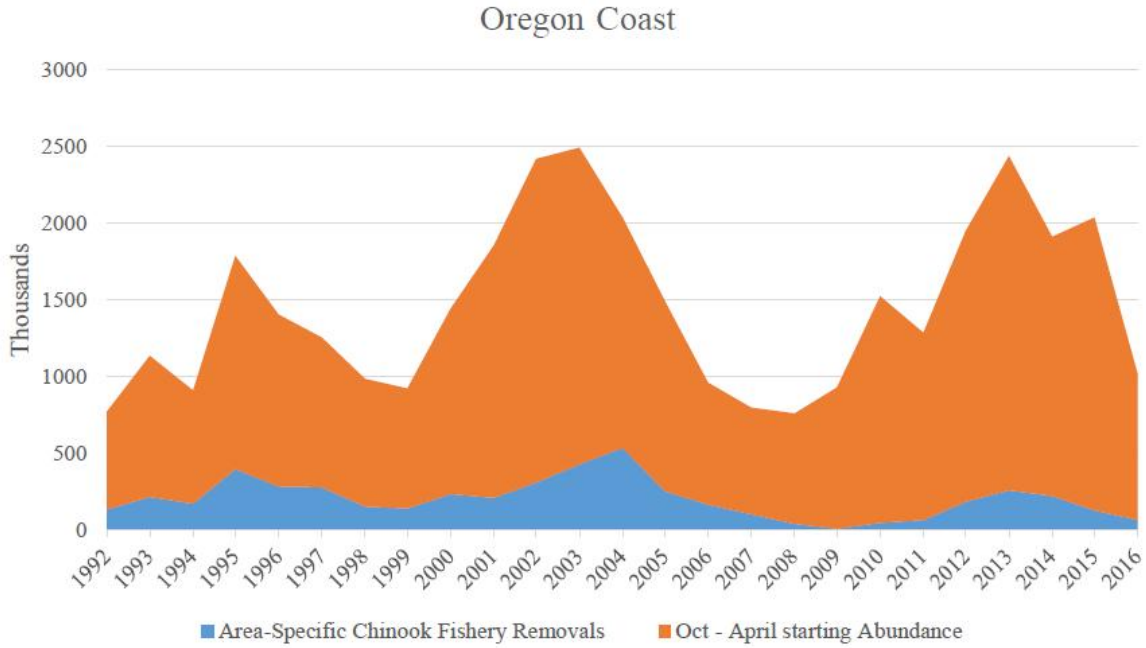

Figure 26. Annual Oregon Coast (Cape Falcon south to Horse Mountain, California) pre-fisheries adult Chinook salmon abundance and reductions attributable to PFMC fisheries (figure reprinted from PFMC 2020a).

Reductions in Chinook salmon abundance attributable to PFMC ocean salmon fisheries are highest in California coastal areas (PFMC 2020a). Pre-fisheries Chinook salmon abundance from 1992 – 2016 ranged from 243,719 to 1,423,376 fish (Table 6). Overall, reductions in Chinook salmon abundance in California coastal waters was estimated to range from 0.4% to 60% or from 1,231 fish to 751,725 fish (Figure 27; Table 6). The estimated average annual abundance in the most recent 10 years (569,194 fish) was 26 percent lower than the average over the entire time series (765,369 fish). However, concurrent with the reduction in average annual abundance, the average percent reduction attributed to the PFMC fisheries declined by twice as much (51%) in the recent 10 years (16.6% reduction in prey) compared to the average percent reduction in prey in the total time series (34.0%).

Although reductions in Chinook salmon abundance are relatively high in California coastal waters, the most abundant SOF stock, Sacramento River fall Chinook (SRFC), has a dominant age-3 maturation rate and so most large adults leave the ocean each fall to return to the river to spawn prior to the whales arriving. This life history (age 3 maturation) means that prey available to the whales off California in the winter months are predominantly smaller individuals newly recruited to the adult stage over the wintertime and the fisheries harvest in the summer on winter adult Chinook salmon abundance is relatively small. Given the whales appear to prefer the larger age 3 – 5 adult fish and the lack of known SRKW occurrence in California waters in summer months, the impacts of the PFMC fisheries may only be relevant in terms of the remaining salmon that would not have spawned in the fall and been available to the whales in the winter (a relatively small fraction of the available salmon).

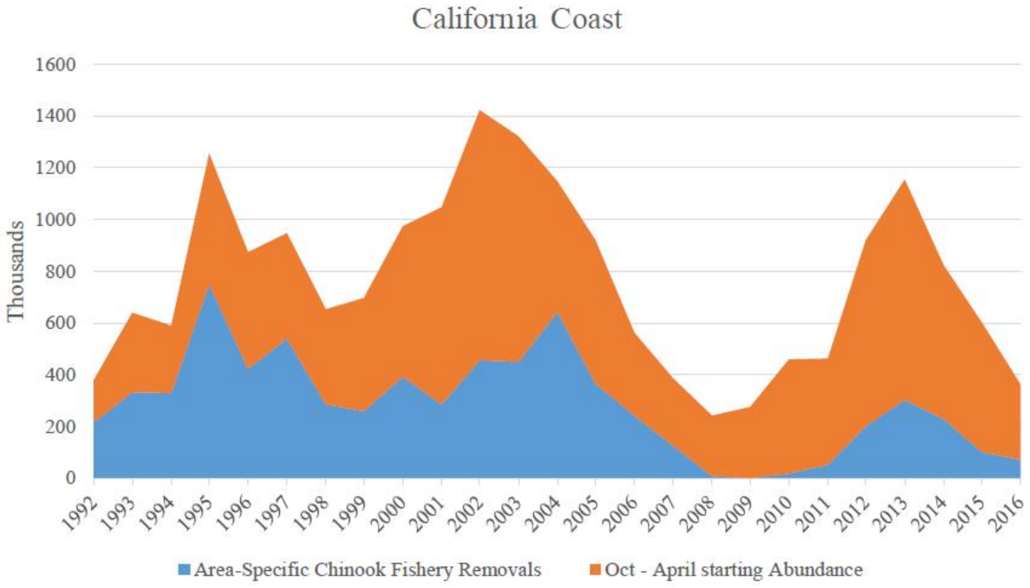

Figure 27. California coast, south of Horse Mountain coastal 1992-2016 trends in annual adult abundance (estimated annually to be present on October 1) and area specific reduction in adult abundance modeled to result from all PFMC salmon fisheries (from October through the following September) (figure reprinted from PFMC 2020a).

In summary, the PFMC salmon fisheries' effects on potential annual prey availability have varied highly over 1992-2016. The average percent reductions of Chinook salmon abundance attributed to the PFMC salmon fisheries over the entire time series was 14.9% coastwide, 4.6% in the NOF area, 1.9% in the Salish Sea, 2.1% in southwest Vancouver Island, 13.5% in Oregon coastal waters, and 34% in California coastal waters. To help put these reductions in context, we first note the percent reductions in abundance attributable to PFMC salmon fisheries is substantially lower in the recent 10-yr period (2007 – 2016) compared to the entire time period (Figure 28). These reduced impacts (i.e., lower percent reductions in Chinook abundance from the PFMC salmon fisheries) were observed coastwide and in each coastal area. For example, during the most recent decade (2007 to 2016), average percent prey reductions attributed to the PFMC salmon fisheries decreased by 53% coastwide (i.e., 53% lower than the average from 1992-2016), decreased by 27% in the NOF area, decreased by almost half in Oregon coastal waters, and decreased by 51% in California coastal waters. The PFMC salmon fishery impacts on NOF Chinook salmon abundance are small relative to both annual variation in NOF Chinook abundance and the total abundance in a given year. Although reductions in Chinook salmon abundance attributable to PFMC salmon fisheries are highest in California coastal areas, SRKW presence in that area primarily occurs in the wintertime and the maturation schedule for the primary stock (SRFC) in this area also limits the carryover effect of fisheries in California during times of the year when the whales are present. Future years that have average coastwide abundance levels similar to those estimated for 1992-2016 would likely see restrictions similar to the most recent decade given the pattern of generally more constraining harvest control rules, conservation objectives, and Pacific Salmon Treaty obligations over the time period. In addition, Amendment 21 would be expected to limit Chinook salmon reductions attributed to the PFMC salmon fisheries in low abundance years as described in the sections below. Therefore, for similar levels of pre-fishing coastwide abundance, we anticipate generally similar reductions in prey abundance attributed to the PFMC fisheries as that observed in the most recent 10-yr period into the foreseeable future.

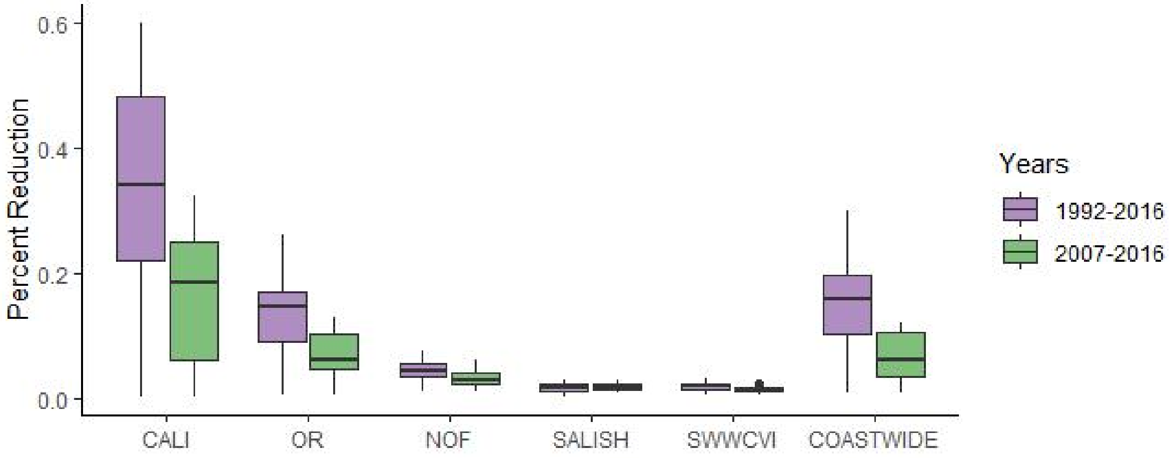

Figure 28. Percent reduction in adult Chinook salmon abundance in each area: California (CA), Oregon (OR), North of Falcon (NOF), Salish (Salish Sea), SWCVI (southwest coast Vancouver Island), and Coastwide (EEZ) over the most recent 10-year time period (2007 – 2016, green), and in the entire time series (1992-2016, purple).

Quantifying Impacts from the PFMC Salmon Fisheries on SRKW demography

For this part of the analysis, we evaluate the Workgroup's effort to quantify the short-term effects from these estimated annual prey reductions and the potential demographic consequences for the whales in order to help provide additional context to the estimated prey reductions described above. In its effort to quantify the impacts from the prey reductions described above on SRKW demography, the Workgroup first examined the relationship between Chinook salmon abundance and SRKW demographic metrics (e.g. survival and fecundity). 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 described in the previous section (NOF, Salish Sea, SWVCI, Oregon coast, and California coast) for the years 1992 – 2016 (PFMC 2020a). The Workgroup then attempted to quantify the effects of the reduction in Chinook abundance due to PFMC ocean salmon fisheries on SRKW performance metrics. 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"). The difference in predicted performance metrics with and without PFMC fisheries was calculated for three performance metrics: survival, fecundity, and the occurrence of peanut head (an indicator of mortality), each modeled independently as a function of the current year's estimated abundance with and without PFMC fisheries. For survival, abundance at a lag of one year was also considered; for fecundity, lags of both one and two years were considered. As a coarser approach, the Workgroup also performed clustering analyses attempting to identify sets of years of similar SRKW demographic performance, and then examined whether years of good or bad demographic performance were consistently associated with high or low Chinook abundance. However, the results of these clustering analyses were less informative and not emphasized in their report (for more details refer to Appendix D in PFMC 2020a).

The Workgroup considered one and two year temporal lags between Chinook abundance and observed SRKW survival and fecundity based on plausible physiological mechanisms linking food supply to future performance (PFMC 2020a). For example, because killer whales have a gestation period of approximately 17 to 18 months (Duffield et al. 1995; Robeck 2016), it may be important to consider Chinook salmon indices in earlier years as predictors of fecundity (Hilborn et al. 2012, Ward et al. 2009, Ward et al. 2013). Also, nutritional stress could lead to reduced body condition and health contributing to increased disease susceptibility and eventual death (PFMC 2020a). Lastly, a lag was included due to the uncertainty in exact birth and death times of some individuals (SRKW metrics have been recorded on an annual bases).

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 2020a). This was always the case for SRKW survival at a lag of one year, for SRKW survival based on current-year abundance estimates that excluded waters south of Cape Falcon, and for SRKW fecundity based on current-year abundances excluding waters south of Cape Falcon (PFMC 2020a). 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 the NOF area may be more consistently important than Chinook salmon abundance in the SOF area (PFMC 2020a).

The Workgroup's analysis that attempted to predict the potential SRKW demographic consequences given the predicted prey reductions attributed to the PFMC fisheries suggested that any effects of the fisheries on SRKW demographics were relatively small. 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 2020a). 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. Although there is more consistent SRKW spatial overlap with the NOF area relative to the SOF area, the Workgroup found that overall, the PFMC salmon fishery impacts on NOF abundance are small relative to both annual variation in abundance and the total abundance in a given year (PFMC 2020a).

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.

Ward and Satterthwaite (2020) performed some simple simulations to answer the question: given the general characteristics and quantity of data on SRKWs, what is the statistical power (probability) needed to detect a change in SRKW demographic parameters if one were to occur given an external perturbation (like a fishery modification) that is hypothesized to affect SRKW demography via its effects on Chinook salmon abundance? They performed a power analysis using data on SRKW fecundity and fitting regression models to the data with varying levels of model complexity (variation in type of model, and whether parameters were shared across individuals and years).

Even under the most optimistic modeling scenario using the simplest model considered (fecundity rates constant across time, and the same among all females), Ward and Satterthwaite (2020) found that adequate power came only if the increase in mean prey abundance was large enough to increase mean fecundity by 20%, which is likely unrealistic for SRKWs given that this would result in a value that appears to be approaching what is presumably the biological maximum for resident killer whales, as seen in robust NRKW populations (an increase in fecundity rates of 30% would result in fecundity rates comparable to NRKWs; Ward et al. 2013, Ward et al. 2009). In other words, given the characteristics and quantity of data (i.e. inherent limitations), we do not have the statistical power to be confident in our ability to detect any biologically relevant change or no change in SRKW vital rates related to changes in Chinook abundance regardless of the cause.

