National Marine Fisheries Service Endangered Species Act (ESA)
Section 7(a)(2) Biological and Conference Opinion and
Magnuson-Stevens Act
Essential Fish Habitat (EFH) Consultation

Consultation on the implementation of Area 2A (U.S. West Coast)
Pacific halibut fisheries and catch sharing plan

NMFS Consultation Number: WCRO-2023-00394

Action Agency: National Marine Fisheries Service (NMFS)

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

Issued By:

Chris Yates
Assistant Regional Administrator

Date: June 23, 2023

Affected Species and Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely to Destroy or Adversely Modify Critical Habitat?
Puget Sound/Georgia Basin (PS/GB) bocaccio (*Sebastes paucispinis*)	Endangered	Yes	No	No	No
PS/GB yelloweye rockfish (*S. ruberrimus*)	Threatened	Yes	No	No	No
Southern green sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	No	No
Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*)[1]	Threatened	Yes	No	No	No

ESA-Listed Species	**Status**	**Is Action Likely to Adversely Affect Species?**	**Is Action Likely to Jeopardize the Species?**	**Is Action Likely to Adversely Affect Critical Habitat?**	**Is Action Likely to Destroy or Adversely Modify Critical Habitat?**
Lower Columbia River Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
Lower Columbia River coho salmon (*Oncorhynchus kisutch*)	Threatened	Yes	No	No	No
Snake River fall Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Sunflower sea star (*Pycnopodia helianthoides*)	Proposed Threatened	Yes	No	N/A	N/A
Southern Resident killer whales (*Orcinus orca*)	Endangered	No	No	No	No
Leatherback sea turtles (*Dermochelys coriacea*)	Endangered	No	No	No	No
Humpback whales (*Megaptera novaeangliae*) Central American	Endangered	No	No	N/A	N/A
Humpback whales (*Megaptera novaeangliae*) Mexico	Threatened	No	No	N/A	N/A
Blue whales (*Balaenoptera musculus*)	Endangered	No	No	N/A	N/A
Fin whales (*Balaenoptera physalus*)	Endangered	No	No	N/A	N/A
Guadalupe fur seals (*Arctocephalus townsendi*)	Threatened	No	No	N/A	N/A

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely to Destroy or Adversely Modify Critical Habitat?
North Pacific right whales (*Eubalaena japonica*)	Endangered	No	No	N/A	N/A
Sei whales (*Balaenoptera borealis*)	Endangered	No	No	N/A	N/A
Sperm whales (*Physeter macrocephalus*)	Endangered	No	No	N/A	N/A
Western North Pacific gray whales (*Eschrichtius robustus*)	Endangered	No	No	N/A	N/A
Green sea turtles (*Chelonia mydas)*	Endangered	No	No	N/A	N/A
Loggerhead sea turtles (*Caretta caretta)*	Threatened	No	No	N/A	N/A
Olive ridley sea turtles (*Lepidochelys olivacea*)	Endangered	No	No	N/A	N/A

[1] Other salmon and steelhead species potentially affected but not likely to be adversely affected are listed in Table 58.

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

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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 U.S.C. 1531 et seq.), as amended, and implementing regulations at 50 CFR part 402. The conference opinion concerning proposed listing of the sunflower sea star 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 if the proposed 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.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson–Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR part 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (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 2 weeks at the NOAA Institutional Repository: https://repository.library.noaa.gov. A complete record of this consultation is on file at the NMFS West Coast Region Lacey Field Office.

1.2. Consultation History

Previous biological opinions for the U.S. West Coast Pacific Halibut fisheries issued in 2014, 2017, and 2018 concluded that the fisheries and continuing implementation of the Catch Sharing Plan (CSP) was likely to adversely affect, but not likely to jeopardize, Puget Sound/Georgia basin bocaccio, yelloweye rockfish, southern green sturgeon, lower Columbia River Chinook salmon, and Puget Sound Chinook salmon (NMFS 2014, NMFS 2017a, and NMFS 2018a). Those opinions also determined that the halibut fisheries and continued implementation of the CSP was not likely to adversely modify the critical habitat of these species, or adversely affect other ESA-listed species or their critical habitats. The 2018 opinion expired on December 31, 2022.

This biological opinion is based on information provided by NMFS's West Coast Region (WCR) Sustainable Fisheries Division (SFD) to WCR Protected Resources Division (PRD) on March 20, 2023. Information was provided by the Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), California Department of Fish and Wildlife (CDFW), International Pacific Halibut Commission (IPHC), and Northwest Indian Fisheries Commission (NWIFC), or accessed from those agencies' websites, to inform this opinion. Information from these organizations was related to data collected by these organizations. NMFS deemed there was sufficient information to consult on the Proposed Action.

For a number of ESA-listed species affected by the Pacific Fishery Management Council (PFMC) and Puget Sound salmon fisheries, including salmon troll and salmon recreational fisheries, managed by NMFS we have completed long-term biological opinions or ESA 4(d) Rule evaluation and determination processes. Table 1 identifies those opinions and determinations still in effect that address impacts on salmonid species affected by the fisheries considered in this opinion. In each determination listed in Table 1, NMFS concluded that the proposed actions were not likely to jeopardize the continued existence of any of the listed species. NMFS also concluded that the actions were not likely to destroy or adversely modify designated critical habitat for any of the listed species. The determinations listed in Table 1 take into account the anticipated effects of the salmon fisheries each year through pre-season planning and modeling. Any impacts on the species listed in Table 1 from the proposed actions under consultation here were accounted for and within the scope of the associated determinations. Specifically, salmon and halibut may be retained on the same recreational fishing trips in areas and times when both salmon and halibut are open — ESA-listed salmon caught on those trips are considered part of the recreational salmon fishery, and have been evaluated in the salmon fishery biological opinions and are, therefore, not part of this proposed action. Additionally, the effects of the commercial salmon troll fishery, in which halibut may also be caught, are evaluated in those salmon fishery biological opinions and are not further considered here. Effects of these fisheries on those species are not analyzed in this opinion.

Table 1. Biological opinions on the effects of Ocean and Puget Sound salmon fisheries on ESA-listed species.

Date (Decision type)	Citation	Species Considered
Salmonid Species		
March 8, 1996 (BO)	(NMFS 1996a)	Snake River Spring/summer Chinook Salmon Snake River Fall-run Chinook Salmon Snake River Sockeye Salmon
April 28, 1999 (BO)	(NMFS 1999)	Central California Coast Coho Salmon Oregon Coast Coho Salmon Southern Oregon/Northern California Coast Coho Salmon
April 28, 2000 (BO)	(NMFS 2000)	Central Valley Spring-run Chinook Salmon California Coastal Chinook Salmon
April 30, 2001 (BO)	(NMFS 2001a)	Upper Willamette River Chinook Salmon Columbia River Chum Salmon Ozette Lake Sockeye Salmon Upper Columbia River Spring-run Chinook Salmon 10 DPSs of Steelhead

Date (Decision type)	Citation	Species Considered
September 14, 2001 (BO, 4(d) Limit)	(NMFS 2001c)	Hood Canal Summer-run Chum Salmon
April 26, 2012 (BO)	(NMFS 2012a)	Lower Columbia River Chinook Salmon
April 9, 2015 (BO)	(NMFS 2015a)	Lower Columbia River Coho Salmon
March 30, 2018 (BO)	(NMFS 2018b)	Sacramento River Winter-run Chinook Salmon
April 28, 2022 (BO)	(NMFS 2022b)	Southern Oregon/Northern California Coast Coho Salmon
May 13, 2022 (BO)	(NMFS 2022c)	Puget Sound Chinook Salmon and Puget Sound Steelhead
February 28, 2023 (BO)	(NMFS 2023a)	California Coastal Chinook Salmon
May 15, 2023 (BO)	(NMFS 2023b)	Puget Sound Chinook Salmon and Puget Sound Steelhead, Southern Resident DPS Killer Whale, Mexican DPS Humpback Whale, Puget Sound/Georgia Basin DPS of Canary Rockfish, Yelloweye Rockfish, and Bocaccio
Non-Salmonid Species		
April 30, 2007 (BO)	(NMFS 2007)	Southern DPS Green Sturgeon
April 30, 2010 (BO)	(NMFS 2010a)	Puget Sound/Georgia Basin DPS of Canary Rockfish, Yelloweye Rockfish, and Bocaccio
April 30, 2010 (BO)	(NMFS 2010a)	Southern DPS Eulachon
April 21, 2021 (BO)	(NMFS 2021a)	Southern Resident DPS Killer Whale

In 2019, a series of regulations were passed that affected the way in which ESA consultations were conducted by modifying several definitions and administrative processes. On July 5, 2022, the U.S. District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 CFR part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019), without making a finding on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5 order. On November 14, 2022, the Northern District of California issued an order granting the government's request for voluntary remand without vacating the 2019 regulations. The District Court issued a slightly amended order two days later on November 16, 2022. As a result, the 2019 regulations remain in effect, and we are applying the 2019 regulations here. For purposes of this consultation and in an abundance of caution, we also considered whether the substantive analysis and conclusions articulated in this biological opinion and incidental take statement would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

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 (see 50 CFR 402.02). Under the MSA, "Federal action" means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by a Federal agency (see 50 CFR 600.910).