Altogether, these 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). Any increases in fecundity would need to be extremely large – perhaps approaching what is possible for the species -- to be likely to detect a significant effect from the change in prey abundance. From this we can conclude 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. However, 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 2020a) 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.

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. The Workgroup's quantitative analysis showed that Chinook abundance in the NOF area and SRKW survival with one year time lag had a statistically significant ($p \leq 0.05$) relationship. This relationship is consistent with the SRKWs spatial distribution and use of this area (the whales have been observed in the NOF area in all seasons, with peak occurrence in the spring). The Workgroup also concluded that SRKWs are likely impacted by reduced prey availability in the NOF area to some unknown degree. Their attempt to quantify SRKW demographic consequences given the PFMC-driven reductions in Chinook abundance in the NOF area were predicted to be small (≤ 0.2% change in both mean estimates in survival and fecundity, see Table 5.5a in PFMC 2020a). Although the strongest relationship between Chinook abundance and SRKW demographics is in the NOF area, overall, the PFMC salmon fishery impacts on Chinook prey available in the NOF area are small relative to both annual variation in abundance and the total abundance in a given year.

Potential for localized prey depletions or for disproportionate removal of prey
In the previous section we described the reductions in Chinook abundance due to the PFMC fisheries, and the Workgroup's assessment of the potential relationship between that reduction in Chinook abundance by season and area specific SRKW demographic metrics. Here we consider two aspects of how the fisheries affect Chinook abundance that may in turn have notable effects on SRKW access to Chinook prey. First, SRKWs have been observed foraging in certain areas (hot spots) more than others, and to the extent the fisheries remove Chinook salmon that might otherwise be available in these areas, they may limit SRKW access to those fish. Second, we consider whether the fisheries are responsive to overall Chinook abundance at particularly low abundance levels, where removal of a disproportionate number of Chinook salmon is more likely to adversely affect SRKWs. Lastly, in the subsection below titled *Increased Risks during Years with Low Chinook Salmon Abundance and Amendment 21*, we consider how the proposed Amendment 21 addresses these concerns.

First, we considered the potential for localized depletions from prey reductions attributed to the PFMC salmon fisheries for additional context to inform our qualitative analysis. On their return to their natal rivers as adults, salmon may congregate in marine areas adjacent to the rivers during the months SRKWs are in the coastal waters of the action area. Therefore, it is possible that the overall reduction in prey resulting from the proposed action would not be evenly distributed across coastal waters, but rather the reductions could cause local depletions of prey and potentially result in the whales leaving areas in search of more abundant prey. For example, a 3.3% reduction in food energy, or approximately 54,000 adult Chinook salmon harvested in the NOF area (i.e., the average estimated reduction in the most recent 10 year time period, refer to Table 6) estimated by the Workgroup's model applies to a broad area with varying spatial use of the whales and a mix of Chinook stocks returning to various coastal and inland rivers. It is reasonable to assume that if the majority of this reduction in Chinook salmon occurred off the mouth of the Columbia River, a foraging hot spot, when SRKWs were likely to be present, it would have a different impact on the whales' foraging success than if this reduction was more spread out or if it occurred in a non-foraging hot spot in the NOF area. It is possible that an increase in searching effort 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 the NOF area, the whales may increase their searching effort and move to other potential foraging areas within their geographic range (e.g. areas SOF). The PFMC salmon fisheries in the SOF area that would overlap with the whales when they move to alternate foraging areas could also increase competition for fish. However, it is difficult to assess the potential for localized depletions and competition with the fisheries where there is potential overlap with the whales because the estimates of prey reduction throughout the action area may not accurately predict reductions in prey available in known foraging hot spots. While we have general information on the whales' distribution and foraging hotspots, unfortunately, the available information and technical tools are not sufficient to analyze prey reductions at a finer scale or resolution.

We also considered how fisheries and fish management respond to overall Chinook abundance and the potential for disproportionately high prey reduction attributed to the PFMC salmon fisheries during different abundance conditions. In most years of the time series analyzed by the Workgroup, the PFMC salmon fisheries were responsive to overall Chinook abundance. For example, Figure 29 shows the correlation between the annual NOF ocean quotas and the post-season abundance estimates for Chinook salmon in the NOF area starting October 1 (Agenda Item F.2.a, Supplemental NMFS Report 1, November 2020). The graph generally shows that in years of low Chinook salmon abundance in the NOF area, the NOF quotas are set lower, whereas in years of high abundance, the quotas are set higher (the regression relationship in Figure 29 depicts the history of Council actions, not a management rule). However, there were a couple of years the fishery management allowed for removal of a disproportionate number of Chinook. For example, there were some years that had low Chinook abundance in the NOF area (e.g. below abundance thresholds the Workgroup had considered, Figure 29), but had quotas above the regression line. We would anticipate that higher quotas in low abundance conditions would have a greater potential for fisheries to reduce prey availability to levels that may not be sufficient to allow for successful foraging.

Here we describe a different example that illustrates an error that occurred between the postseason harvest rate and preseason projected rate that occurred between 1992 and 2016. Reductions in Chinook salmon between Cape Falcon, OR to Horse Mt., CA due to the PFMC salmon fisheries ranged from 0.7% in 2009 to 26.3% in 2004 (PFMC 2020a). The estimated pre-fishery Chinook salmon abundance between Cape Falcon and Horse Mt in 2004 was slightly above average; however, the age-4 ocean harvest rate in PFMC salmon fisheries for Klamath River Fall Chinook salmon was 35 percent that year, higher than any other value since 1991 by at least 14% (PFMC 2020a). In 2006 and 2021, inputs to the Klamath Ocean Harvest Model (KOHM) were adjusted (limited to more recent data) in response to higher catch per unit effort that resulted in higher harvest rates in the more recent years. This is a good example of the responsiveness of Council management to correct for changing biological conditions, changes in salmon or salmon-at-age distribution, fishery changes, and model performance over time (PFMC 2020a).

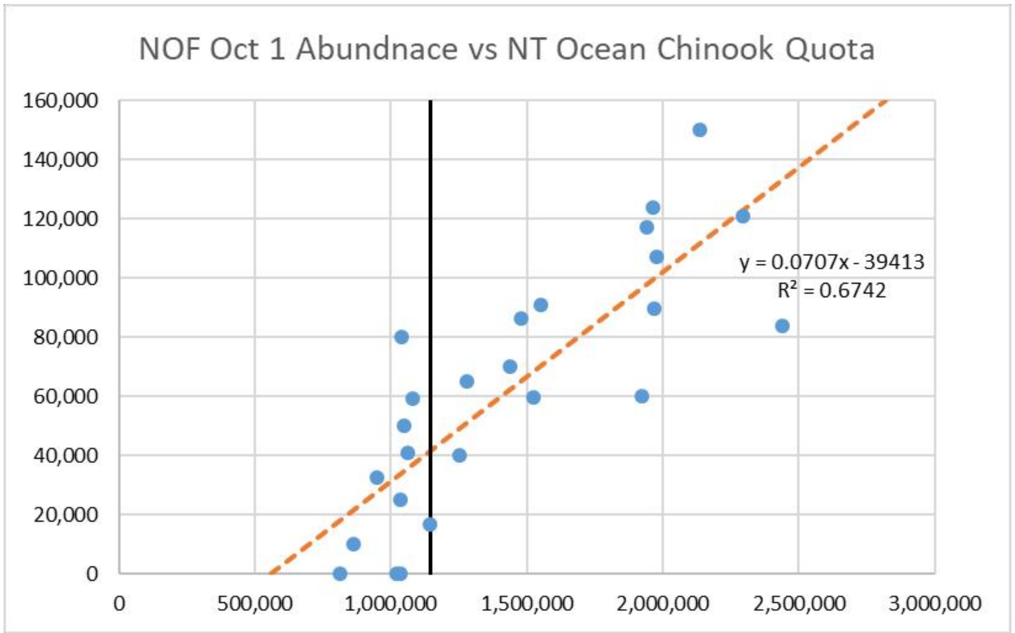

Figure 29. Regression relationship between non-treaty North of Falcon Chinook quotas and postseason estimates of October 1 Chinook abundance in the North of Falcon area. The orange dashed line represents the regression line and the vertical black line represents one of the low abundance thresholds (1,144,311 fish) the Workgroup considered (reprinted from Agenda Item F.2.a, Supplemental NMFS Report 1, November 2020).

Increased Risks during Years with Low Chinook Salmon Abundance and Amendment 21

Given the concerns with localized prey depletions and potential for disproportionate prey removal, we consider whether the effects of reductions in Chinook salmon abundance could be more significant to SRKWs at some low level of Chinook abundance and how those risks are mitigated through Amendment 21. The current status of SRKWs likely factors into these questions. 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 the PFMC 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 2017). 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. Good fitness and body condition coupled with stable group cohesion and reproductive opportunities are important for reproductive success.

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 abundance over multiple consecutive years in the late 1990s likely due to common factors affecting changes in the killer whale populations (NMFS 2008a; Towers et al. 2015). From 1995 to 2001, the SRKW population declined almost 20%; one year (2001) had relatively high Chinook abundance in the NOF area and one year (1997) had fair abundance (i.e., closer to average abundance in the NOF area), whereas the remaining five years had relatively low Chinook abundance levels with several years in succession (i.e., ranked among the seven lowest Chinook abundance years NOF during the period the SRKW Workgroup analyzed) (PFMC 2020a). Similar to the past, we expect multiple years with relatively low Chinook salmon abundance levels to occur in the future. If SRKWs are unable to acquire enough energy in multiple years, this may lead to reduced reproductive output if there is failed reproduction at any of the various reproductive stages in adult females (e.g. failure to ovulate, failure to conceive, or miscarriage, successfully nurse calves, etc.). Additionally, females are likely to stop foraging behaviors in the presence of vessels (within 400 yards), and as suggested by the author, this may have impacts on reproduction if they are unable to forage to meet energetic requirements for reproduction (Holt et al. 2021). The results in Stewart et al. (in press) also suggest that SRKWs in poor body condition have a higher likelihood of mortality, while accounting for age and sex. 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, and effects of prey availability should be combined across consecutive years, it is vital to have increased protections in years of low Chinook salmon abundance levels.

Throughout the time period the SRKW Workgroup analyzed (1992 - 2016), there have been some years with low Chinook abundance when the status of the whales was relatively better (i.e., improved survival and fecundity) than years with high Chinook abundance. For example, in 1994, NOF Chinook salmon abundance was at its lowest level but SRKW fecundity and survival in that year was considered relatively high by the Workgroup. Similar observations were made in 2007 (relatively low Chinook salmon abundance coupled with relatively high SRKW fecundity and survival). These types of events suggest that in some situations, the whale population may have the ability to grow during these single low Chinook abundance year events. However, as mentioned above, there were also consecutive years with low Chinook abundance during the time period the Workgroup analyzed that was concurrent with low SRKW survival and fecundity, suggesting a higher risk to SRKW demography in these consecutively low abundance years.

In light of the Workgroup's conclusion that Chinook abundance NOF may consistently be more important to SRKWs than other ocean areas, that multiple consecutive years of low Chinook abundance appear to have the highest potential to adversely affect SRKW demographics, and there may be a spectrum of risk dependent on the whales' status, for future fishing seasons, the proposed Amendment 21 includes a low Chinook abundance threshold representing a low pre-fishing Chinook salmon abundance in the NOF area[26] to trigger targeted management action[27]. The low Chinook abundance threshold in the NOF area included in Amendment 21 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). The risks of consecutive years of low abundance is important to both short and long-term effects and is also discussed in the long-term effects section below.

Amendment 21 to the FMP is designed to minimize the effects of PFMC fisheries on prey availability and address the concerns for both the potential for local depletions, and for disproportionately high percent prey reductions in years of particularly low Chinook abundance in times and areas where/when the fisheries and whales overlap in NOF and SOF areas. The measures include restrictions on non-treaty 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. One such measure would ensure that no more than 50% of the non-treaty quota in the NOF area would be caught in the spring (May/June) when the whales have a higher likelihood of occurring in the NOF area. Historically, as much as two-thirds of the quota has been allocated to the May/June time period. The Columbia River and Grays Harbor control zones, both identified as hot spots (including a spatial expansion of the Columbia River control zone), would be closed from January 1st till June 15th. The KMZ (in Oregon and California waters) and Monterey Bay would be closed beginning October 1 through March 31 the following year, both areas are described as important areas for foraging (refer to

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[26] 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 proposed action provides that the threshold should be recalculated using the same approach.

[27] Targeted, area-based fishery management measures have also been considered and supported in a joint DFO-NOAA Prey Availability Workshop held in November 2017 to improve Chinook salmon availability (Trites and Rosen 2018), whereas 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).

the Effects to Critical Habitat section), and during the months the whales are more likely to occur (i.e., winter and early spring months). Other closures would occur around river mouths when Chinook stocks would return to those natal rivers and SRKW are more likely to be present in those areas. The actions are intended to reduce the likelihood of an overlap and competition for Chinook salmon by reducing harvest during times and areas when SRKW are more likely to be present.

Under Amendment 21, prey would be more available and accessible across SRKW's geographic range than would otherwise occur without the restrictions during years of low abundance when prey availability is more limited. Although Chinook salmon abundance is more consistently important to SRKWs in the NOF area, improving foraging opportunities across the whales' range is important because SRKWs may increase their search area for better foraging opportunities in years with low Chinook salmon abundance. These reduced impacts on prey availability are expected to allow for more successful foraging, and contribute to SRKW's energetics, health, reproduction, and survival during low Chinook salmon abundance conditions.

To summarize the short-term annual effects analysis, in most years, the annual percent reductions in prey from PFMC salmon fisheries are expected to be small, particularly in areas of highest potential for overlap with the SRKWs (e.g. the NOF area). Overall prey reductions from PFMC salmon fisheries have also decreased over time. However, in some years the prey reductions attributed to the PFMC salmon fisheries could potentially affect the ability of the whales to meet their bioenergetic needs resulting in the whales leaving areas in search of more abundant prey or experiencing compromised health or reproduction. We consider how the areas and timing of the prey reductions could result in localized depletions or occur at disproportionately high levels, increasing concerns about potential impacts of the fisheries on the whales. We note that reductions in prey and effects on the health of the whales would be a greater concern during periods of low Chinook salmon abundance. Several factors regarding the proposed action reduce the potential for these negative effects. The fisheries are responsive to Chinook salmon status and abundance to meet objectives for salmon stocks. In years of relatively high Chinook salmon abundance, we would not expect prey reductions from PFMC salmon fisheries to limit foraging opportunities or cause local depletions to an extent that would affect survival and fecundity of SRKW. Even during these lower risk conditions for the whales, prey reductions would be limited by harvest control rules, conservation objectives for salmon, and Pacific Salmon Treaty obligations. Given the whales' poor status, and because impacts on prey availability present more risk at lower abundance levels, selection of a low Chinook salmon abundance threshold to trigger management actions under Amendment 21 will reduce the risk the fisheries pose to SRKWs by reducing prey availability. The low abundance threshold is based on a time period that includes consecutive years of low abundance when the whale population declined, body condition and growth was low, and there was observable reduced social cohesion. Furthermore, this threshold also includes years when the whales had relatively good status (factoring in the spectrum of risk to the whales), which makes it a more conservative threshold given the list of uncertainties discussed in this opinion. The management responses included in Amendment 21 when the low abundance threshold is reached are intended to limit the overall level of Chinook salmon removal and reduce the potential for localized depletions in times and areas where/when the fisheries and whales have the potential to overlap. Limits to quotas will avoid disproportionately high removals during low abundance conditions, and closures will reduce the potential for temporal and spatial overlap and competition for prey resources under these higher risk conditions. These measures will likely limit reductions to the

SRKW prey base and reduce overlap with fisheries allowing them to successfully forage, accumulate energy, and support their survival and reproduction

Long-Term Effects from the PFMC Fisheries

Here we consider long-term effects of the proposed action by relying, in part, on salmon determinations and conclusions in previous biological opinions, and also on the adaptability and response of the Council salmon fisheries to changes in Chinook salmon abundance. We also consider the long-term implications of the implementation of management actions described in the proposed action under Amendment 21 that are designed to reduce impacts on SRKWs during years of low Chinook salmon abundance, including consecutive years of relatively low abundance. Lastly, we analyze the way the fishery framework would respond to an extremely low abundance potentially driven by climate change or long-term cycles in ocean conditions.

As discussed in the description of the proposed action, the PFMC develops recommended annual management measures consistent with its FMP, which includes stock and stock complex-specific reference points, objectives and/or harvest control rules for the affected stocks. The objectives and harvest control rules are designed to ensure the fishery responds to changes in abundance over time and is sustainable by accounting for the available information on the productivity, abundance and status of individual salmon stocks. The objectives are generally in terms of spawning escapement goals or ceiling exploitation rates, while the harvest control rules are used to derive annual objectives taking into account annual abundance forecasts. Reference points are used to determine if a stock or stock complex is overfished (below minimum stock size threshold) or experiencing overfishing (exploitation exceeding a particular rate). For ESA-listed salmon stocks, objectives are defined by either fishery management actions or limits on take that have been determined through section 7 consultation to be not likely to jeopardize the listed stock or adversely affect critical habitat.

The Council uses a variety of management tools to manage the ocean fisheries each season including management boundaries and seasons, quotas, minimum harvest lengths, fishing gear restrictions, area restrictions, commercial landing limits, and recreational daily bag limits. Natural fluctuations in salmon abundance require that annual fishing periods, quotas, and bag limits be designed to respond to the conditions present each year. Measures that are suitable one year may not be suitable the next. New information on the fisheries and salmon stocks also may require other adjustments to the management measures. Typically state and tribal managers apply the same harvest controls to territorial seas or any other areas in state waters. Details on the use of these measures are contained in Chapter 6 of the FMP (PFMC 2016).

As discussed previously in this Opinion, under the annual salmon fishery management measures recommended by the Council and approved by NMFS, salmon stocks (ESA-listed and non-listed) in the fishery are expected to meet all of the applicable conservation objectives in the FMP and the provisions of the applicable biological opinions. This expectation is supported by the models used to evaluate the effects of the proposed fishing regimes and whether they would meet the conservation objectives. Thus the fisheries are managed annually to sustain non-ESA listed salmon stocks to avoid jeopardizing the continued existence of ESA listed stocks.

In the long term, consecutive years of low Chinook salmon abundance may be important to consider because this may decrease SRKW reproduction at multiple reproductive stages and lead to increases in inter-birth interval (calving interval), decreasing lifetime reproductive success. As summarized in Bradford et al. (2012) and Miller et al. (2011), across a variety of mammal species, female body condition and energy reserves potentially affect reproduction and/or result in reproductive failure at multiple stages: from before pregnancy, i.e. fertility, ovulation, and probability of pregnancy (Armstrong and Brit 1987, Lockyer 1987, Cook et al. 2004, Williams et al. 2013, Kenyon et al. 2014), to during pregnancy such as fetal growth (Lockyer 2007), to late pregnancy and after birth (offspring survival, Cameron et al. 1993). For whales, rates of ovulation in a population may be linked to feeding conditions in one year/feeding season, whereas births may be linked to conditions in the following year, and thus effects of prey availability should be combined across consecutive years (as suggested in Lockyer 1987 and discussed in Bradford et al. 2012).

The pattern of Chinook abundance across consecutive years is also an important consideration for reproductive success. During certain life stages (pregnancy and lactation), food consumption in the adult female killer whale may increase to compensate for the increased energetic costs associated with reproduction (Noren 2011). Increases in calving intervals in the SRKW population due to reduced feeding conditions when energetic costs increase over multiple years may lead to overall lower total reproductive output in the lifespan of an individual than would be physiologically possible. Although this is less known on impacts of reduced feeding conditions on reproductive output for SRKWs, we can generally examine what is known in other marine mammal species. For example, there is evidence for North Atlantic right whales (*Eubalaena glacialis*) that failure to replenish fat stores and poor body condition may lead to decreases in reproduction and increases in the average calving interval across reproductive females (Miller et al. 2011, 2012, and summary in Meyer-Gutbrod et al. 2015). In the 1990s, right whale reproduction greatly declined, which correlated with declines in their main prey, *C. finmarchicus*, reaching lowest reproduction in 1999/2000 (see Greene and Pershing 2003, 2004 and summary in Meyer-Gutbrod et al. 2015 and sources therein). Multiple studies showed that in the 1990s (compared to 1980s) during the same time as low prey availability, the average calving interval increased in the population across reproductive females (Knowlton et al. 1994, Kraus et al. 2001, Meyer-Gutbrod et al. 2015, and noted by Miller et al. 2011), and then decreased again when prey increased in the 2000s (Meyer-Gutbrod et al. 2015). Energetic models for beaked whales (*Ziphiidae*) suggest that in times/areas of low habitat quality (i.e., low prey density or availability of energy rich prey) females are likely able to survive but likely not to reproduce, as inter-calf intervals were longer with poor habitat quality (New et al. 2013). The authors suggest that minor chronic declines in the energy individuals acquire may potentially be as detrimental to reproduction as brief, large declines in energy acquisition (New et al. 2013). These studies imply effects of prey availability should be considered across consecutive years for SRKWs given reproductive success is likely reliant on several years of optimal prey availability. The consideration of multiple years of low abundance in determining the low abundance threshold used to trigger additional management measures, together with the consistency of the salmon conservation objectives with sustainability of the salmon populations would minimize impacts on SRKW viability. Under Amendment 21, if Chinook abundance does not meet the low abundance threshold in consecutive years, the additional management measures will also be implemented in consecutive years, reducing the impact of the fisheries on SRKWs when they are at particular risk from low prey abundance.

Lastly, to assess long-term impacts of the proposed action we consider the response of the fishery management framework to changing ocean conditions that may influence ocean survival and distribution of Chinook salmon and other Pacific salmon, further affecting the prey available to SRKWs. Similar to retrospective analyses described in the NMFS report provided at the

November 2020 PFMC meeting (Agenda Item F.2.a, Supplemental NMFS Report 1, November 2020), we ran retrospective model runs of simulated salmon abundance outside the range observed from 1992-2016. We used a 40% Chinook salmon abundance decline scenario to cover the situation of a prolonged and broad scale down turn in productivity and abundance that could occur as a consequence of long-term cycles in ocean conditions or global climate change (similar to NMFS 2019e). The two model runs used in this analysis included: (1) a fisheries management scenario without Amendment 21, "No Amendment 21 scenario", with an additional 40% decline in all salmon abundances to simulate a prolonged decline in productivity and abundance of salmon and (2) a management scenario similar to the proposed action, "threshold scenario," also with an additional 40% decline. A 40% reduction in Chinook salmon abundance is also the approximate reduction or difference between highest and lowest individual years of salmon abundance during the 1992-2016 time period, so it is within the realm of realistic population declines but represents an extreme.

We found that when the abundance was reduced by 40% in the "No Amendment 21", the resulting projected NOF catch of Chinook salmon decreased by an average of approximately 47%. Similarly, in the "threshold scenario", when the abundance was reduced by 40%, the resulted projected NOF catch of Chinook salmon decreased even more, by an average of approximately 52%. The "threshold scenario" resulted in, on average, more salmon available off NOF, Oregon, and California areas compared to the "No Amendment 21" scenario. Thus, under low abundance scenarios we expect that percent reductions in prey availability due to fisheries would decrease relative to higher abundance scenarios. The application of Amendment 21 on top of existing salmon management measures would result in an even further decrease to these percent reductions. Salmon abundance in the NOF area under the "threshold scenario" was predicted to go below the abundance Chinook salmon threshold in 17 out of 25 years, including multiple years back-to-back. Therefore, there is the potential for the management responses of the proposed action to be triggered in multiple consecutive low abundance years, particularly if ocean conditions negatively influence ocean survival and distribution of Chinook salmon. The proposed action puts in place added protections in every year of relatively low Chinook abundance to improve availability and accessibility to prey for SRKW when salmon abundance is low across multiple or consecutive years in the event of a potential future prolonged and broad scale down turn in Chinook salmon productivity and abundance as a potential consequence of climate change conditions. In general, we found: (1) that the existing salmon management measures are responsive to abundance and become increasingly restrictive as abundance declines (when abundance reduces by 40%, catch in the NOF area is expected to be reduced by 47%), and (2) that the application of Amendment 21 on top of existing salmon management measures results in even further fishery restriction at lower Chinook salmon abundances, beyond that required to meet the salmon management measures (catch in the NOF area is reduced by 53%).

In summary, the PFMC 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. Moreover, fisheries are designed to ensure salmon stocks (ESA-listed and non-listed) in the fishery meet the applicable conservation objectives in the FMP and the provisions of the applicable biological opinions. In addition to the protections that the FMP provides for salmon stocks, the low Chinook abundance threshold was based on a range of years including several periods when there were multiple and consecutive years of low abundance. This is important 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, and the effects of prey availability may be cumulative across consecutive years. Lastly, the proposed action puts in place added protections in every year of relatively low Chinook abundance to improve availability and accessibility to prey for SRKW when salmon abundance is low across multiple or consecutive years in the event of a potential future prolonged and broad scale down turn in Chinook salmon productivity and abundance as a potential consequence of climate change conditions.

2.5.2. Effects on Current and Proposed Southern Resident Killer Whale 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 and proposed critical habitat in coastal waters along the U.S. west coast from the border of Canada and Washington, to Point Sur, California. Based on the natural history of the SRKWs and their habitat needs, we identified three physical or biological features essential to conservation in designating critical habitat in inland waters of Washington: (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. These same three physical or biological features are consistent with the essential features in the proposed critical habitat in coastal waters. This analysis considers effects to these features and identifies where there are differences in those effects between the existing inland and proposed coastal critical habitat. 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 also draws heavily on the previous assessment of impacts to the whales when considering effects on the habitat features.

As discussed above, NMFS identified six specific areas off the U.S. West Coast, delineated based on their habitat features and use by SRKWs (Figure 30), as proposed critical habitat. The six area boundaries reflect the spatial scale of the whales' movements and behavioral changes (e.g., where tagged whales were primarily traveling versus observed foraging), as well as to align with some existing fishery management boundaries (e.g., geographic points used by the PFMC in salmon management, see Figure 30). Areas 1 and 2 in the proposed critical habitat align generally with the NOF spatial area defined by the Workgroup, Areas 3 and 4 align with the Oregon area as defined by the Workgroup, and Areas 5 and 6 align with the California area as defined by the Workgroup. The six areas have some similarities and all of them contain all three essential features.

Areas 1 and 2 are considered high-use areas for SRKWs, particularly for foraging, based on presence documented through sightings, acoustic recordings, and satellite tag data, and documented consumption of essential prey sources (NMFS 2019c). Prey is the primary essential feature of Areas 1 and 2, but passage and water quality are also important features of high-use areas where foraging behaviors occur. Prey is also the primary essential feature of Areas 4 and 6 off California. Area 4 is characterized as "an important feeding habitat" for SRKWs. Area 6 is characterized as the southernmost feeding area for SRKWs and contains essential prey resources (NMFS 2019c). Area 3 is considered an important corridor between Areas 1 and 2 and Area 4 feeding areas. Similarly, Area 5 is considered an important corridor between the Area 4 and Area 6 feeding areas. Passage is the primary habitat feature identified in these areas. While foraging may be occurring, it has rarely been observed in Area 3 despite dedicated monitoring for predation (NMFS 2019c). The majority of activity observed in Area 3 is travel.

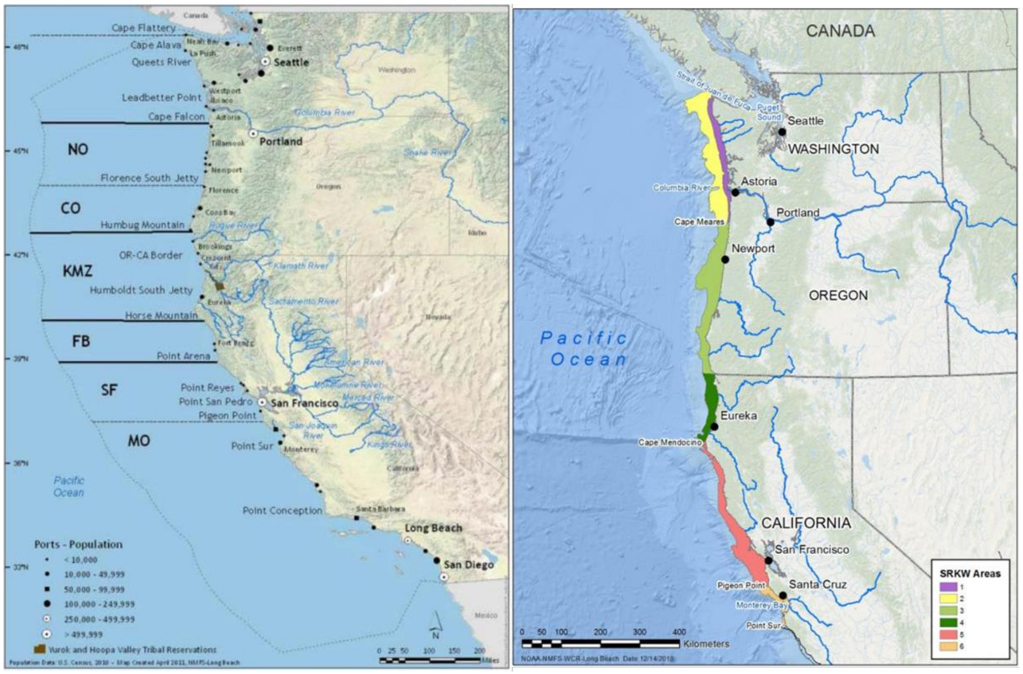

Figure 30. Comparison between the spatial areas as described in the Workgroup report (PFMC 2020a) and the proposed critical habitat areas (Areas 1 – 6).