The proposed action is the ongoing management of the Pacific halibut (*Hippoglossus stenolepis*) (halibut) fishery off the United States (U.S.) West Coast (Washington, Oregon, and California). This includes recreational fisheries, the non-tribal commercial fisheries, both directed and incidental, tribal fisheries, and ongoing annual surveys conducted by the IPHC. The proposed action does not include halibut caught incidentally in the commercial salmon troll or commercial sablefish fishery and does not include salmon caught while recreationally fishing in times and areas where salmon seasons are open, as the effects of those actions have been evaluated in other biological opinions.

1.3.1. Overview of the Halibut Fishery, Regulations, and Catch Sharing Plan Annual Implementation

Fishing for Pacific halibut in United States and Canadian waters (Convention waters) is governed by the Convention between Canada and the United States for the Preservation of the Halibut Fishery of the North Pacific Ocean and Bering Sea (Halibut Convention), signed at Ottawa, Ontario, on March 2, 1953, as amended by a Protocol Amending the Convention, signed at Washington, DC, on March 29, 1979. Under the Halibut Convention, the IPHC issues regulations governing Pacific halibut fisheries. The IPHC has divided the Convention waters into regulatory areas. Area 2A encompasses all waters off the states of Washington, Oregon, and California (Figure 1). The IPHC sets annual mortality limits for catch of halibut in all regulatory areas; these limits are represented as the total constant exploitation yield (TCEY) and fishery constant exploitation yield (FCEY). The TCEY is the mortality of all halibut greater than 26 inches from directed and non-directed fisheries. An FCEY, equal to the TCEY, minus projected discards and bycatch, is set for each IPHC area. Consistent with the Halibut Convention, each country can establish additional regulations so long as those regulations are more restrictive than those issued by the IPHC. The IPHC annually sets the mortality limits for halibut fisheries in Area 2A.

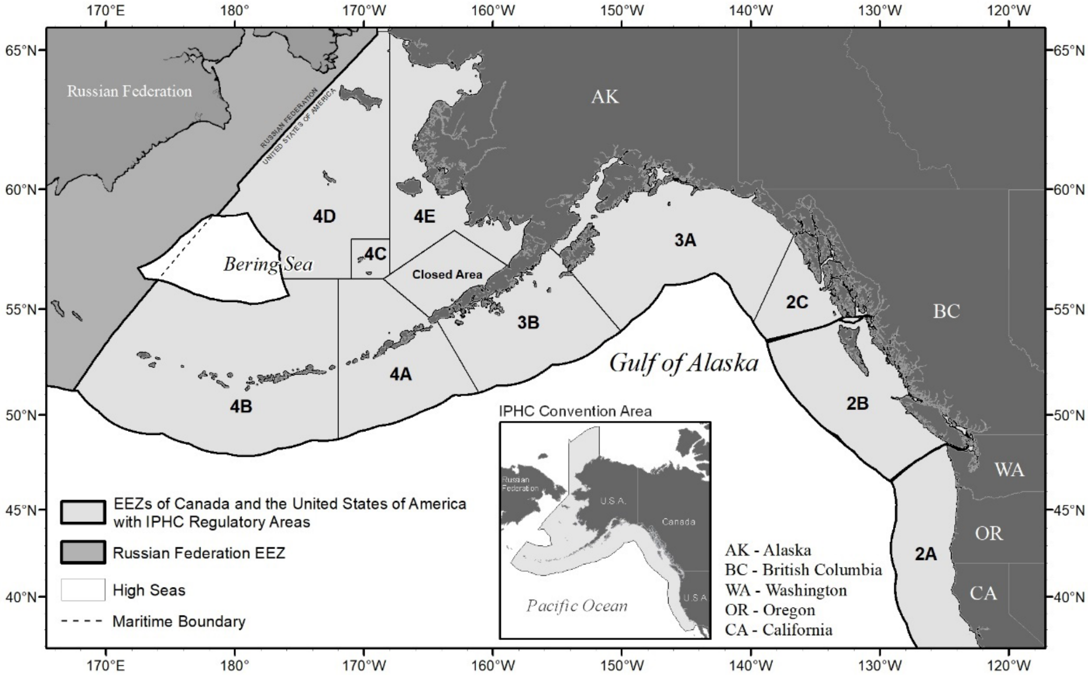

Figure 1. International Pacific Halibut Commission (IPHC) regulatory areas (IPHC 2022a)

Consistent with the Halibut Convention, the U.S. adopts domestic regulations to manage the portions of the halibut fishery in U.S. waters. The Northern Pacific Halibut Act of 1982 (Halibut Act) at 16 U.S.C. § 773c provides that the Secretary of Commerce (Secretary) has general responsibility to carry out the Halibut Convention between the U.S. and Canada, and the Secretary adopts regulations necessary to carry out the purposes and objectives of the Convention and the Halibut Act.

In Area 2A, the NMFS West Coast Region is responsible for management of halibut fisheries, with close coordination with PFMC and the Washington, Oregon, and California state agencies (WDFW, ODFW, and CDFW). Section 773c(c) of the Halibut Act authorizes the regional fishery management council having authority for the geographic area concerned to develop regulations governing the Pacific halibut catch in U.S. Convention waters that are in addition to, but not in conflict with, regulations of the IPHC for Area 2A. The Council has exercised its authority by developing the CSP (PFMC 2022b), which recommends a management framework, including dividing Area 2A into sectors for purposes of management, and outlines allocations for the Area 2A halibut tribal, non-tribal directed and incidental commercial fisheries, and recreational fisheries. The IPHC adopts allocations for Area 2A consistent with the framework in the CSP. NMFS publishes an annual rule to implement IPHC regulations for all IPHC regulatory areas in the United States, which includes catch allocations for the various sectors and subareas within Area 2A. NMFS publishes separate rules implementing annual management measures for Area 2A.

Prior to the 2023 season, NMFS implemented annual management measures for Area 2A recreational fisheries and incidental-commercial fisheries only. The IPHC issued annual management measures for the non-tribal directed commercial fishery. Effective January 4, 2023, NMFS published a final rule that transitioned some management activities in the Area 2A directed commercial fishery from the IPHC to NMFS (87 FR 74322; December 5, 2022). Specifically, these management activities include creating a permitting system for commercial and recreational charter fisheries and establishing a regulatory framework for the directed commercial fishery.

1.3.2. Halibut Fishery Sectors, Seasonality, and Geographic Extent

Halibut is harvested coastwide in Convention waters (which include both state and federal waters) from Washington to California. Various closed areas are used in the recreational and non-tribal commercial fisheries to protect overfished species, such as yelloweye rockfish. Because groundfish species are the primary bycatch in the halibut fishery, most of the closed areas applied to the halibut fisheries are designed to minimize the catch of overfished groundfish species. Additionally, some nearshore areas are designated in the Washington, Oregon, and Columbia River subareas (see section 1.3.2.3 Recreational Fisheries), with separate open days and subarea allocations, restricting fishing to those areas.

The halibut fisheries in Area 2A are allocated a small percentage, generally less than 2%, of the annual coastwide TCEY set by the IPHC. Under the CSP allocation framework, the Washington tribal allocation is 35% of the Area 2A FCEY. The allocation to non-tribal fisheries is divided into four shares: a commercial fishery (30.7%), and recreational fisheries in Washington (35.6%), Oregon (29.7%), and California (4.0%) (Figure 2). The CSP further subdivides the recreational fisheries into geographic areas (subareas), each with separate allocations and seasons (PFMC 2022b).

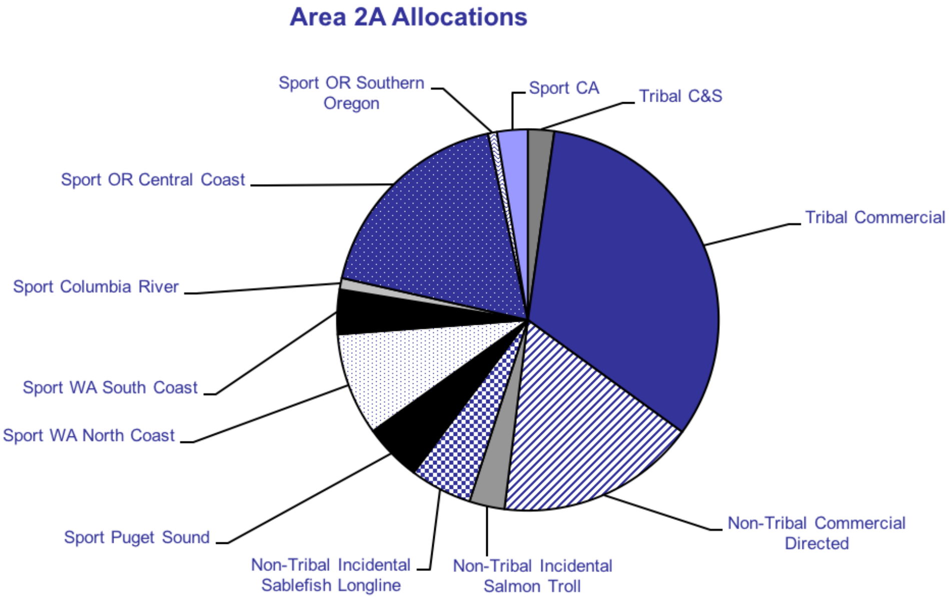

Figure 2. Area 2A (U.S. West Coast) halibut fishery sector allocations.

1.3.2.1. Tribal Fisheries

Thirteen western Washington tribes possess and exercise treaty fishing rights to halibut (Table 2). Tribal allocations have been included in the CSP since 1995. Tribal fishing occurs off the coast of Washington and in inland marine waters. Each tribe has Usual and Accustomed (U&A) areas designated in federal regulations at 50 C.F.R. § 300.64. Table 2 lists the areas fished by each tribe. The area numbers listed in Table 2 correspond to the areas, as applicable, defined by the WDFW and shown in Figure 3.

The tribal allocation in the CSP is currently 35% of the overall Area 2A FCEY. The overall tribal allocation is divided into a tribal commercial component, typically occurring between March and June, and the year-round ceremonial and subsistence (C&S) component. Halibut caught by the C&S component is not sold. The tribes manage their allocation jointly based on a management plan, and each tribe manages its fisheries through its own regulations and in compliance with any applicable court orders or court-approved agreements.

Table 2. Commercial and C&S halibut areas fished by each tribe as designated by federal regulations at 50 C.F.R. § 300.64. Area numbers correspond to those shown in Figure 3.

Treaty Tribe	**Areas Fished**
Hoh	From the line running west from the mouth of the Quillayute River (47°154'18" N. lat.) south to the line running west from the mouth of the Quinault River (47°121'00" N. lat.)
Jamestown S'Klallam	Areas 20B, 22A, 23A, 23B, 23C, 23D, 25A, 25B, 25C, 25D, 25E, 27A, 27B, and 29
Lower Elwha S'Klallam	Areas 20B, 22A, 23A, 23B, 23C, 23D, 25A, 25B, 25C, 25D, 25E, 27A, 27B, and 29
Lummi	Inland marine waters from the Canadian border south to the environs of Seattle, including areas 20A, 20B, 21A, 21B, 22A, 22B, and 23B; 23A north of the line from Trial Island off Victoria to the flashing horn buoy between Dungeness Spit and Hein Bank; area 25A north of the line from the previous point to Point Wilson; and all of area 25B and 26A.
Makah	North of Norwegian Memorial (48°02'15" N. lat.), east of 125°44" W. long. and west of Tongue Point (123°42'30" W. long.)
Nooksack	Areas 20A, 20B, 21A, 21B, 22A, and 22B
Port Gamble S'Klallam	Areas 20B, 22A, 23A, 23B, 23C, 23D, 25A, 25B, 25C, 25D, 25E, 27A, 27B, and 29
Quileute	Sand Point (48°07'36" N. lat.) to Queets River (47°31'42" N. lat.)
Quinault	Pacific Ocean between Point Chehalis (46°53'18" N. lat.) and Destruction Island (47°40'06" N. lat.)
Skokomish	Marine areas 27C, 27B, 27A, and 25C (south of the line from Olele Point to Foulweather Bluff excluding Port Gamble Bay).
Suquamish	Areas 20A, 20B, 21A, 21B, 22A, 22B, 23A, 23B, 24B, 24D, 25A, 25B, and 26A
Swinomish	Areas 20A, 20B, 21A, 21B, 22A, 22B, 23A, 23B, 24A, 24C, 24D, 25A, 25B, and 26A
Tulalip	Areas 20A; 20B; 21A (west of a line from Vendovi Island to the northernmost tip of Guemes Island, along the eastern shore of Guemes Island to Clark Point to March Point); 23A (northeast of a line from Trial Island light to Protection Island); 23B; 24B; 24C (south of a line extended due west of Camano City to Whidbey Island); 24D; 25A (north and east of a line from Trial Island light to Protection Island to McCurdy Point); and 25B (Point Monroe and excluding that portion of area 26B east of a line from Meadow Point to West Point to Alki Point).

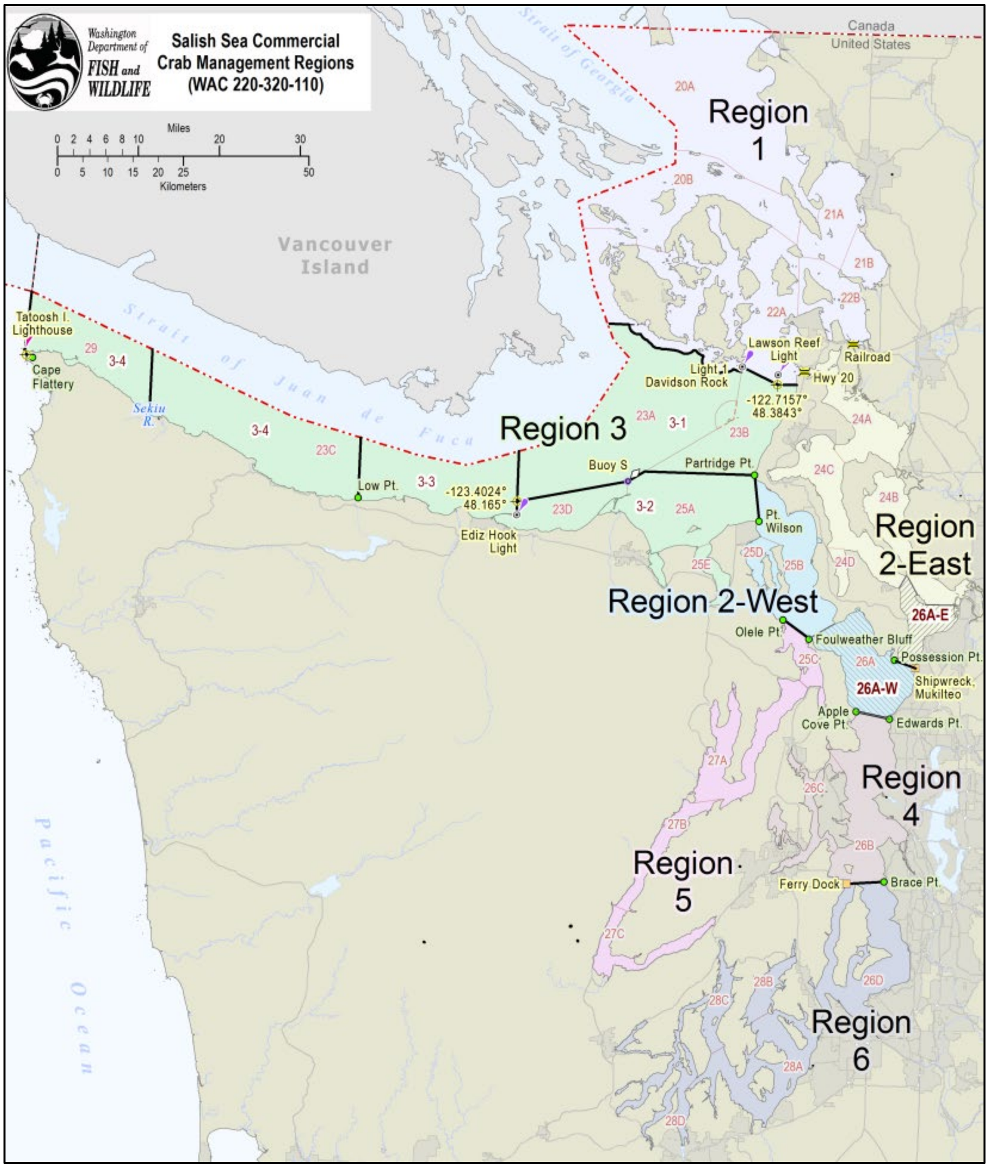

Figure 3. Map of WDFW Marine Fish-Shellfish Management and Catch Reporting Areas of Washington inland marine waters, provided here to reference non-coastal halibut usual and accustomed fishing areas listed in Table 2.