The proposed action has the potential to affect passage conditions and the quantity and availability of prey in the proposed critical habitat. Although the proposed 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 specifically, prey quantity, quality, and availability. 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 2.4.3 ("Prey Quality"), 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 are 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. 2019). As noted above, SRKW mainly consume larger (age 3 and older) salmon, and larger fish typically have higher energy content. Ohlberger et al. (2019) 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 that at the current level of harvest that the fishery would appreciably decrease Chinook size (i.e., quality) thereby reducing the conservation value of the prey feature.

Effects of the proposed fishing include the potential for exposure to the physical presence and sound generated by vessels associated with the proposed action. This increase in vessel presence and sound in the proposed critical habitat, contribute to total effects on passage conditions. As described above, there is some potential for the vessels associated with the fishing activities to overlap with the whales in the NOF area (Areas 1 and 2) every month the fishing season is open, and in waters off Oregon and California (in Areas 3 – 6) in the early and later months of the season but likely not every year or consistently. If there is an effect on passage in these areas in future fishing seasons, it would more likely occur in March, April, May, and October. There are no effects on passage conditions resulting from PFMC salmon fisheries expected in the inland waters of Washington.

Although we cannot quantify the increase in vessels in the vicinity of the whales that may result from the proposed action, it is reasonable to expect that authorization of the proposed fishery will result in more vessels in the whales’ proposed critical habitat than there would be if no fishing is authorized. However, the amount of vessels around the whales would likely be less in years when salmon abundance is below the low Chinook salmon abundance threshold because the spatial and temporal overlap between the fishery and the whales is reduced due to additional fishery area/time closures and quota restrictions in the NOF area in the spring when the whales are more likely to be there, but still likely more overlap than if no fishing was authorized.

For reasons described above and summarized here, if interactions 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 proposed critical habitat. Although there is some potential for the PFMC fisheries to overlap with SRKWs, fishing vessels operate at slow speeds or in idle when actively fishing and the effects are expected to be minimal. 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 disturbance would likely be transitory, including small avoidance movements away from vessels. NMFS and other partners have outreach programs in place to educate vessel operators, including the fishing community, about regulations and guidelines to minimize impacts to the whales. The number and dispersed nature of fishing vessels is not expected to result in blocking movements of the whales in their travel corridors. Therefore, 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.

Effects of the proposed action reduce prey quantity and availability in proposed critical habitat resulting from the harvest of adult Chinook salmon. The extent of reductions in adult Chinook salmon in the action area due to the ocean salmon fisheries is described in detail in the Effects analysis.

It is difficult to assess how reductions in prey abundance may vary throughout proposed critical habitat and we have less confidence in our understanding of how reductions could result in localized depletions in the areas of proposed critical habitat. Reductions in local abundance of prey from the PFMC salmon fishing may result in the whales leaving critical habitat areas in search of more abundant prey. However, seasonal prey reduction throughout proposed critical habitat may not accurately predict reductions in prey available in their foraging hot spots.

As described in the Effects to Species section, the percent of potential abundance remaining after Council directed salmon ocean fisheries occur has been increasing over time – meaning for the proposed critical habitat these fisheries have been taking a lower proportion of the available abundance over time and having a decreasing effect on the conservation value of the habitat areas. In the most recent decade (2007-2016) percent prey reduction by the PFMC fishery across the entire EEZ (coastwide) was on average 7% (3.3% in Areas 1 and 2, 7% in Areas 3 and 4, and 16.6% in Areas 5 and 6). For inland waters, reductions in prey quantity are expected to be very small as described in the effects section (1.9% reduction in Salish Sea prey on average over the most recent decade, 2007-2016). The reductions of Chinook salmon attributed from PFMC fisheries are not expected to increase in future years as described above.

In years when Chinook abundance falls below the low abundance threshold, additional management responses will likely reduce impacts on prey availability and reduce spatial and temporal overlap of the fisheries and SRKWs within the proposed critical habitat in both NOF and SOF areas. These reduced impacts to prey availability and the whales would better support successful foraging, particularly in proposed critical habitat by reducing overlap of the fisheries and whales and by reducing any competition for prey resources, reducing the chance the whales would need to leave the area to look for better foraging opportunities. The areas that have the proposed targeted responses are considered important foraging areas, and contribute to SRKW's energetics, health, reproduction, and survival during relatively low Chinook salmon abundance conditions.

In low abundance years (below threshold) multiple management responses would occur in the NOF area in proposed critical habitat Areas 1 and 2; these are considered high use areas for SRKW specifically for foraging. For Areas 1 and 2 (NOF), additional management responses would ensure non-tribal fishery catch quota NOF is not disproportionately high in low Chinook abundance years, and catch (quota) would be shifted from spring (May through June) to later in the season when the whales are less likely to be in the area. Also in Area 1, the Columbia River and Grays Harbor control zones (in Area 1, including an expansion of the Columbia River control zone), would be closed from January 1st till June 15th in years when the NOF Chinook abundance is below the low abundance threshold. Therefore, the action likely reduces direct overlap and competition between Council managed salmon fisheries and SRKW in low abundance years in Areas 1 and 2, by focusing harvest during times and areas when SRKW are less likely to be present, reducing the impacts on prey available in critical habitat.

Furthermore, additional management responses in proposed critical habitat Areas 3-6 would also likely reduce impacts on prey availability and accessibility by potentially reducing direct overlap between Council fisheries and SRKW, reducing the impacts on prey available in critical habitat. Multiple time/area closures would occur (as described in detail in the proposed action) including a delay in the start of the SOF Troll fishery through April 1st (same location as proposed critical habitat Area 3, see Figure 30), closures of the Oregon KMZ (critical habitat Area 3) from October 1st through March 31st of the following year, closures of the California KMZ control zone and expanded Klamath River control zone (critical habitat Area 4), and closures of the Monterey management area (critical habitat Area 6) fisheries from October 1st through March 31st of the following year. Closures would occur during times of year when SRKW are more likely to be in these areas, therefore reducing overlap with the fisheries, thereby likely reducing impacts on prey availability and accessibility for the whales in these areas in years of relatively low Chinook abundance.

In summary, the three physical or biological features in critical habitat are water quality, prey availability and quality, and passage conditions. The proposed action likely has little effect on prey quality and we do not anticipate adverse effects to water quality. Direct effects of the proposed fishing include the potential for exposure to the physical presence and sound generated by vessels associated with the proposed action. This increase in vessel presence and sound in the proposed critical habitat contribute to total effects on passage conditions. However, based on fishing vessel movements that don't focus on or follow the whales together with the large size of the management areas and the dispersed nature of the fishing fleet, the direct vessel impacts of vessels would likely be minimal and transitory. 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.

Effects of the proposed action reduce prey quantity and availability in proposed critical habitat resulting from the harvest of adult Chinook salmon. In the most recent decade (2007-2016) percent prey reduction by the PFMC fishery was 3.3% in Areas 1 and 2, 7% in Areas 3 and 4, 16.6% in Areas 5 and 6, and 1.9% reduction in the inland waters. As described above, the prey reductions attributed to the PFMC salmon fisheries could cause local depletions of prey in the whales' critical habitat and potentially affect the ability of the whales to meet their bioenergetic needs resulting in the whales leaving areas in search of more abundant prey. In years of relatively high Chinook salmon abundance, we would not expect prey reductions from PFMC salmon fisheries to limit foraging opportunities or cause local depletions to an extent that would appreciably reduce the conservation value of the prey feature. Even during these lower risk conditions for the whales, prey reductions would be limited by harvest control rules for salmon and would be expected to be low in areas of the highest potential for overlap with the SRKW (NOF, Areas 1 and 2). Given the whales' poor status, and because impacts on prey availability may present increased risk at lower abundance levels, management responses included in Amendment 21 are intended to reduce the overall level of Chinook removal and the potential for localized depletions in times and areas of critical habitat where/when the fisheries and whales overlap, thereby reducing overlap and direct competition of prey resources under these higher risk conditions.

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 and 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the status and environmental baseline sections (Section 2.2 and Section 2.4).

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on SRKWs, 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. Tribal, state and local government actions will likely be in the form of legislation, shoreline growth management, administrative rules, or policy initiatives and fishing permits. These actions may include changes in ocean policy and increases and decreases in the types of activities currently seen in the action area, including changes in the types of fishing activities, resource extraction, or designation of marine protected areas, any of which could impact listed species or their habitat. Government actions are subject to political, legislative and fiscal uncertainties. Private activities are primarily associated with other commercial and sport fisheries, construction, dredging and dredge material disposal, vessel traffic and sound, alternative energy development, offshore aquaculture/mariculture, and marine pollution. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, it is difficult to assess the cumulative impacts and the relative importance of effects additional to those already identified, but that these effects may occur at somewhat higher or lower levels than those described in the Baseline.

NMFS, in coordination with its multiple partners, have implemented targeted management actions identified in the recovery plan (NMFS 2008a) and informed by research. Transboundary efforts between the U.S. and Canada have occurred to address all the threats identified in the recovery plan. Be Whale Wise is a partnership of governmental agencies, non-profits and other stakeholders that implement and educate the public about best vessel practices in the Salish Sea to protect marine resources, including SRKWs. There is currently a voluntary ¼ mile "Whalewatch Exclusion Zone" along the west side of San Juan Island from Mitchell Bay to Eagle Point (and ½ mile around Lime Kiln) as part of the San Juan County Marine Resources Committee Marine Stewardship Area; these are key summer foraging areas for the whales. San Juan County expanded this area to include a ¼ mile no vessel zone to Cattle Point starting in 2018 and WDFW has been increasing education and outreach regarding this area, including with the fishing community.

On March 14, 2018, WA Governor's Executive Order 18-02 was signed and it orders state agencies to take immediate actions to benefit Southern Resident killer whales and established a Task Force to identify, prioritize, and support the implementation of a longer term action plan need for Southern Resident killer whale recovery. The Task Force provided recommendations in a final Year 1 report in November 2018[28] that addressed the three main threats to SRKW, including many actions specific to salmon recovery. State legislation was put into place to protect salmon habitat (House Bill 1579), address harmful contaminants (Senate Bill 5135 and

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

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. This state law (Senate Bill 5577) also 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). On December 18th, 2020, new commercial whale watching rules were adopted that will take effect in 2021. These rules specify that commercial whale watching occur at distances of <1 nmi from July-September during 2 2-hr time periods in the day for no greater than three vessels at once, makes the no-go zone on the west side of San Juan island mandatory for commercial whale watching, and establishes training, reporting, monitoring, and license procedures[29]. 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[30] 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. In response to recommendations of the Washington State Southern Resident Killer Whale Task Force, the Washington State Legislature provided approximately $13 million in funding "prioritized to increase prey abundance for southern resident orcas" (Engrossed Substitute House Bill 1109) for the 2019-2021 biennium (July 2019 through June 2021). As a result of this additional funding, over 10.8 million additional hatchery-origin Chinook salmon were released in 2020 to augment the SRKW prey base and over 10.1 million additional hatchery-origin Chinook salmon are expected to be released in 2021. In addition, over 8 million additional chum salmon are being produced and over 5 million additional coho. The released smolts would return as adults and be part of the prey base 3 – 5 years later.

The state passed House Bill 1579 that addresses habitat protection of shorelines and waterways (Chapter 290, Laws of 2019 (2SHB 1579)), and funding was included for salmon habitat restoration programs and to increase technical assistance and enforcement of state water quality, water quantity, and habitat protection laws. Other actions included measures to increase survival through the hydropower system on the lower Snake and Lower Columbia rivers, passed legislation to decrease impacts of predatory fish on salmon (Chapter 290, Laws of 2019 (2SHB 1579)), provided funding to the Washington State Department of Transportation to complete fish barrier corrections, and funding to implement a lower Snake River dams stakeholder engagement process. These measures won't improve prey availability in the near term, but are designed to improve conditions in the long term.

In 2019 and 2020, Canada implemented conservation actions including area-based fishery closures, interim sanctuary zones, and both voluntary initiatives and mandatory vessel

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[29] https://wdfw.wa.gov/species-habitats/at-risk/species-recovery/orca/rule-making

[30] Available here: https://www.governor.wa.gov/sites/default/files/OrcaTaskForce_FinalReportandRecommendations_11.07.19.pdf

regulations[31] as part of interim orders to protect the whales. Discussions are currently ongoing for measures for the year 2021 and beyond.

Additional activities that may occur in the coastal waters off Washington, Oregon, and California, will likely consist of state or foreign government actions related to ocean use policy and management of public resources, such as fishing or energy development projects. Changes in ocean use policies as a result of non-federal government action are highly uncertain and may be subject to sudden changes as political and financial situations develop. Examples of actions that may occur include development of aquaculture projects; changes to state fisheries which may alter fishing patterns; installation of hydrokinetic projects near areas where SRKWs are known to occur; designation or modification of marine protected areas that include habitat or resources that are known to affect marine mammals in general; and coastal development which may alter patterns of shipping or boating traffic. Examples of actions that may occur in the Salish Sea include increased boat traffic, increased pollution, and increased pressure on salmonids through habitat alterations due to this highly urbanized area. However, none of these potential state, local, or private actions, can be anticipated with any reasonable certainty in the action area at this time, and most of those described as examples would likely involve federal involvement of some type given the federal government's role in regulating activity in the ocean across numerous agencies and activities.

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 action. 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 action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

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 2008a). 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 1995, the SRKW population size was 98 whales, the highest recorded abundance since the annual censuses began in the 1970s. In 2009, the SRKW population size was 87 whales. At present, the SRKW population has declined to near historically low levels. As of the 2020 summer census, the population is 72 whales, with two calves born in fall of 2020 and one 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. 2004; Hilborn et al. 2012; Ward et al. 2013). The majority of the population projections using different

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

estimates of fecundity and survival show a continued steady decline over the next 25 years (Ward 2019). This predicted downward trend in the model are 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 5). 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 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, 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 2017).

Coastal salmon fisheries managed under the PFMC FMP will affect SRKWs and their critical habitat through effects of vessel activities, and effects from reduction in prey availability. We have analyzed the potential effects of future PFMC salmon fisheries managed under the FMP including the proposed Amendment 21 on SRKWs and that analysis also forms the basis for the critical habitat analysis.

We considered new information regarding SRKW seasonal movements in assessing the overlap in space and time between SRKW, the salmon fisheries, and the areas where the effects of the salmon fisheries are felt (action area). 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. During the spring, summer, and fall months, SRKWs have typically spent a substantial amount of time in the Salish Sea (inland waterways of Washington and British Columbia) (Bigg 1982; Ford et al. 2000; Krahn et al. 2002; Hauser et al. 2007). 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 recent years (Hanson and Emmons 2010; Ettinger et al. in revision, The Whale Museum unpubl. data).

Land- and vessel-based opportunistic sightings have been documented, and survey-based visual sightings, satellite tracking, and passive acoustic research have been conducted, providing an updated estimate of the whales' coastal geographic range. Satellite tagging results indicate J pod has high use areas in the Salish Sea during winter months, whereas K and L pods occur almost exclusively in coastal waters, primarily off Washington, with hot spot areas in the NOF area off Grays Harbor and the Columbia River. Acoustic detections occurred off Washington coast in all months of the year (Figure 12), with peak detections per month in both March and April, indicating that SRKWs may be present in the NOF coastal waters at nearly any time of year, more often than previously believed (Hanson et al. 2017). They also occur in coastal waters off Oregon, and California during December to mid-May with only occasional visits into the Salish Sea. Similarly, passive acoustic recorders have corroborated the results from the satellite tagging efforts and detected SRKWs along the coast, particularly off the Washington coast (although acoustic effort was higher off Washington).

Although still considered limited, the new SRKW spatial and temporal data since 2009 has allowed for an updated assessment on the general overlap of the PFMC fisheries and SRKWs. Because the whales are observed in the NOF area in all seasons, the limited data available suggest there is some potential for overlap with the PFMC salmon fisheries throughout the fishing season in this area, with a potentially higher likelihood of overlap in the spring (PFMC 2020a). For SOF, although predicting the whales' movements and habitat use in any particular area is uncertain and the limited data available seems to suggest considerable year-to-year variation, the current data suggest overlap with salmon fisheries may be more likely to occur off Oregon from March through May and off California in April, May, and October.

Vessels and Gear Interactions

We expect the general seasonal patterns of the fisheries and fisheries effort in future years to be similar compared to what occurred during 2009 to 2018 given the combination of generally more constraining salmon harvest control rules, conservation objectives, and Pacific Salmon Treaty obligations (PFMC 2020a). Assuming SRKWs do not significantly change their seasonal and temporal distribution, we also anticipate the direct interaction of SRKWs with fishing vessels and gear to be similar to the previous 10 years. Although there is some potential for direct interaction between SRKWs and salmon fishing vessels and gear in the U.S. coastal portion of the action area because of the potential spatial and temporal overlap between the whales' distribution and the distribution of the Council salmon fisheries, vessel strikes or reports of entanglement in general are rare and have not been observed in association with PFMC ocean salmon fisheries and are therefore considered unlikely.

If interactions resulting in disturbance from vessel proximity and sound were to occur, the highest likelihood for interaction is during the NOF fishing season, particularly in the spring, and in the beginning months of the season off Oregon and California (i.e., April and May). We would expect less overlap, less noise and sound exposure to SRKWs, and less interaction between vessels and SRKWs during years when Chinook salmon abundance is below the low abundance threshold defined in Amendment 21, as management responses will result in more constrained salmon fisheries and additional fishery area/time closures (in areas and at times when the likelihood of overlap of fishing vessels and SRKWs is higher). Vessel and acoustic disturbances may cause short-term behavioral changes, avoidance, or a decrease in foraging (if interactions were to occur). However, fishing vessels operate at slow speeds or in idle when actively fishing. Although when in transit, vessels would likely travel at faster speeds with potential to affect the whales' behavior, fishing vessels do not target whales, no interactions of ocean fishing vessels and SRKWs have been reported, and any disturbance that may occur would likely be transitory. Based on the operation of fishing vessels that are spread out over the U.S. coastal portion of the action area, we expect that any transitory or small amount of disturbance caused by the fishing vessels in both high and low Chinook salmon abundance conditions is not likely to disrupt normal behavioral patterns or distribution, or cause harm to the whales.

In addition to the minor effects from the fishing vessels and gear associated with the PFMC salmon fisheries, SRKWs are also exposed to an environmental baseline and cumulative effects that include commercial shipping, cruise ships, and military, recreational and other fishing vessels that occur in the coastal range of SRKWs and additional whale watching, ferry operations, recreational and fishing vessel traffic that occur in the Salish Sea. 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, Washington State regulations were updated to increase vessel SRKW viewing distances (see RCW 77.15.740). In addition, a 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.

Reduction of Prey Availability

The most significant effect of the action is likely the removal of adult Chinook salmon from the action area that might otherwise be available to SRKWs as prey. Less was known in 2009 about diet preferences of SRKWs in coastal waters of the action area. There were no fecal or prey samples or direct observations of predation events (where the prey was identified to species) in coastal waters. However, it was reasonable to expect that SRKWs likely prefer larger Chinook salmon in coastal waters given their prey preferences in the Salish Sea (NMFS 2009). Since 2009, the available prey samples collected in coastal waters indicate Chinook salmon are the primary species detected and consequently an important dietary component. Prey other than Chinook salmon detected in diet samples on the outer coast have included steelhead, chum, lingcod, and halibut (Hanson et al. 2021). The samples collected opportunistically in winter and spring in coastal waters 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 comprise over 90% of 33 Chinook salmon prey diet samples for which genetic stock origin was determined for SRKWs in coastal waters.

The PFMC fisheries are managed to meet conservation objectives and harvest control rules for individual salmon stocks or stock groups consistent with avoiding jeopardy to ESA listed salmon, ensuring sustainable levels of harvest on non-listed salmon, and meeting Pacific Salmon Treaty obligations (PFMC 2020a). The harvest attributed to the PFMC fisheries reduces the number of Chinook salmon available to SRKWs throughout the action area, i.e., in the coastal portion of the action area, and to a lesser degree in the inland portion of the action area. The magnitude of the impact on prey availability depends in part on overall Chinook salmon abundance, the spatial and temporal overlap between the salmon stocks and SRKWs, and the likelihood the SRKWs would encounter and consume the Chinook salmon stocks harvested by the PFMC salmon fisheries in the absence of the fisheries.

The abundance, productivity, spatial structure, and diversity of Chinook salmon are affected by a number of natural and human actions (baseline and cumulative effects) 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 (see Shelton et al. 2020 for predicted distribution shifts). Prey availability may also be affected by the increased competition from other predators including other resident killer whales and pinnipeds (Chasco et al. 2017) as well as pelagic fish, sharks, and birds.

We evaluated the potential short-term (or annual) effects as well as the long-term effects of changes in prey availability attributed to the PFMC salmon fisheries. In analyzing the short-term effects of prey reduction we considered the Workgroup's estimated annual fishery reductions in Chinook abundance by spatial and temporal area for the fishery management years 1992 – 2016 (PFMC 2020a), and assessed how the impacts from the proposed PFMC salmon fisheries compare to the past (1992 – 2016) to provide some context. As described in the Effects section, the FRAM data from this retrospective time period were the best available at the time of the analysis.

As described in the baseline and short-term effects sections, the Workgroup estimated annual, area-specific reductions in Chinook salmon from PFMC fishery removals from 1992-2016. Though reductions by the fishery vary from year to year, the percent reduction in Chinook salmon due to the fisheries has declined during the time series due to increasingly conservative management for salmon species. During the most recent decade analyzed (2007 to 2016), average percent prey reductions attributed to the PFMC salmon fisheries decreased by 53% coastwide compared to over the entire time period (i.e., the average percent reduction from 1992-2016 was 14.9%, whereas the average percent reduction in the recent decade was 7.0%; Table 6). In other words, the adverse effect from the fisheries, in terms of prey reduction, is less than it used to be. Simultaneously, average pre-fisheries abundances in these areas primarily increased, leaving a higher proportion of prey available to the whales. In addition to the reduced impacts to prey availability from the PFMC salmon fisheries over the time series (1992 – 2016), the Workgroup found that overall, the PFMC salmon fishery impacts on NOF Chinook salmon abundance are small (e.g., an average 3.3% reduction in 2007 – 2016) relative to both annual variation in NOF Chinook abundance and the total coastwide Chinook salmon abundance in a given year. Although prey reduction in SOF waters is at least twice that in NOF waters, the higher frequency of SRKW detection in NOF waters compared to SOF waters puts a greater importance on prey reduction in NOF waters. Furthermore, the maturation schedule for the primary stock (SRFC) in the SOF area also limits the carryover effect of fisheries in California during times of the year when the whales are present. Future years that have average coastwide abundance levels similar to those estimated for 1992-2016 would likely see fishery management similar to the most recent decade given the generally more constraining harvest control rules, conservation objectives, and Pacific Salmon Treaty obligations. Therefore, for similar levels of pre-fishing coastwide abundance, we anticipate generally similar reductions in prey availability attributed to the PFMC fisheries as that observed in the most recent 10-yr period into the foreseeable future.

In our short-term effects analysis of prey reduction from the PFMC fisheries, we also considered the Workgroup's effort to quantify the short-term effects from these annual prey reductions and the potential demographic consequences for the whales. There are several challenges to quantitatively characterizing the relationship between SRKWs and Chinook salmon including (1) there are multiple, interacting factors or threats at play, (2) the strength of any one effect likely varies through time leading to a situation known as "non-stationarity", and (3) existing data on SRKW is likely too limited to produce enough statistical power to detect a statistically significant relationship, even if a biologically significant relationship exists. The multiple threats affect SRKW's demographic performance through time, in addition to random chance, and these effects can confound the analysis of the effects of prey abundance. While efforts to quantify the relationship between Chinook abundance and SRKW health and status have largely been unsuccessful, the available science strongly supports a relationship. We considered the Workgroup's effort to quantify the effects of the prey reductions on SRKW but also took a weight-of-evidence approach to considering short-term effect given the limitations on quantifying the relationship.

In its effort to quantify the impacts from the prey reductions attributed to the PFMC salmon fisheries, the Workgroup's analysis showed that winter Chinook abundance in the NOF area and SRKW survival with one year time lag had a statistically significant relationship ($p \leq 0.05$). This relationship is consistent with the SRKWs spatial distribution and use of this area (the whales have been observed in the NOF area in all seasons, with peak occurrence in the spring). When scenarios with the PFMC-driven reductions in Chinook abundance in the NOF area were compared to scenarios without the reductions, a very small (≤ 0.2%) change in survival and fecundity was predicted. The Workgroup found that overall, the PFMC salmon fishery impacts on NOF abundance are small relative to both annual variation in abundance and the total abundance in a given year.

Our weight-of-evidence approach also took into account qualitative considerations. We considered additional aspects of the action that could have negative consequences, including the potential for localized prey depletions or disproportionately high removals of prey in relatively low Chinook salmon abundance years, and increased risk during periods of low Chinook salmon abundance and the aspects of the action, including Amendment 21, that give us confidence that the negative effects will be limited or mitigated. An aspect of the proposed action that is a potential concern and could have negative consequences includes local prey depletions and reduced prey accessibility. It is possible that the overall reduction in prey resulting from the PFMC salmon fisheries would not be evenly distributed across coastal waters, but rather the reductions could cause local depletions of prey and potentially result in the whales leaving areas in search of more abundant prey. If the localized prey depletions occur in foraging hot spots in the NOF area, the whales may increase their searching effort to other areas within their geographic range (e.g. including areas SOF), increasing the potential for overlap with the SOF fisheries. In years of higher Chinook salmon abundance, we would not expect prey reductions from PFMC salmon fisheries to limit foraging opportunities or cause local depletions to an extent that would affect survival and fecundity of SRKW.

Another aspect that is a potential concern is whether the fisheries are responsive to overall Chinook abundance and the potential for disproportionately high prey reduction attributed to the PFMC salmon fisheries. In most years of the time series analyzed by the Workgroup, the PFMC salmon fisheries were responsive to Chinook abundance. However, there were some instances of disproportionately large fishery removals in years of lower abundance.

Given the concerns with localized prey depletions and potential for disproportionate prey removal, we considered whether the effects of reductions in Chinook abundance could be significant to SRKWs at some level of Chinook abundance. Intuitively, at some low Chinook abundance level, the prey available to the whales may not be sufficient to forage successfully leading to adverse effects (such as reduced body condition and growth and/or poor reproductive success). When prey is scarce, whales likely spend more time foraging than when it is plentiful. Increased energy expenditure and prey limitation can cause nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources and as a chronic condition can lead to reduced body size and condition of individuals and lower birth and survival rates of a population (e.g., Trites and Donnelly 2003). In combination with other threats, this could affect SRKW survival and fecundity.

Although there is currently no quantitative model that identifies a low Chinook abundance threshold at which we expect that low prey availability would measurably affect the condition of the whales, there is evidence SRKWs and other killer whale populations that are known to consume Chinook salmon may have experienced adverse effects from low prey availability in the late 1990s. Because of the past occurrence of low SRKW status coinciding with multiple years of low Chinook salmon abundance, and the factors described above, Amendment 21 to the FMP was designed to mitigate these effects on SRKWs. Amendment 21 has a threshold representing a low pre-fishing Chinook salmon abundance in the NOF area, below which the Council and states would implement specific management measures for SRKWs. The threshold is specifically focused on abundance in the NOF area since SRKWs are present more frequently in this area and the limited data available support a stronger relationship of the abundance in this area with SRKW viability. The threshold used in this approach is based on years of low Chinook salmon abundance in the 1990s which corresponded with a time period when the whale population declined, body condition and growth was low, and there was observable reduced social cohesion. The threshold is also based on years that had generally lower SRKW survival but also included some years of increased survival. As mentioned above, the status of the whales is an important component of the assessment. Removals of prey likely present more risk at lower abundance levels and when the whales have a poor status. Thus, including a threshold that consists of a mix of years with relatively good and relatively poor SRKW status, to address concerns of low Chinook abundance and consider the spectrum of risk based on the whale status is a more conservative approach than an abundance threshold that only factors in abundance levels when the whales' status was poor. The period of time included in the threshold also included two periods of consecutive years of low Chinook abundance which are relevant to SRKW reproductive health and survival. The Chinook abundance included in the proposed action is responsive to a range of abundance conditions under which SRKWs could experience increased adverse effects from low prey availability.