The C&S allocation is based on the previous year's catch estimate, and the commercial allocation is the tribal allocation minus C&S. Management of the tribal commercial fishery is divided into three fishery components: unrestricted, restricted, and late season (mop up). Allocations between the restricted and unrestricted fishery are developed by the tribes and are not included in the CSP. These allocations are not further subdivided by individual tribe; rather, all the tribes participating in each commercial fishery manage collectively. The tribal halibut fishery harvest, opening dates and duration, and landing limits for the four components, are shown in Table 3.

Table 3. Tribal fishery year, type of fishery, dates and number of hours/days, limits, and harvest, 2018–2022 (J. Petersen, NWIFC, personal communication, December 7, 2022).

Year	Fishery	Fishery dates, hours, and limits	Harvest (pounds)
2018	Unrestricted	Mar 24 – Apr 28 (36 hr)	154,400
	Restricted	Mar 24 – Apr 28 (37 hr, 500 lb/vessel/day)	38,039
	Late season	May 4 – May 23 (30 hr, no limits)	215,699
	C&S	Jan 1 – Dec 31 (365 d)	28,000
2019	Unrestricted	Mar 15 – May 15 (55 hr)	375,822
	Restricted	Mar 15 – May 15 (84 hr, 500 lb/vessel/day)	49,586
		May 20 – Jun 15 (72 hr, 500 lb/vessel/day)	67,430
	Late season	Jun 11 – Jul 24 (327 lb/tribe)	2,053
	C&S	Jan 1 – Dec 31 (365 d)	32,200
2020	Unrestricted	Mar 14 – Sept 30 (55 hr)	277,421
		Mar 14 – Sept 30 (36 hr/tribe)	84,449
	Restricted	Mar 14 – Sept 30 (222 hr)	94,400
	Late season	Oct 5 – Nov 15 (800 lb/vessel/day)	32,645
	C&S	Jan 1 – Dec 31 (365 d)	39,726
2021	Unrestricted	Mar 6 – May 16 (55 hr)	246,180
	Restricted	Mar 6 – May 16 (102 hr)	67,127
	Late season	May 16 – Jun 20 (24 hr, 800 lb/vessel/day)	180,832
	C&S	Jan 1 – Dec 31 (365 d)	32,200
2022	Unrestricted	Mar 6 – May 31 (55 hr)	308,881
	Restricted	Mar 6 – May 31 (122 hr)	121,145
	Late season*	Jun 3 – Sep 30 (48 hr, 2,200 lb/vessel/period; or 72 hr, 1,500 lb/vessel/period)	68,109
	C&S**	NA	NA

* Preliminary as of Dec 7, 2022

** Open until Dec 31; catch estimates available Jan 2022

Tribes both in Puget Sound and on the Washington coast participate in the tribal commercial fishery. From 2018 to 2022, harvest from Puget Sound tribes has accounted for an average of 16% of the overall tribal commercial harvests (Table 4).

Table 4. Tribal commercial fishery number of vessels, landings, and harvest divided into Puget Sound and Coastal Tribes (J. Petersen, NWIFC, personal communication, December 7, 2022).

	Puget Sound Tribes*			Coastal Tribes		
Year	**Vessels**	**Landings**	**Harvest (pounds)**	**Vessels**	**Landings**	**Harvest (pounds)**
2018	176	278	136,080	65	138	339,764
2019	171	313	68,375	59	229	426,516
2020	170	51	19,614	66	332	469,301
2021	170	159	40,032	64	208	454,107
2022	170	292	82,597	65	273	415,538

*Some Puget Sound tribes fish both inside Puget Sound and in the Strait of Juan de Fuca.

1.3.2.2. Non-tribal Commercial Fisheries

The non-tribal commercial fisheries are divided into three sectors: the directed fishery (south of Point Chehalis), incidental catch in the sablefish fishery (north of Point Chehalis), and incidental catch in the salmon troll fishery. Under the CSP allocation framework, the non-tribal commercial fishery is currently allocated 30.7% of the non-tribal Area 2A allocation, with the directed fishery sector receiving 85% and the incidental troll sector receiving 15%. Under the CSP allocation framework, the incidental sablefish sector is allocated a portion of the Washington recreational sector allocation. The effects of incidental catch of halibut in the salmon troll and incidental catch of halibut in the sablefish fishery on ESA-listed species were evaluated in consultations evaluating the salmon and groundfish fisheries so are considered part of the baseline and not part of this action.

The non-tribal directed commercial fishery is a derby-style fishery, currently open for 58 hours approximately every other week until the allocation is taken or projected to be exceeded. This fishery typically takes place in the summer months and has historically had two to five open fishing periods per season. Harvest per opening in 2018 through 2022 ranged from 31,121 pounds to 120,392 pounds, with 33 to 88 vessels participating during each fishing period (Table 5).

Table 5. Non-tribal directed commercial fishery season openings, number of hours, harvest, and vessels by year, 2018–2022 (IPHC 2022b and IPHC unpublished commercial opening landings summaries, July 21, 2022 and August 3, 2022).

Year	Fishery dates and hours	Harvest (pounds)	Vessels
2018	Jun 27 (10 hr)	83,359	45
	Jul 11 (10 hr)	66,844	33
	Jul 25 (10 hr)	51,480	48
2019	Jun 26 (10 hr)	120,392	88
	Jul 10 (10 hr)	84,717	70
	Jul 24 (10 hr)	57,993	59

Year	Fishery dates and hours	Harvest (pounds)	Vessels
2020	Jun 22–24 (58 hr)	47,488	60
	Jul 6–8 (58 hr)	65,078	60
	Jul 20–22 (58 hr)	57,462	42
	Aug 3–5 (58 hr)	54,930	44
	Aug 17–19 (58 hr)	31,121	40
2021	Jun 22–24 (58 hr)	91,579	77
	Jul 6–8 (58 hr)	83,117	57
	Jul 20–22 (58 hr)	61,133	42
2022*	Jun 28–30 (58 hr)	75,944	NA
	Jul 12–14 (58 hr)	67,548	NA
	Jul 26–28 (58 hr)	61,125	NA

*Preliminary.

This fishery requires a permit to participate, but there is no limit to the number of participants. Most of the landings in the directed commercial fishery occur off Oregon, followed by Washington, and a small amount is landed in the directed commercial fishery occurring off California. The directed commercial fishery is managed through a series of fishing periods based on the directed commercial fishery allocation and fishing period limits, which is the maximum amount of halibut that may be retained and landed by a vessel during one fishing period. Fishing period limits are based on vessel class size and the number of permits issued to ensure the directed commercial fishery allocation is not exceeded.

Since 2003, non-tribal commercial vessels operating in the directed fishery have been required to fish offshore of a mandatory, depth-based closed area known as the Rockfish Conservation Area (RCA) (50 C.F.R 300.63(f)). Most directed halibut fishing occurs seaward of the RCA in waters up to 150 fathoms in depth.