The management actions the Council, NMFS and the states would implement in years where abundance is below the threshold are intended to further minimize fishing effects on SRKW access to prey and limit the potential for vessel/noise interactions. The management responses will ensure that there is not disproportionately high removal of Chinook in low abundance years in the NOF area by further limiting NOF non-tribal Chinook salmon quotas. It will also reduce the likelihood of localized prey depletions by reducing the spatial and temporal overlap of the fisheries and the whales (i.e., shift a greater proportion of fishing in the NOF area from the spring when SRKWs are more likely to be present to summer), and close times and areas that may be important for SRKW foraging. Management actions will also occur in the SOF area to improve foraging opportunities across the whales' range. This is important because SRKWs may increase their search area for better foraging opportunities in years with low Chinook salmon abundance. These actions reduce the likelihood of overlap and competition for Chinook salmon between Council managed salmon fisheries and SRKW through area and time closures during times when SRKWs are more likely to be in these areas, specifically in areas of high use by SRKWs.

Our long-term effects analysis on the impacts from the PFMC fisheries on prey availability relies in part on the fact that fisheries are managed for sustainable levels for all affected salmon stocks, consistent with the applicable FMP objectives and standards. In biological opinions addressing effects on ESA-listed salmon from fisheries managed under the FMP, NMFS concluded that actions are not likely to appreciably reduce the survival and recovery of ESA-listed salmon or provided a RPA for the Council to set management measures consistent with survival and recovery.

In addition, Amendment 21 would address years where overall Chinook abundance is low. Consecutive years of low abundance may compound effects on reproduction by impacting multiple phases (ovulation, conception, gestation, lactation) over extended periods and increase calving intervals. For example, 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, and effects of prey availability may be combined across consecutive years. The PFMC 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. The implementation of protective management measures at the low Chinook abundance threshold addresses the concern about fishery removal at lower abundance levels over consecutive years because the threshold is based on a range of years including several periods when there were multiple and consecutive years of low abundance. Amendment 21 ensures that multiple years of low abundance would result in multiple years of protective management measures.

In our long-term effects assessment we also considered changing ocean conditions that may influence ocean survival and distribution of Chinook and other Pacific salmon, further affecting the prey available to SRKWs in the long term. We compared how the PFMC fisheries may respond to a substantial decline in abundance outside that observed e.g., due to effects of changing ocean conditions with and without Amendment 21. In general, we found that the existing salmon management measures are responsive to abundance and become increasingly restrictive as abundance declines (when abundance reduces by 40%, catch in the NOF area is expected to be reduced by 47%). The application of Amendment 21 on top of existing salmon management measures is also expected to result in even further fishery restrictions at lower Chinook salmon abundances, beyond that required to meet the salmon management measures (catch in the NOF area is reduced by 53% when abundance is reduced by 40%). Thus, under low abundance scenarios we expect that percent reductions in prey availability due to fisheries would decrease relative to higher abundance scenarios. The application of Amendment 21 on top of existing salmon management measures would result in an even further decrease to these percent reductions. Salmon abundance in the NOF area was predicted to go below the abundance Chinook salmon threshold in 17 out of 25 years, including multiple years back-to-back. Therefore, there is the potential for the management responses of the proposed action to be triggered in multiple consecutive low abundance years, particularly if ocean conditions negatively influence ocean survival and distribution of Chinook salmon.

With Amendment 21, we expect reductions in prey abundance from the fisheries during high or low abundance years to result in only a minor change at most in foraging behavior or the overall health of any individual whale which would not change the status of the population. This is partly because the spatial and temporal distributions of whales and fish are not entirely overlapping; in other words there is a low probability that all the Chinook salmon vulnerable to the fisheries would be intercepted by SRKWs across their vast range in the absence of the proposed action. Effects to individuals or groups of whales from K and L pods from the action may be greater as these pods have potential for more overlap with coastal salmon fisheries compared to J pod whales, although it is difficult to estimate the extent of overlap of individual whales, prey and fishing effort or quantify behavioral changes. But even assuming a measurable effect to foraging behavior of some individual whales, we do not expect that the transitory and small behavior changes from small percent reductions in the NOF area (an average 3.3% reduction) where Chinook abundance is consistently more important to the whales, would rise to the level of an appreciable reduction in the likelihood of survival or reproductive success of any individual whale or change the distribution or trajectory of the population.

In addition to reductions in prey availability due to the PFMC salmon fisheries, salmon harvest from other fisheries also affects prey availability in the action area. 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. Nevertheless, the percent reductions in Chinook abundance in the coastal waters of WA and OR resulting from the SEAK fisheries under the currently effective 2019 – 2028 PST Agreement are less than reductions under the previous PST Agreement (2009 – 2018) and are expected to range from 0.2% to 12.9% (NMFS 2019e). NMFS estimated that the percent reductions of adult Chinook salmon in inland waters of WA from the SEAK fisheries were expected to range from 0.1% to 2.5%. 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 (NMFS 2019e). NMFS estimated that the percent reductions of Chinook salmon from the Puget Sound fisheries in 2007-2016 in inland waters of WA annually were expected to range from 2.6% to 4.7% with the greatest reductions occurring in July – September when the whales are more likely to occur in these waters. The groundfish fisheries in the EEZ off the West Coast catch Chinook salmon as bycatch while conducting these fisheries (Table 4). Chinook salmon bycatch in the groundfish fishery ranged from 7,281 to 21,951 from 2011 to 2018 (NMFS 2017b; WCGOP data). In sum, fishery impacts on Chinook have been reduced coastwide over the past decade, particularly in those areas where SRKWs are more likely to occur. Fishery management frameworks increase constraints in years of low Chinook abundance.

Additional hatchery production of Chinook funded through the programmatic funding initiative as one of the U.S. domestic actions associated with the implementation of new PST Agreement is designed to conserve Puget Sound critical populations, increase hatchery production 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. For example, hatcheries in Washington State are in the midst of enumerating the spring 2020 release and the release of over 18 million Chinook production funded by federal and state governments is anticipated in the spring of 2021.

In addition to increased hatchery production, the PST-related funding initiative is expected to fund projects to improve habitat conditions for specified populations of Puget Sound Chinook salmon, which we anticipate would increase Puget Sound Chinook abundance, also benefiting

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, the Washington State passed House Bill 1579 that included addressing habitat protection of shorelines and waterways, and funding was included for salmon habitat restoration programs and to increase technical assistance and enforcement of state water quality, water quantity, and habitat protection laws, along with other actions. By improving conditions for these populations, we anticipate salmon abundance in these watersheds, including Chinook salmon, would increase, also potentially benefiting SRKWs.

For future years, the benefits of the funding initiative related to U.S. domestic actions associated with the new PST Agreement, as described in the Environmental Baseline, for increasing hatchery production are expected to increase the prey base in 3 - 5 years following implementation. The time frames for realizing benefits from improvements to habitat are longer. While funding was received in FY20 and FY21 to support the increased hatchery production and habitat improvements, continued improvements are contingent on additional years of funding. There are also other ongoing measures intended to support SRKW recovery efforts in the long term as described in the Cumulative Effects section.

Designated and Proposed Critical Habitat

In November 2006, NMFS issued a final rule designating approximately 2,560 square miles of inland waters of Washington State as critical habitat for the SRKW DPS. 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) in addition to maintaining critical habitat designation in inland waters of Washington. 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 from the U.S. international border with Canada south to Point Sur, California. The six area boundaries reflect the spatial scale of the whales' movements and behavioral changes (e.g., where tagged whales were primarily traveling versus observed foraging), as well as to align with some existing fishery management boundaries (e.g., geographic points used by the PFMC in salmon management, see Figure 30). Based on the natural history of the SRKWs and their habitat needs, NMFS identified three physical or biological features essential to conservation: (1) Water quality to support growth of the whale population and development of individual whales, (2) Prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth, and (3) Passage conditions to allow for migration, resting, and foraging.

The proposed action has the potential to affect passage conditions and the quantity and availability of prey in the proposed critical habitat. Effects of the proposed fishing include the potential for exposure to the physical presence and sound generated by vessels associated with the proposed action. This increase in vessel presence and sound in the proposed critical habitat, contribute to total effects on passage conditions. For reasons described above and summarized here, based on the operation of fishing vessels we expect that any transitory or small amount of disturbance caused by the fishing vessels in both high and low Chinook salmon abundance conditions is not likely to disrupt normal behavioral patterns or distribution, or cause harm to the whales or impair the prey (i.e., availability) and passage features of their existing and proposed critical habitat.

The analysis of effects to the whales above considers pathways of effects that also apply to prey features. For reasons described above and summarized here, the percent of potential Chinook prey abundance remaining after Council directed salmon ocean fisheries occur has been increasing over time – meaning for the proposed critical habitat these fisheries have been taking a lower proportion of the available abundance over time and having a decreasing adverse effect on the conservation value of the critical habitat areas. In the most recent decade (2007-2016) percent prey reduction by the PFMC fishery was 3.3% in proposed critical habitat Areas 1 and 2, 7% in Areas 3 and 4, 16.6% in Areas 5 and 6, and 1.9% reduction in the inland waters. As described above, the prey reductions attributed to the PFMC salmon fisheries have the potential to cause local depletions of prey in the whales' critical habitat and potentially affect the ability of the whales to meet their bioenergetic needs resulting in the whales leaving areas in search of more abundant prey. In years of relatively high Chinook salmon abundance, we would not expect prey reductions from PFMC salmon fisheries to limit foraging opportunities or cause local depletions to an extent that would appreciably reduce the conservation value of the prey feature. Even during these lower risk conditions for the whales, prey reductions would be limited by harvest control rules for salmon and would be expected to be low in areas of the highest potential for overlap with the SRKW (NOF, Areas 1 and 2). Given the whales' poor status, and because impacts on prey availability may present increased risk at lower abundance levels, management responses included in Amendment 21 complement the broader FMP framework and are specifically intended to reduce the overall level of Chinook removal and the potential for localized depletions in times and areas of critical habitat where/when the fisheries and whales overlap, thereby reducing overlap and direct competition of prey resources under these higher risk conditions. We rely on the analysis of prey reductions, effects on the whales, and actions that limit or mitigate risks to the whales to inform our conclusions that the effects to critical habitat passage and prey features will likely be small, transitory, and minimized by the actions identified in Amendment 21.

Summary Conclusion

In conclusion, the Council's salmon fisheries are designed to be consistent with FMP objectives, control rules for ESA listed and non-ESA listed salmon stocks, and obligations under the PST and thus we anticipate that the Council salmon fisheries will continue to respond to changes in Chinook salmon abundance, and that the management actions under Amendment 21 further limit the effects of the fisheries to SRKWs in particularly low Chinook abundance years. Our conclusion is based on the best available information about the status of the SRKWs, their relationship with Chinook salmon, the status of designated and proposed critical habitat, and the prey reductions expected from the PFMC salmon fisheries, including complex analyses conducted by the PFMC Workgroup. We also considered actions that mitigate or reduce the potential risks, including the Chinook abundance threshold and management actions in Amendment 21 designed to reduce the effects of the fishery on SRKWs, as well as actions in the environmental baseline like the ongoing hatchery and habitat actions intended to increase the prey available to 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 the predominant prey species and there is intuitively a linkage between Chinook abundance and the whales' status although the available analysis has 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 average percent reductions in abundance attributable to PFMC salmon fisheries is substantially lower in the recent decade compared to over the entire time period analyzed (decreased by 53% coastwide), continuing a trend established over the last 30 years. We expect to see restrictions similar to the most recent decade given the generally more constraining harvest control rules, conservation objectives, and Pacific Salmon Treaty obligations that have been incorporated into management of the fisheries. For the proposed critical habitat, the PFMC salmon fisheries have been taking a lower proportion of the available abundance over time and have had a decreasing adverse effect on the conservation value of the critical habitat areas.

Based on the spatial and temporal SRKW geographic distribution and the PFMC Workgroup's analyses, Chinook abundance in the NOF area appears to be consistently be more important to SRKWs than other ocean areas. In the NOF area, prey reductions attributable to the PFMC fishery are expected to be small relative to annual variation in NOF Chinook abundance and the total abundance in a given year (an average 3.3% reduction in the NOF area, or proposed critical habitat Areas 1 and 2) even in years of high Chinook abundance. As described above, Areas 1 and 2 are considered high-use areas for SRKWs, particularly for foraging and prey is the primary essential feature in these areas. Although reductions in Chinook salmon abundance attributable to PFMC salmon fisheries are highest in the SOF area, SRKW presence in that area primarily occurs in the wintertime when salmon fisheries do not occur and there is limited carryover effect of fisheries in California during times of the year when the whales are present. The Workgroup concluded that SRKWs are likely impacted by reduced prey availability in the NOF area to some unknown degree and attempts to predict demographic changes suggested small changes were possible (≤ 0.2% change in both mean estimates in survival and fecundity, although the Workgroup cautioned the interpretation of these regression results are warranted given the limitations of the data; PFMC 2020a)

In most years considered in the Workgroup's analysis, the PFMC salmon fisheries were responsive to overall Chinook salmon abundance. However, some past years had relatively high removals during years of low Chinook salmon abundance. In addition, the overlap of fisheries and whales, particularly in the NOF area, creates the potential for localized prey depletions or increased competition; however, it is difficult to assess how reductions in prey abundance resulting in localized depletions may vary throughout proposed critical habitat. The potential for disproportionate prey removal or localized depletions to an extent that would affect survival and fecundity of SRKW or adversely affect critical habitat would most likely occur during low Chinook abundance years. The authorization of the PFMC ocean salmon fishery through approval of the FMP and promulgation of regulations implementing the plan, including approval and implementation of Amendment 21, includes an approach which is responsive to the abundance of Chinook salmon 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 in times and areas where/when the fisheries and whales overlap, and when Chinook abundance is low. The low Chinook abundance threshold was based on a range of years including several periods when there were multiple and consecutive years of low abundance. This is important 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, and the effects of prey availability may be combined across consecutive years. The low abundance threshold is considered a conservative approach because it is based on years that consist of a mix of relatively good and relatively poor SRKW status, which considers the spectrum of risk based on the whale status to address concerns of low Chinook salmon abundance.

The proposed action has the potential to affect passage conditions in the proposed critical habitat. The increase in vessel presence and sound in the proposed critical habitat contribute to total effects on passage conditions. Although there is some potential for the vessels associated with the fishing activities to overlap with the whales in the NOF area (Areas 1 and 2) every month the fishing season is open, and in waters off Oregon and California (in Areas 3 – 6) in the early and later months of the season, fishing vessels operate at slow speeds or in idle when actively fishing, do not target whales and the effects are expected to be minimal. Based on the operation of fishing vessels we expect that any transitory or small amount of disturbance caused by the fishing vessels in both high and low Chinook salmon abundance conditions is not likely to disrupt normal behavioral patterns or distribution, or cause harm to the whales or impair the prey (i.e., availability) and passage features of their existing and proposed critical habitat.

The environmental baseline and cumulative effects include ongoing effects of human activities in the action area that contribute to the top three limiting factors for the whales' status, but there are also improvements in recent years that are expected to continue, such as reductions in northern fishery impacts under the new PST Agreement, additional hatchery production to provide increased prey for the whales, increased restrictions on vessel traffic near the whales, and efforts by state, tribal, and by other partners to improve salmon habitat conditions in Washington. Efforts are underway to produce additional hatchery fish to increase prey availability for the whales throughout their range, 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 vessel disturbance to the whales and NMFS initiated scoping in 2019 to evaluate the need to revise existing federal regulations. These efforts along with voluntary measures are underway to reduce impacts of vessels on foraging. Actions to grow the prey base and reduce interference with foraging, combine to provide confidence that this action to manage fisheries in a way that addresses the needs of the whales will not result in mortality or prevent reproduction.

The status of SRKWs has declined over the last decade and is expected to continue to have a depressed status if their demographic rates do not improve. Given it is likely that multiple threats are acting together to impact the whales, multiple actions are being implemented to address all the threats to improve conditions for the whales, one of which includes the management measures of Amendment 21. With multiple ongoing efforts to ensure that recovery of both Chinook salmon and SRKW progresses and the inclusion of protective management for the whales in coastal salmon fisheries management, we find that the proposed action will not likely appreciably reduce the likelihood of survival and recovery of SRKWs, and is not likely to appreciably diminish the conservation value of its designated or proposed 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.

2.8. Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that 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.

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.

2.9.1. Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

The harvest of salmon that may occur under the proposed action is likely to result in some level of harm constituting take to SRKWs 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. However, K and L pods are known to use coastal waters off Washington, Oregon, and California more than J pod, and greater prey reduction attributed to the PFMC salmon fisheries occurs in the coastal waters than in inland waters of the Salish Sea where J pod primarily occurs. 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 PFMC salmon fisheries, as quantitative regression analyses have limitations (as discussed in Section 2.5, Effects of the Action). Therefore, NMFS will use surrogates for the extent of take.

NMFS' analysis above concluded that the amount of harm or take from the proposed fisheries to SRKWs is in part related to the proportion of Chinook abundance removed by the fisheries on an annual basis, particularly in years when Chinook salmon abundance is below the threshold established under Amendment 21. The proposed action is designed to meet the conservation objectives for salmon stocks managed under the FMP, while incorporating SRKW needs under Amendment 21, at both the coastwide and NOF area levels. In years when pre-fishing Chinook salmon abundance in the NOF area is below the threshold, under Amendment 21 the specified spring (May/June) required quota cap will be established during the pre-season management process and fisheries will be managed to keep catch levels within the overall NOF non-tribal Chinook salmon quotas. Because we can quantify and monitor catches relative to overall quotas inseason, NMFS will use the NOF non-tribal overall quotas implemented under Amendment 21 as a surrogate for incidental take of SRKWs. If the overall NOF non-tribal Chinook salmon catch exceeds the overall NOF non-tribal Chinook salmon quota, this will constitute an exceedance of take.

NMFS will also monitor the percent reduction of Chinook salmon coastwide attributed to the PFMC salmon fisheries as a surrogate for incidental take of SRKWs. We can quantify this value, and it represents the extent of effects on prey availability. As described in the Effects section, due to weak stock management in Council salmon fisheries, a relatively large portion of the overall Chinook salmon abundance goes unharvested. The proportion that goes unharvested has been increasing over the time period 1992 – 2016 (PFMC 2020a; Figure 24). Future years that have average coastwide abundance levels similar to those estimated for 1992 – 2016 would likely see restrictions similar to the most recent decade given the pattern of generally more constraining harvest control rules, conservation objectives, and Pacific Salmon Treaty obligations. The extent of take NMFS expects for SRKWs in future years is expected to vary but be within the range of prey reductions coastwide that occurred during the most recent decade (2007 to 2016) (described in Section 2.5.1, Table 6). Therefore, NMFS will use percent reductions in coastwide Chinook salmon abundance attributable to the PFMC fisheries as another measure of expected take in addition to the surrogate described above. Over the most recent decade, coastwide percent reductions is estimated to have ranged from 0.9 – 12.2%. If the percent reduction in coastwide abundance in any one year exceeds the maximum of the range of percent reduction in coastwide abundance estimated for 2007 to 2016 this will constitute an exceedance of take. We will estimate the expected prey reductions coastwide based on post-season estimates of pre-fishing abundance to estimate the amount of annual take and evaluate if it is within the range we analyzed.

As described above, NMFS anticipates PFMC salmon fisheries occurring in future seasons will be implemented and managed to meet limits on impacts to salmon stocks (both ESA-listed and non-ESA-listed) through updates to harvest control rules, updated conservation objectives, and with the provisions of the Pacific Salmon Treaty. Fisheries will be managed and we will confirm they are consistent with Amendment 21 in years of low Chinook abundance, and keep percent reductions from exceeding recent levels.

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

2.9.3. Reasonable and Prudent Measures

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

1. The consistency of implementation of the action with SRKW take surrogates shall be monitored and shall be reviewed using the best available measures. In years when Chinook abundance is below the low abundance threshold included in Amendment 21, catch will be monitored to determine if it is within the NOF overall non-treaty quota and within the non-treaty commercial quota for spring (May/June). Percent prey reductions will be assessed with respect to the range of reductions from 2007-2016.
2. NMFS will conduct continued monitoring to support the PFMC's Chinook abundance models, validate assumptions in the effects analysis, and provide annual forecasts and estimates needed to evaluate take surrogates. Although NMFS is the federal agency responsible for carrying out this reasonable and prudent measure, monitoring includes coordination with other entities. In practical terms, it is the states and tribes that monitor Chinook salmon catch impacts.

2.9.4. Terms and Conditions

The terms and conditions described below are non-discretionary, and the NMFS or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The NMFS or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this 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, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement reasonable and prudent measure 1:

1a. NMFS shall monitor Chinook salmon catch when preseason abundance levels are estimated to be below the NOF area low abundance threshold as defined in Amendment 21, to ensure the NOF overall non-treaty quota is not exceeded. Implementation of the FMP through annual regulations for the fisheries will be tracked in the annual Preseason Report III available at the conclusion of each season planning process and just prior to the beginning of each fishery season. The preseason forecast of Chinook salmon abundance will be compared with the low abundance threshold for incorporating measures specified in Amendment 21.

1b. NMFS, in coordination with the PFMC, shall estimate annual fishery abundance reductions (in percent reduction) of age 3+ Chinook salmon when post-season data becomes available. The annual estimated reduction in Chinook attributable to the fishery represent the difference between end of year abundances absent fishing and end of year abundances after PFMC fisheries occur (e.g., total mortalities resulting from fisheries across the entire management year). This shall be done using the methodology developed by the PFMC's Ad Hoc Workgroup for the stratifications defined by the PFMC SRKW Ad Hoc Workgroup: Coastwide, NOF, Oregon coast, California coast, Salish, and SWCVI. The resulting percent reductions will be calculated from the annual estimated reduction attributable to fishing mortality.

1c. Annual estimated percent Chinook age 3+ reductions coastwide will be compared to the ranges of percent reductions described in Section 2.5.1, Table 6, which occurred during the most recent decade (2007 to 2016). NMFS will consider the percent reductions to be within the range of effects analyzed and consistent with the ITS if coastwide percent reductions do not exceed the high end of the range (12.2%).

2. The following terms and conditions implement reasonable and prudent measure 2:

2a. NMFS, in cooperation with the affected states and tribes, shall ensure monitoring of catch in the PFMC commercial and recreational salmon fisheries occur at levels that are at least comparable to those used in recent years to provide estimates of the catch of salmon to the extent possible. The catch monitoring program shall be stratified by time, and management area. NMFS shall ensure this information is provided in the following year after a management cycle has been completed.

2b. Given that harvest of salmon may 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, NMFS shall 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. NMFS will provide any new information to the PFMC and in NMFS' 5-year reviews on the ESA-listing of the SRKW DPS under Section 4(c)(2)(A) of the ESA.

2c. NMFS, in coordination with the PFMC, shall periodically review and report findings to the PFMC:

- the performance of models and model inputs used to assess preseason pre-fishing Chinook abundance estimates as described in 1b; and
- whether any substantive updates have occurred to the models that result in changes to the pre-fishing abundance time series used to determine the Chinook low abundance threshold or changes to the estimates of coastwide percent reduction of Chinook salmon for the most recent decade (2007 to 2016).

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 action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

NMFS has broad authority that can be used to further the survival and recovery of SRKWs and their prey. We recommend that NMFS implements the following measures to reduce the risks of the proposed action and provide information for future consultations involving the implementation of fisheries regulations that may affect SRKWs, as well as reduce the adverse effects associated with fishing activities:

1. Improve information on whale distribution along the U.S. west coast throughout the year as a spatial and temporal scale to provide better information on the overlap of salmon fisheries and SRKWs.

2. Continue filling data gaps for specific pods, which includes assessing the different spatial and temporal distributions among pods to inform diet studies and evaluation of priority prey for the whales.
3. Work with researchers, states and tribal fishery managers on tools to evaluate effectiveness of harvest management and potential mitigation measures (habitat restoration and hatchery production and operations) to contribute to the prey base of SRKWs.
4. 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.
5. 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.
6. Improve understanding of links between prey availability and body condition and any links to reproduction or survival.
7. Improve understanding of interactions within the ecosystem to assess food-web impacts on SRKW and their prey; including status, diets, and impacts of other large predators of salmon (particularly other marine mammals) and status of salmon prey and impacts of changes on lower trophic level species on salmon and SRKW.
8. Improve modeling of salmon populations to incorporate impacts of climate change and environmental factors on salmon distribution and annual variation in salmon mortality.
9. Improve estimates of Chinook salmon stock abundances and distributions and data on SRKW temporal and spatial distribution, including winter distributions particularly in the NOF area, and the potential for localized depletion in areas by fisheries by better understanding SRKW temporal and spatial distribution and Chinook salmon availability (abundance and density) at finer spatial scales.

2.11. Reinitiation of Consultation

This concludes formal consultation for Consultation on the Implementation of the Ocean Salmon Fisheries as Managed under the Pacific Salmon Fishery Management Plan with Amendment 21 for Southern Resident Killer Whales and their Current and Proposed Critical Habitat.

As 50 CFR 402.16 states, reinitiation of consultation is required and shall be requested by the Federal agency or by the Service 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 ITS 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 identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat 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 action.

3. 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.

3.1. 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 opinion are applicants and action agencies listed on the first page. Other interested users could include agencies, applicants, and the American public. Individual copies of this opinion were provided to the NMFS. The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adheres to conventional standards for style.

3.2. 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.

3.3. 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 contain more background on information sources and quality.

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

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

4. REFERENCES

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5. APPENDICES

5.1. Appendix A.

Table A.1. Hatchery programs that have been addressed in previously completed ESA Section 7 consultations.

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
USFWS Artificial Propagation Programs in the Lower Columbia and Middle Columbia River	Little White Salmon/Willard National Fish Hatchery Complex Coho	November 27, 2007	NMFS (2007), NMFS (2016a)
	Little White Salmon/Willard National Fish Hatchery Complex spring Chinook		
	Little White Salmon/Willard National Fish Hatchery Complex URB fall Chinook		
	Carson National Fish Hatchery spring Chinook		
	Spring Creek National Fish Hatchery fall Chinook (tule)		
	Eagle Creek National Fish Hatchery coho		
	Eagle Creek National Fish Hatchery winter steelhead		
	Warm Springs National Fish Hatchery Warm Springs River spring Chinook		
Letter: Request for Concurrence with the Yakima Nation Fisheries' assessment of potential impacts	Lake Cle Elum/ Yakima Basin Lakes	July 1, 2009	Turner (2009)
Umatilla River Spring Chinook Salmon, Fall Chinook Salmon,	Umatilla spring Chinook	April 19, 2011	NMFS (2011), NMFS (2016b)
	Umatilla fall Chinook		
	Umatilla coho		

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
and Coho Salmon Hatchery Programs			
Snake River Fall Chinook Salmon Hatchery Programs, ESA Section 10(a)(1)(A) permits, numbers 16607 and 16615	Lyons Ferry Hatchery Snake River fall Chinook	October 9, 2012	NMFS (2012)
	Fall Chinook salmon Acclimation program		
	Idaho Power Company fall Chinook		
	Nez Perce Tribal Hatchery Snake River fall Chinook		
Entiat National Fish Hatchery Summer Chinook Salmon Hatchery Program	Entiat summer Chinook	April 18, 2013	NMFS (2013a)
Snake River Sockeye Salmon Hatchery Program	Snake River sockeye	September 28, 2013	NMFS (2013b)
Yakima River Spring Chinook Salmon, Summer/Fall Chinook Salmon, and Coho Salmon Hatchery Programs	Upper Yakima River spring Chinook/Cle Elum Supplementation and Research Facility (CESRF)	November 25, 2013	NMFS (2013c)
	Yakima River summer and fall run Chinook production program		
	Yakima River coho Reintroduction program		
Sandy River Spring Chinook Salmon, Coho Salmon, Winter Steelhead, and Summer Steelhead Programs	Sandy River spring Chinook	August 7, 2014	NMFS (2014b)
	Sandy River coho		
	Sandy River winter steelhead		
	Sandy River summer steelhead		
Issuance of Section 10(a)(1)(A) Permit 18928 for the Chief	Chief Joseph Hatchery Okanogan spring Chinook	October 27, 2014	NMFS (2014c)

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
Joseph Hatchery Okanogan Spring Chinook Salmon Program			
Reinitiation of the Issuance of Three Section 10(a)(1)(A) Permits for the Upper Columbia River Chiwawa River, Nason Creek, and White River Spring Chinook Salmon Hatchery Programs	Chiwawa spring Chinook	May 29, 2015 (original signed July 3, 2013)	NMFS (2015a)
	Nason Creek spring Chinook		
Six Lower Snake River Spring/Summer Chinook Salmon Hatchery Programs	Catherine Creek spring/summer Chinook	June 24, 2016	NMFS (2016c)
	Upper Grande Ronde spring/summer Chinook		
	Imnaha River spring/summer Chinook		
	Lookingglass Creek spring Chinook		
	Lostine spring/summer Chinook		
	Tucannon River Endemic spring Chinook		
Issuance of a Section 10(a)(1)(A) Permit 18583 for the Upper Columbia Wenatchee River Summer Steelhead Hatchery Program	Wenatchee summer steelhead	July 20, 2016	NMFS (2016d)
	Methow Hatchery spring Chinook		NMFS (2016e)