1.3.2.3. Recreational Fisheries

The halibut recreational fisheries include individual anglers and charter boats. Recreational halibut fisheries occur off Washington, Oregon, and California, with catches generally occurring from northern California to Washington. The framework for days open for the various recreational sectors and subareas is included in the CSP, and NMFS annually implements management measures consistent with that framework. Fisheries remain open until the projected allocation for the sector or subarea is taken, the closure date described in the annual management measures has elapsed, or the overall season dates set by the IPHC have passed. Subarea allocations are based on angler participation in each region, and although recreational subarea allocations may be adjusted, this has not occurred since 2015. Effort values, such as angler-days, are not presented here. Pre- and post-COVID fishing practices have changed, resulting in effort values that are not comparable between seasons, and because sampling is inconsistent late in the season and not comparable to early season effort values this information is not the best available. Although effort values are not used in this biological opinion, the number of fishing days and daily harvests are included to show fishery trends.

Washington

Under the allocation framework in the CSP, recreational fisheries in Washington coastal and inland marine waters have an allocation of 35.6% of the non-tribal FCEY and effort occurs in four subareas: Puget Sound subarea, North Coast subarea, South Coast subarea, and Columbia River subarea (which occurs in both Washington and Oregon waters). The boundaries of these subareas correspond to WDFW marine catch areas (MCAs) (Figure 4) as described below. The allocation for the incidental catch in the sablefish fishery allocation is subtracted from the Washington recreational allocation; this portion of the halibut fishery is not consulted on here as it is included in the biological opinions for the groundfish fisheries.

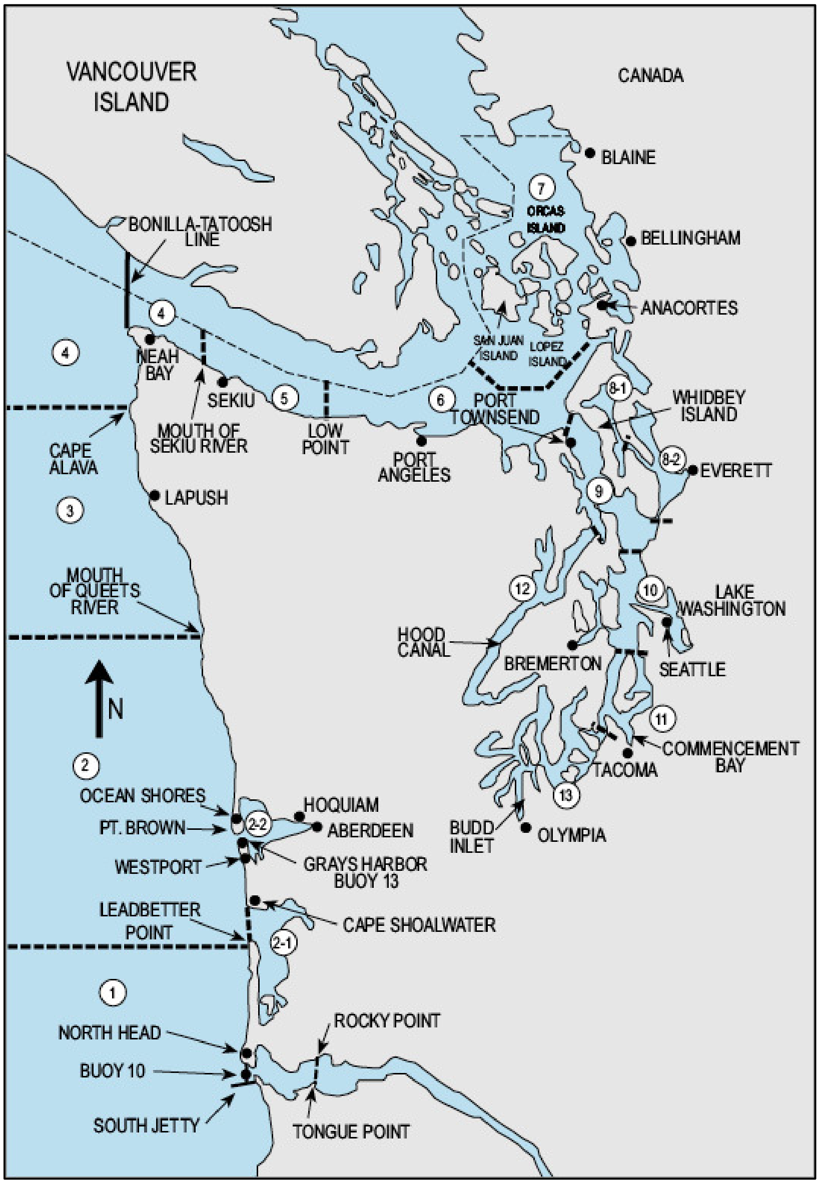

Figure 4. Recreational fisheries marine catch areas off Washington, shown here to reference the subareas described below (WDFW 2023).

Puget Sound Subarea

Under the allocation framework in the CSP, the Puget Sound subarea is allocated 23.5% of the first 130,845 pounds of the recreational fishery allocation for waters off Washington, and an additional 32% of the next 130,845–224,110 pounds. The subarea consists of all waters east of the Sekiu River mouth (MCAs 5–13; Figure 4), including most of the Strait of Juan De Fuca, the San Juan Islands area, the southern Strait of Georgia to the Canadian border, Admiralty Inlet, Hood Canal, the Whidbey Island subbasin, and Puget Sound. Harvest is not expected to occur in MCAs 11–13, and most of the Puget Sound subarea recreational catch of halibut is taken in the Strait of Juan de Fuca. From 2018 to 2022, the fishery was open between 10 and 87 days (Table 6).

Table 6. Puget Sound subarea open dates, days open, and harvest, 2018–2022 (NMFS 2018d, NMFS 2020a, NMFS 2021b, NMFS 2022a, and PFMC 2022a).

Year	Dates open	Number of days open	Harvest (pounds)
2018	May 11, 13, 25, 27, Jun 7, 9, 16, 21, 23, 30	10	42,093
2019	May 2, 4, 9, 11, 18, 24, 26, 30, Jun 1, 6, 8, 13, 15, 20, 22, 27–29	18	38,703
2020	May 20–31 alternating days, Jun 1–30 alternating days, Aug 6–8, 13–15, 20–22, 27–29, Sept 3–5, 10–12, 17–19, 24–26, 27–29	48	59,002
2021	Apr 22–24, Apr 29–May 1, 6–8, 13–15, 20–22, 28–30, Jun 3–5, 10–12, 17–19, 24–26, Aug 19–21, 26–28, Sept 2–4, 9–11, 16–18, 23–24	48	54,955
2022	Eastern Strait of Juan de Fuca and Puget Sound: Apr 7–9, 14–16, 21–23, 28–30, May 5–7, 12–14, 19–21, 27–29, June 2–4, 9–11, 16–18, 23–25, 30, Aug 11–Sept 30.	87	58,721
	Western Strait of Juan de Fuca*: May 5, 7, 12, 14, 19, 21, 27–29, Jun 2–4, 9–11, 16–18, 23–25, 30, Aug 11–Sept 30.	72	

* Applies only to MCA 5.

North Coast Subarea

Under the allocation framework in the CSP, the North Coast subarea is allocated 62.2% of the first 130,845 pounds of the WA recreational fishery allocation, and an additional 32% of the next 130,845–224,110 pounds. The subarea is the area west of the Sekiu River mouth and north of the Queets River (MCAs 3 and 4). From 2018 to 2022, the fishery was open between 10 and 62 days (Table 7).

Table 7. Washington North Coast open dates, days open, and harvest 2018–2022 (NMFS 2018d, NMFS 2020a, NMFS 2021b, NMFS 2022a, and PFMC 2022a).

Year	Dates open	Number of days open	Harvest (pounds)
2018	May 11, 13, 25, 27, Jun 7, 9, 16, 21, 23, 30	10	110,929
2019	May 2, 4, 9, 11, 18, 24, 26, Jun 6, 8, 15, 20, 22, 27–29	15	141,607
2020	Aug 6–8, 13–15, 20–22, 27–29, Sept 3–5, 10–12, 17–19, 24–26, 27–29	27	59,993
2021	May 6, 8, 13, 15, 20, 22, 28, 30, Jun 3, 5, 10, 12, 17, 19, 24, 26, Aug 19–21, 26–28, Sept 2–4, 9–11, 16–18, 23–24	34	84,759
2022	May 5, 7, 12, 14, 19, 21, 27, 29, Jun 2, 4, 9–11, 16–18, 23–25, Jun 27–Jul 3, Aug 11–15, 18–22, 25–29, Sept 1–5, 8–12, 15–19, 22–26, 29–30	62	95,448

South Coast Subarea

Under the allocation framework in the CSP, the South Coast subarea is allocated 12.3% of the first 130,845 pounds of the WA recreational fishery allocation, and an additional 32% of the next 130,845–224,110 pounds. The subarea lies to the south of Queets River and north of Leadbetter Point, WA (MCA 2; Figure 4). The south coast subarea allocation is initially allocated to the primary all-depth fishery, and a nearshore fishery opens if sufficient quota remains after the all-depth fishery closes. If allocation remains in the South Coast subarea, the nearshore fishery opens the Saturday after the closure of the all-depth fishery and typically runs seven days per week until the subarea allocation is reached. From 2018 to 2022, the fishery was open between 5 and 19 days (Table 8).