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
Issuance of Four Section 10(a)(1)(A) Permits for Spring Chinook Salmon Hatchery Programs in the Methow Subbasin	Winthrop National Fish Hatchery spring Chinook	October 13, 2016	
Mitchell Act Funded Hatchery Programs	Bonneville coho	January 15, 2017	NMFS (2017a)
	Bonneville fall Chinook (tule)		
	Big Creek Chinook (tule)		
	Big Creek coho		
	Big Creek chum		
	Big Creek winter steelhead		
	Gnat Creek winter steelhead		
	Klaskanine winter steelhead		
	Klaskanine coho		
	Klaskanine fall Chinook (tule)		
	Clackamas summer steelhead		
	Clackamas winter steelhead		
	Clackamas spring Chinook		
	Grays River coho		
	N. F. Toutle fall Chinook (tule)		
	N. F. Toutle coho		
	Kalama fall Chinook (tule)		
	Kalama coho (type N)		
	Kalama summer steelhead		
	Kalama winter steelhead		

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
	Washougal fall Chinook (tule)		
	Washougal coho		
	Walla Walla spring Chinook		
	Ringold Springs steelhead		
	Ringold Springs coho[1]		
	Clearwater River coho restoration project		
	Lostine River coho restoration project;		
	Deep River coho (MA/SAFE)		
	Deep River fall Chinook		
	Klickitat coho		
	Klickitat URB fall Chinook		
	Klickitat spring Chinook		
	Klickitat (Skamania) summer steelhead		
	Beaver Creek summer steelhead		
	Beaver Creek winter steelhead		
	Beaver Creek (Elochoman) coho[1]		
	South Toutle summer steelhead		
	Coweeman winter steelhead		
	Cathlamet Channel Net-pen spring Chinook		
	Klineline winter steelhead (Salmon Cr.)		
	Washougal summer steelhead (Skamania Hatchery)		

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
	Washougal winter steelhead (Skamania Hatchery)		
	Rock Creek winter steelhead		
	Kalama spring Chinook		
	Umatilla River coho		
	Sandy River spring Chinook		
	Sandy River winter steelhead		
	Sandy River summer steelhead		
	Sandy River coho		
	Carson National Fish Hatchery spring Chinook		
	Little White Salmon National Fish Hatchery spring Chinook		
	Willard National Fish Hatchery fall Chinook		
	Eagle Creek National Fish Hatchery winter steelhead		
	Eagle Creek National Fish Hatchery coho		
Issuance of a Tribal 4(d) Rule Determination for a Tribal Resource Management Plan (TRMP) submitted by the Confederated Tribes of the Colville Reservation (CTCR), and Funding and Carrying out	Chief Joseph summer/fall Chinook	February 24, 2017	NMFS (2017b)
	Chief Joseph spring Chinook		
	Okanogan River steelhead		

Biological Opinion	**Programs Authorized in Opinion**	**Signature Date**	**Citation**
Activities Pursuant to that TRMP			
Mid-Columbia Coho Salmon Restoration Program: Operation and Construction	Mid-Columbia Coho Restoration Program	February 28, 2017	NMFS (2017c)
Four Lower Snake River Steelhead Hatchery Programs	Wallowa summer steelhead	July 11, 2017	NMFS (2017d)
	Little Sheep Creek/Imnanha summer steelhead		
	Lyons Ferry summer steelhead		
	Tucannon River summer steelhead		
Leavenworth National Fish Hatchery Spring Chinook Salmon Program (Reinitiation 2016)	Leavenworth National Fish Hatchery Spring Chinook	September 29, 2017	NMFS (2017e)
Little White Salmon National Fish Hatchery Upriver Bright Fall Chinook Salmon Program	Little White Salmon National Fish Hatchery URB fall Chinook (Corps)	October 5, 2017	NMFS (2017f)
Two Steelhead Hatchery Programs in the Methow River	Wells Complex summer steelhead	October 10, 2017	NMFS (2017g)
	Winthrop National Fish Hatchery summer steelhead		
Five Snake River Basin Spring/Summer Chinook Salmon Hatchery Programs	Rapid River spring Chinook	November 27, 2017	NMFS (2017h)
	Hells Canyon spring Chinook		
	South Fork Salmon River (SFSR) summer Chinook		

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
	Johnson Creek Artificial Propagation and Enhancement Project summer Chinook		
	South Fork Chinook Eggbox Project summer Chinook		
Five Clearwater River Basin Spring/Summer Chinook Salmon and Coho Salmon Hatchery Programs	Kooskia spring Chinook	December 12, 2017	NMFS (2017i)
	Clearwater Fish Hatchery spring/summer Chinook		
	Nez Perce Tribal Hatchery spring/summer Chinook		
	Dworshak spring Chinook		
	Clearwater River coho (at Dworshak and Kooskia)		
Nine Snake River Steelhead Hatchery Programs and one Kelt Reconditioning Program in Idaho	Steelhead Streamside Incubator (SSI) Project	December 12, 2017	NMFS (2017j)
	Dworshak National Fish Hatchery B-Run Steelhead		
	East Fork Salmon Natural A-run Steelhead		
	Hells Canyon Snake River A-run Summer Steelhead		
	Little Salmon River A-run Summer Steelhead		
	Pahsimeroi A-run Summer Steelhead		
	South Fork Clearwater (Clearwater Hatchery) B-Run Steelhead		
	Upper Salmon River A-Run Steelhead		
	Salmon River B-Run		
	Snake River Kelt Reconditioning		

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
Four Summer/Fall Chinook Salmon and Two Fall Chinook Salmon Hatchery Programs in the Upper Columbia River Basin	Chelan Falls summer/fall Chinook	December 26, 2017	NMFS and USACE (2017)
	Wenatchee summer/fall Chinook		
	Methow summer/fall Chinook		
	Wells summer/fall Chinook		
	Priest Rapids fall Chinook		
	Ringold Springs fall Chinook		
Four Salmon River Basin Spring/Summer Chinook Salmon Hatchery Programs in the Upper Salmon River Basin	Yankee Fork spring Chinook	December 26, 2017	NMFS (2017k)
	Panther Creek summer Chinook		
	Panther Creek summer Chinook egg box		
	Upper Salmon River spring Chinook		
	Pahsimeroi summer Chinook		
Hood River Spring Chinook Salmon and Winter Steelhead Hatchery Programs	Hood River spring Chinook	February 2018	NMFS (2017l)
	Hood River winter steelhead		
Five Middle Columbia River Summer Steelhead and Spring Chinook Hatchery Programs	Touchet endemic summer steelhead	February 2018	NMFS (2017m)
	Umatilla summer steelhead		
	Round Butte spring Chinook		
	Touchet River spring Chinook		
	Walla Walla spring Chinook		
Five Elwha River Hatchery Programs	Elwha Channel Hatchery summer/fall Chinook	December 2014	NMFS (2014d)
	Lower Elwha Fish Hatchery steelhead		
	Lower Elwha Fish Hatchery coho		

Biological Opinion	**Programs Authorized in Opinion**	**Signature Date**	**Citation**
	Lower Elwha Fish Hatchery chum		
	Lower Elwha Fish Hatchery odd and even year pink salmon		
Three Dungeness River Hatchery Programs	Dungeness River Hatchery spring Chinook	May 31, 2016	NMFS 2016f
	Dungeness River Hatchery coho		
	Dungeness River Hatchery pink		
Four Snake River fall Chinook Hatchery Programs	Lyons Ferry Hatchery	August 2018	NMFS 2018c
	Fall Chinook Acclimation Project		
	Nez Perce Tribal Hatchery		
	Idaho Power Company		
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	Dungeness early winter steelhead	April 13, 2016	NMFS 2016h;
	Kendall Creek winter steelhead		

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

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
Six Hatchery Programs in the Snohomish River Basin	Bernie Kai-Kai Gobin Salmon Hatchery “Tulalip Hatchery” subyearling summer Chinook	September 27, 2017	NMFS 2017n
	Wallace River Hatchery summer Chinook		
	Tulalip Bay Hatchery coho		
	Wallace River Hatchery coho		
	Everett Bay net pen coho		
	Tulalip Bay Hatchery chum		
Hatchery Programs for Lake Ozette Sockeye	Lake Ozette sockeye	June 9, 2015	NMFS 2015b
Six Hatchery Programs for Spring Chinook, Summer Steelhead, and Rainbow Trout in the Upper Willamette River Basin	North Santiam spring Chinook	May17, 2019	NMFS 2019c
	South Santiam spring Chinook		
	McKenzie spring Chinook		
	Middle Fork Willamette spring Chinook		
	Upper Willamette summer steelhead		
	Upper Willamette rainbow trout		
Hatchery Programs for Hatchery Programs on the Oregon Coast	Rogue River spring Chinook	October 19, 2017	NMFS 2017o
	Rogue River summer steelhead		
	Rogue/Applegate River winter steelhead		
	Indian Creek STEP fall Chinook		
	Elk River fall Chinook		
	Chetco River fall Chinook		
	Chetco River winter steelhead		
	Coquille River winter steelhead		

Biological Opinion	**Programs Authorized in Opinion**	**Signature Date**	**Citation**
	Coquille River fall Chinook		
	Coos River fall Chinook		
	Coos River winter steelhead		
	Tenmile Lakes winter steelhead		
	Tenmile Lakes rainbow trout		
	North Umpqua River spring Chinook		
	North Umpqua River summer steelhead		
	Calapooya Creek fall Chinook		
	Lower Umpqua River fall Chinook		
	Umpqua River coho		
	South Umpqua River winter steelhead		
	Munsel Creek coho (STEP)		
	Siuslaw River winter steelhead		
	Alsea Hatchery/Lakes rainbow trout		
	Alsea River winter steelhead		
	Yaquina Bay fall Chinook		
	Siletz River winter steelhead		
	Siletz River summer steelhead		
	Salmon River fall Chinook		
	Nestucca River summer Steelhead		
	Nestucca River spring Chinook		
	Little Nestucca River spring Chinook		
	Nestucca River STEP fall Chinook		

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
	Nestucca River winter steelhead Wilson River winter steelhead Trask River coho Trask River fall Chinook Trask River spring Chinook Wilson River winter steelhead Trask River Spring Chinook (Whiskey Creek STEP) North Fork Nehalem coho Nehalem River winter steelhead		
Rogue River Coho Hatchery Program	Rogue River coho	January 1999	NMFS 1999
Two Rowdy Creek Hatchery Programs	Rowdy Creek steelhead Rowdy Creek Chinook	June 11, 2019	NMFS 2019d
Two Trinity River Hatchery Programs	Trinity River steelhead Trinity River Chinook	August 20, 2018	NMFS 2018a
One Trinity River Hatchery Program	Trinity River coho salmon	June 11, 2020	NMFS 2020a
One Mad River Hatchery Program	Mad River steelhead	December 22, 2016	NMFS 2016j
One Russian River Hatchery Program	Russian River coho (captive brood)	September 14, 2020	NMFS 2020b
One Iron Gate Hatchery Program	Iron Gate coho	October 29, 2014	NMFS 2014e
Three Hatchery Programs at Coleman	Central Valley fall-run Chinook salmon	February 6, 2014	NMFS 2014f

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
National Fish Hatchery	Central Valley late-fall Chinook salmon		
	California Central Valley steelhead		
Two Hatchery Programs at Livingston Stone National Fish Hatchery	Sacramento River Winter Chinook (Integrated-Recovery Supplementation)	September 27, 2017	NMFS 2017p
	Sacramento River Winter Chinook (Captive Broodstock)		
One San Joaquin Hatchery Program	Central Valley spring-run Chinook	August 22, 2018	NMFS 2018b

[1] Proposed future program.

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5.2. Appendix B

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

1. UnMarked Nooksack/Samish Fall
2. Marked Nooksack/Samish Fall
3. UnMarked North Fork Nooksack Spring (Spr)
4. Marked North Fork Nooksack Spr
5. UnMarked South Fork Nooksack Spr
6. Marked South Fork Nooksack Spr
7. UnMarked Skagit Summer/Fall Fingerling (Fing)
8. Marked Skagit Summer/Fall Fing
9. UnMarked Skagit Summer/Fall Yearling (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 White River Spring Fing
28. Marked White River Spring Fing
29. UnMarked Hood Canal Fall Fing
30. Marked Hood Canal Fall Fing
31. UnMarked Juan de Fuca Tribes Fall
32. Marked Juan de Fuca Tribes Fall
33. UnMarked Columbia River Oregon Hatchery Tule
34. Marked Columbia River Oregon Hatchery Tule
35. UnMarked Columbia River Washington Hatchery Tule
36. Marked Columbia River Washington Hatchery Tule
37. UnMarked Lower Columbia River Wild
38. Marked Lower Columbia River Wild
39. UnMarked Columbia River Bonneville Pool Hatchery
40. Marked Columbia River Bonneville Pool Hatchery
41. UnMarked Columbia River Upriver Summer
42. Marked Columbia River Upriver Summer
43. UnMarked Columbia River Upriver Bright

44. Marked Columbia River Upriver Bright
45. UnMarked Cowlitz River Spring
46. Marked Cowlitz River Spring
47. UnMarked Willamette River Spring
48. Marked Willamette River Spring
49. UnMarked Snake River Fall
50. Marked Snake River Fall
51. UnMarked Oregon North Coast Fall
52. Marked Oregon North Coast Fall
53. UnMarked West Coast Vancouver Island Total Fall
54. Marked West Coast Vancouver Island Total Fall
55. UnMarked Fraser River Late
56. Marked Fraser River Late
57. UnMarked Fraser River Early
58. Marked Fraser River Early
59. UnMarked Lower Georgia Strait
60. Marked Lower Georgia Strait
61. UnMarked White River Spring Year
62. Marked White Spring Year
63. UnMarked Lower Columbia Naturals
64. Marked Lower Columbia Naturals
65. UnMarked Central Valley Fall
66. Marked Central Valley Fall
67. UnMarked WA North Coast Fall
68. Marked WA North Coast Fall
69. UnMarked Willapa Bay
70. Marked Willapa Bay
71. UnMarked Hoko River
72. Marked Hoko River
73. UnMarked Mid Oregon Coast Fall
74. Marked Mid Oregon Coast Fall