Table 8. Washington South Coast open dates, days open, and harvest, 2018–2022 (NMFS 2018d, NMFS 2020a, NMFS 2021b, NMFS 2022a, and PFMC 2022a).

Year		Dates open	Number of days open	Harvest (pounds)
2018	All-depth	May 11, 13, 25, 27, Jun 21	5	54,149
	Nearshore	Jun 2–6	5	614
2019	All-depth	May 2, 5, 9, 12, 24, Jun 6, 20, 28, 29	9	74,801
2020	All-depth	Aug 6, 13, 16, 20, 23, 27, 30, Sept 3, 4, 6, 10, 11, 13, 17, 20, 24, 27–29	19	54,550
2021	All-depth	May 6, 9, 13, 16, 20, 23, 27, Jun 17, 20, 24, Aug 27, Sept 24	12	90,626
2022	All-depth	May 5, 8, 12, 15, 19, 22, 26, Jun 16, 19, 23, 26, 28, 30, Aug 19, 25, 28, Sept 3, 4, 23	19	71,203

Columbia River Subarea

Under the allocation framework in the CSP, the Columbia River subarea is shared with Oregon and includes waters from Leadbetter Point south to the Oregon border (MCA 1), then continues southward to Cape Falcon (Figure 4). The allocation for the subarea is derived from both the Washington and Oregon recreational allocations. The subarea is allocated two percent of the first 130,845 pounds of the Washington recreational fishery allocation and 2.3% of the Oregon recreational allocation. A nearshore fishery is allocated 500 pounds to accommodate incidental halibut retention during bottomfish fishing when the all-depth halibut fishery is closed. From 2018 to 2022, the fishery was open between 6 and 24 days (Table 9).

Table 9. Columbia River all-depth open dates, days open, and harvest, 2018–2022 (NMFS 2018d, NMFS 2020a, NMFS 2021b, NMFS 2022a, and PFMC 2022a).

Year	Dates open	Number of days open	Harvest (pounds)
2018	May 3, 4, 6, 10, 11, Jun 21	6	15,661
2019	May 2, 5, 9, 12, 24, 26, Jun 20, 28	8	17,039
2020	Aug 6, 13, 16, 20, 23, 27, 30, Sept 3, 4, 6, 10, 11, 13, 17, 20, 24, 27, 28, 29	17	5,617
2021	May 6, 9, 13, 16, 20, 23, 27, Jun 3, 6, 10, 13, 17, 20, 24, Aug 27, Sept 24	16	21,477
2022	May 5, 8, 12, 15, 19, 22, 26, Jun 2, 5, 9, 12, 13, 16, 19, 20, 23, 26, 30, Aug 19, 25, 28, Sept 3, 4, 23	24	20,211

Oregon

Recreational fishing for halibut off of Oregon is divided among three subareas for management and catch allocation purposes: Columbia River subarea (described above, which is shared with Washington); Central Coast subarea; and the Southern Oregon subarea. Boundaries for subareas are described in the sections below and shown in Figure 5. Subarea allocations likely to go unharvested may be transferred to other subareas. The most popular fishing areas are located in the Central Coast subarea.

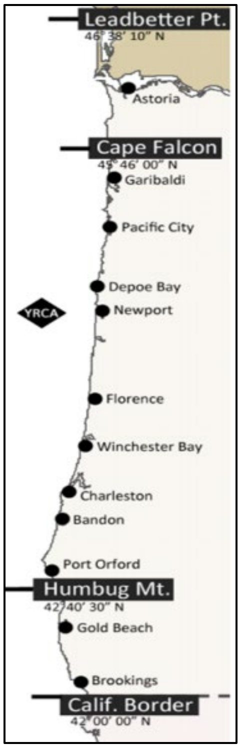

Figure 5. Map of Oregon Coast subarea and coordinates for subarea definitions.

Central Coast Subarea

Under the allocation framework in the CSP, the Central Coast subarea, which includes waters from Cape Falcon to Humbug Mountain, receives 93.79% of the Oregon halibut recreational fishery allocation. The subarea is divided into three components: spring, summer, and nearshore. The spring season opens in mid-May and closes when the allocation is attained, or transitions into the summer season, which opens in early August. The nearshore season opens May 1. Both the summer and nearshore seasons remain open until October 31 or until the allocation is caught. From 2018 through 2022, the all-depth components of the fishery combined were open from 24 to 143 days (Table 10).

Table 10. Oregon Central Coast open dates, days open, and harvest by month, 2018–2022 (NMFS 2018d, NMFS 2020a, NMFS 2021b, NMFS 2022a, and PFMC 2022a, and L. Mattes, ODFW, personal communication, November 22, 2022).

Year	Season	Dates open	Number of days open	Harvest (pounds)
2018	Spring all-depth	May 10–12, 24–26, Jun 7–9, 21–23, Jul 5–7	18	127,774
	Summer all-depth	Aug 3–4, 17–18, 31–Sept 1	6	51,186
	Nearshore	Jun 1–Oct 31	153	25,087
2019	Spring all-depth	May 9–11, 16–18, 23–25, 30–Jun 1, 6–8, 20–22, Jul 4–6, 18–20	24	89,062

Year	Season	Dates open	Number of days open	Harvest (pounds)
	Summer all-depth	Aug 2–3, 9–10, 16–17, 23–24, 30–31, Sept 6–8, 13–15, 20–22, 27–29, Oct 4–6, 11–13, 18–20, 25–27	26	50,742
	Nearshore	Jun 1–Oct 31	153	14,806
2020	Spring all-depth	May 21–23, 28–30, Jun 11–13, 18–20, Jul 9–11, 16–18, 23–25, 30–Aug 1	24	114,235
	Summer all-depth	Aug 6–8, 20–22, 27–29, Sept 3–5, 10–12, 17–19, 24–26, Oct 1–3, 8–10, 15–17, 22–24, 28–31	36	20,160
	Nearshore	May 1–Oct 31	184	23,493
2021	Spring all-depth	May 13–15, 20–22, Jun 3–5, 10–12, 17–19, Jul 1–3, 15–17, 29–31	24	69,795
	Summer all-depth	Aug 5–7, 12–14, 19–21, 26–28, Sept 2–4, 9–11, Sept 13–Oct 31	66	41,799
	Nearshore	May 1–Sept 13	136	10,982
2022	Spring all-depth	May 12–Jun 30, Jul 7–9, 14–16, 21–23, 29–30	73	123,359
	Summer all-depth	Aug 4–6, 11–13, 25–27, Sept 1–3, Sept 5–Oct 31	70	41,947*
	Nearshore	May 1–12, Jul 1–Sept 4	77	4,846

*Preliminary, unpublished data.

Southern Oregon Subarea

The Southern Oregon subarea boundaries are Humbug Mountain to the Oregon/California border. Under the allocation framework in the CSP, the Southern Oregon Subarea receives 3.91% of the Oregon halibut recreational fishery allocation. It is open seven days a week from May 1 through October 31 or until the subarea allocation is caught. The fishery did not close before October 31 during the 2018 through 2022 seasons (Table 11).

Table 11. Southern Oregon Subarea open dates, days open, and harvest by month, 2018–2022 (NMFS 2018d, NMFS 2020a, NMFS 2021b, NMFS 2022a, and PFMC 2022a).

Year	Dates open	Number of days open	Harvest (pounds)
2018	May 1–Oct 31	184	6,043
2019	May 1–Oct 31	184	3,972
2020	May 1–Oct 31	184	7,380
2021	May 1–Oct 31	184	5,699
2022	May 1–Oct 31	184	8,714*

*Preliminary, unpublished data.

California

Under the allocation framework in the CSP, the California subarea is defined as all waters off California and is allocated 4% of the Area 2A non-tribal allocation. The recreational fishery for Pacific halibut off California occurs off the north coast in ocean waters from Sonoma to Del Norte counties. Primary angling locations are off Eureka, Shelter Cove, Trinidad, and Crescent City (M. Parker, CDFW, personal communication, December 16, 2022). A negligible number of trips targeting halibut occur south of Point Arena (38° 57.5′ N. lat.). The fishery opens May 1, and remains open seven days a week until the allocation has been caught, or November 15, whichever is earlier. To provide a longer season, CDFW has occasionally recommended, and NMFS has implemented, periodic closures within the season. Season opening and closing dates from 2018 through 2022 are shown in Table 12.

Table 12. California open dates, days open, and harvest, 2018–2022 (NMFS 2018d, NMFS 2020a, NMFS 2021b, NMFS 2022a, and PFMC 2022a).

Year	Dates open	Number of days open	Harvest (pounds)
2018	May 1-Jun 15, Jul 1-15, Aug 1-15, Sept 1-21	97	31,156
2019	May 1-Oct 31	184	17,440
2020	May 1-Aug 11	103	64,107
2021	May 1-Jun 30, Sept 1-Nov 15	137	24,800
2022	May 1-Aug 7	99	39,967

1.3.3. Gear Fished in the Halibut Fishery

Commercial and recreational fishing for halibut in Area 2A is only permitted with hook-and-line gear, and spear for recreational fisheries only, as specified in IPHC regulations. Hook-and-line gear includes rod and reel (no more than two hooks), hand line, longline (setline), and troll. Gear restrictions are part of the IPHC regulations that NMFS publishes annually in the Federal Register.

1.3.3.1. Commercial Fishery

For directed commercial fishing, the typical gear configuration consists of a “skate,” which is made up of a mainline, gangions, and circle hooks (Figure 6). The gangions are approximately three to four feet long with a hook attached to the end. The typical gear is set up with an 1,800-foot skate with six lines per skate, tied together and set in strings of 4 to 12 skates each (IPHC 2014). Hooks are typically spaced 12 to 18 feet apart and baited with salmon, herring, octopus, or sometimes Pacific cod. The ends of each skate set are attached to surface lines with buoys and, typically, radar reflectors. Gear is left to soak for four to 48 hours, but the average soak for each skate is about 12 hours.

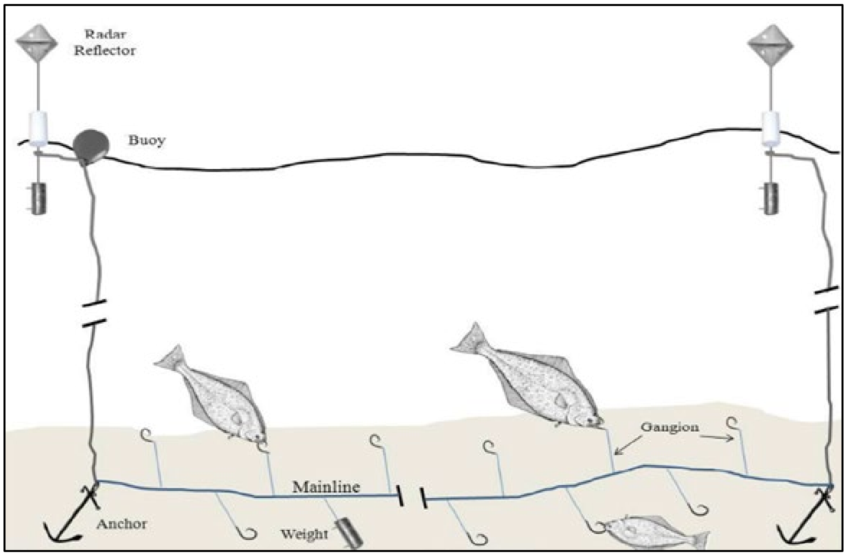

Figure 6. Gear schematic for longline (setline) halibut fisheries.

1.3.3.2. Tribal Fisheries

Gear used in the tribal fisheries include:

- Hook-and-line (rod and reel, no more than two hooks)
- Hand line (no more than two hooks)
- Longline (setline), snap gear only
- Bottom troll (no more than six lines)

Bait is typically the same as the non-tribal directed commercial fishery: salmon, herring, octopus, and sometimes Pacific cod.

1.3.3.3. Recreational Fisheries

Recreational gear in all of Area 2A is restricted to a single heavy line with no more than two hooks attached, or to spear fishing. Typically, 40- to 80-pound-test (18 to 36 kg) lines and circle or treble hooks are used, either 6/0 or 8/0. Anglers use large jigs, and bait may be artificial worms, herring, tuna bellies, octopus, squid, salmon bellies, or live sanddabs while targeting halibut (L. Wargo, WDFW, personal communication, December 19, 2022 and M. Parker, CDFW, personal communication, December 16, 2022). Barbless hooks must be used when fishing in the Puget Sound subarea, as a conservation measure to minimize incidental hooking mortality of salmon. Anglers may also use a gun or harpoon to assist in landing Pacific halibut taken with hook and line gear (M. Parker, CDFW, personal communication, December 16, 2022 and WDFW 2023). There are no depth restrictions for the recreational fishery, and gear is fished on or near the bottom.

Rockfish caught incidentally to the halibut fishery may suffer from barotrauma, and state regulations require or recommend the use of descending devices. The WDFW requires anglers to have a descending device rigged and ready for immediate use on board the fishing vessel during all recreational halibut fisheries.

1.3.4. IPHC Fishery Independent Setline Survey (FISS)

The IPHC conducts standardized assessment surveys to collect information on the halibut stock, such as growth, distribution, area-wide biomass, age composition, sexual maturity, and relative abundance of bycatch species. Another objective of the survey is to log marine mammal and seabird occurrence and interactions with fishing gear.

Each survey region consists of a regular distribution of stations on a 10×10 nautical-mile grid, where a single coordinate indicates the center of the set (IPHC 2021). The center of each station is within the survey depth range of 10 to 400 fathoms. The ends of some sets may extend shallower or deeper than the standard range to cover data gaps. The FISS surveyed waters in Puget Sound in 2011, 2014, 2017, and 2018, but is not scheduled to be surveyed in 2023 or 2024.

The IPHC survey collects extensive data on distribution of halibut and the occurrence of bycatch in Area 2A. This survey informs the IPHC's decision on the TCEY and provides data that the Council and NMFS may consider when managing the Area 2A fishery. NMFS, therefore, considers the survey to be an activity similar to and a component of the proposed action.

1.3.5. Fishery Data Collection Programs

Data collection programs are operated by the WDFW, ODFW, and CDFW for the recreational sectors through dockside sampling, creel surveys, and other means that vary by state. The non-tribal directed commercial fishery data comes from the West Coast Groundfish Observer Program (WCGOP) and state fish tickets. Tribal fishery data collection programs vary among tribes and catches are compiled by the NWIFC. Descriptions of these data collection programs are provided here to explain how data are obtained in the proposed action, but are not part of the proposed action in and of themselves, except for the IPHC FISS, which is part of the proposed action and consulted on in this biological opinion.

Vessels 26 feet or greater in overall length participating in commercial tribal and non-tribal fisheries are required by the IPHC to maintain logbooks. IPHC logbook data are submitted to IPHC and used in stock assessment; however, bycatch is not recorded in IPHC logbooks. Logbooks are required to include the following information:

- The name of the vessel and the state and/or tribal vessel number
- The date(s) upon which the fishing gear is set or retrieved
- The latitude and longitude coordinates, or a direction and distance from a point of land, for each set or day
- The number of skates deployed or retrieved, and number of skates lost
- The total weight or number of halibut retained for each set or day (IPHC logbooks do not require information on species other than halibut)

1.3.5.1. Non-tribal Directed Commercial Fishery

Catch of halibut in the directed fishery is monitored by the IPHC through state fish tickets and is reported to NMFS in-season. Beginning in the 2023 season, state fish ticket data will be reported directly to NMFS for catch accounting.

Observer data are available for the years 2018–2022, and include biological information such as length and viability for halibut, fishing effort, and bycatch information, as well as catch location.

The IPHC sends port samplers to various ports to collect logbook data and biological samples. In 2021, the IPHC stationed samplers in Newport and Charleston, OR, and Ilwaco and Bellingham, WA (IPHC 2022c) (see Figures 4 and 5). When boats offload in ports with samplers, the captains are interviewed, logbook data are collected, and halibut fork length measurements and otoliths are taken. The logbook and biological data are later used for stock assessment purposes.

1.3.5.2. Tribal Fisheries

Fishery regulations, catch monitoring, and enforcement are the responsibility of each individual tribe. Each tribe has slightly different regulations regarding what information is required on their fish tickets; however, all landed catch (both halibut and other non-target species) is required to be reported on fish tickets. Catch that is not landed, considered to be minimal, is not required to be reported on tribal fish tickets. Data from fish tickets is transmitted to the NWIFC, which collects and distributes the data for use by the treaty tribes for collective in-season management according to the management plan. Each December, the NWIFC compiles individual tribal catch data and sends a report to NMFS of ESA-listed species caught incidental to the halibut fishery. In 2021, tribal staff sent biological samples to IPHC from several Washington ports (IPHC 2022c).

1.3.5.3. Recreational Sectors

Washington

The WDFW monitors catch of halibut through a sampling program in both the Puget Sound region and coastal subareas (L. Wargo, WDFW, personal communication, December 19, 2022). Under the sampling approach described below, halibut catch and effort estimates are available on a weekly basis. During the recreational halibut fishery, WDFW enforcement conducts on-the-water patrols.

The WDFW Ocean Sampling Program (OSP) produces fishery estimates for salmon, groundfish, Pacific halibut, tuna, and sturgeon to meet state and federal needs. This includes weekly estimates of catch (number of fish) and effort (angler trips) by species and management area for in-season management of quota-managed species. Begun in 2015, expanded in 2017, and continuing since, the Puget Sound Sampling Program (PSSP) conducts intensive sampling that also provides weekly estimates of catch and effort for in-season management of the Pacific halibut fishery. Bycatch data on non-targeted released species are collected through the dockside sampling programs, but data on the condition of the released fish (including listed species) is not collected.

From 2018 through 2022, WDFW staff onboard aircraft continued to collect location data of all recreational fishing vessels throughout Puget Sound on all days the halibut season was open. In MCAs 5–10, all days when open for halibut during the early season (April–June) were sampled. However, during the late or extended season (August and September), weekdays (Monday–Thursday) were randomly selected for sampling and catch estimates were expanded to account for non-sampled days. All weekend days (Friday–Sunday), during which the highest effort typically occurs, were sampled.

For ports where effort is estimated from counts of vessels, exit/entrance numbers are counted daily by boat type (charter or private) either leaving the port (as early as 3:30 a.m. through the end of the day) or entering the port (approximately 8:00 a.m. through dusk). Interviews are systematically conducted based on daily effort levels as boats return to port. Halibut fishing trips are determined by angler interviews and defined based on angler-reported target species. Bycatch is assigned to the halibut fishery for trips where halibut is the target species.

Angler interviews include:

- Primary target species ("trip type")
- Number of anglers
- Management area fished
- Number of released fish, by species
- Depth at which most rockfish were caught
- Non-fishing trips (recorded as such and expanded)
- Examination of catch; retained catch is counted and species identified by the sampler. Salmon are electronically checked for coded wire tags (CWT), and other biological data are collected.

Sampling rates and schedules:

- In MCAs 1–5, sampling rates vary by port and boat type. Generally, where there are fewer than 30 boats, the goal is 100 percent coverage. The sampling rate goal decreases as boat count increases.
- Sampling in MCA 6 is a census, i.e., 100% (missed vessels may reduce sampling rate to 95%).
- In MCAs 7, 8–1, 8–2, 9, and 10 the minimum sampling rate is 20%. On low effort days, the sampling rate is typically higher.
- Fishing does not tend to occur in MCAs 11-13.
- Boats are selected systematically for sampling; a consistent sample rate is maintained throughout the day.
- Overall sampling rates average approximately 40%–50% in coastal subareas (MCAs 1–4) through the season.
- Sampling schedules for weekdays/weekend days are stratified in all ports except the Columbia River north jetty (land-based fishery). In MCAs 1–4, the weekday stratum includes Monday–Friday, whereas in Puget Sound Friday is included in the weekend stratum. All weekend days, with rare exceptions, and a random two or three weekdays are sampled. For coastal MCAs 1–4, holidays are included in weekend stratum, whereas inclusion in the weekend stratum varies depending on the holiday for Puget Sound.

Oregon

The recreational Pacific halibut fishery off the Oregon coast is sampled as part of the Oregon Recreational Boat Survey (ORBS) program (L. Mattes, ODFW, personal communication, November 22, 2022). There is not a halibut-specific sampling program. However, during the all-depth openings in the Central Oregon Coast subarea, additional staff are scheduled at the busiest ports, such as Garibaldi, Charleston, and Newport, to reflect the additional effort.

The ocean recreational catch of Pacific halibut is estimated weekly by multiplying average catch per boat (obtained from interviews) by the total effort for each port. In each port, separate catch estimates are made by boat type (charter, private) and trip type (target species such as bottom fish, salmon, or halibut, for example).

- Private boat effort: In most ports, the ODFW has video camera systems to record boats crossing the bar to enter the ocean. Samplers then review the video and record the number of boats exiting between 0415 and 2015 each day to determine effort. Interviews at the docks are used to determine the proportions of boats engaging in each trip type (bottomfish or halibut, for example).
- Charter boat effort: Charter offices are the primary source for charter boat counts by trip type. Charter boats are also counted as they leave the harbor.
- Average catch per boat: Dockside interviews are used to determine average catch per ocean boat by trip type and boat type.

Sampling procedures specify that interviews be conducted randomly and representatively throughout the week. Port samplers do not focus on certain trip types or catch. The overall sampling rate goal is 20%, to meet salmon CWT expansion requirements; however, in most ports and for most fisheries, the sampling rate is often higher.

For halibut trips, effort, and harvest in the Central Oregon Coast subarea, the data are further divided into the nearshore and all-depth fisheries, based on the day of the week. All halibut trips and landings occurring on days that the all-depth fishery is open are assigned to the all-depth fishery, regardless of actual depth of fishing or harvest. For the Oregon portions of the halibut estimates in the Columbia River subarea and the Southern Oregon subarea, this is not an issue because there is only one season/fishery at a time. Landing estimates from all ports in a subarea and fishery are then combined for the weekly total for that subarea.

Bycatch estimates are reported from ORBS to the Recreational Fisheries Information Network (RecFIN), a joint program coordinated between NMFS and the Pacific State Marine Fisheries Commission (PSMFC), and include a combination of landed and released dead fish from trips targeting halibut. Bycatch species (including green sturgeon) are reported by the ORBS program.

California

The CDFW recreational sampling program (known as the California Recreational Fisheries Survey [CRFS]), began collecting recreational catch information in 2004 (M. Parker, CDFW, personal communication, December 16, 2022). CRFS provides a comprehensive approach to recreational fishery data collection throughout the state, and the information is used to estimate total marine recreational catch and effort in California. It is a coordinated sampling survey designed to gather information for all finfish species, including Pacific halibut, from anglers in all modes of recreational fishing. Catch and effort data are collected on the four major modes of fishing (i.e., the type of place or boat where the fishing occurred): private and rental boats (PR);

commercial passenger fishing vessels (CPFVs, also commonly called party boats or charter boats); man-made structures (e.g., piers and jetties); and beaches and banks. Sampling generally occurs year-round for all modes. Monthly estimates of catch and effort are produced. Estimates are produced for each of six geographic districts and for each fishing mode. The same methods are used statewide so estimates from all districts are directly comparable. Preliminary estimates are typically available about 40 days after the end of the sampling period.

One component of the CRFS program collects effort data from CPFV logs, and for some PR modes and beach and bank mode from a telephone survey. The other part of the data collection program is field sampling. The sampling program provides a random stratified 20% coverage rate for primary sample sites and 10% for secondary sites. CRFS sampling staff intercept anglers in all four fishing modes to collect fishing information. Samplers collect data on target species, fishing location, and bottom depth during interviews at the dock or onboard the CPFV. Samplers record the number, length, and weight (if possible) of fish observed in the catch, along with the angler's demographic and fishing activity information, including if a descending device was aboard. In addition, the species, number, and condition of discarded fish (alive or dead), including non-target species, is reported by anglers and recorded.

1.3.6. Fishery Enforcement Monitoring

Enforcement uses Vessel Monitoring Systems (VMS) to monitor the location and speed of participants in commercial fisheries along the west coast. VMS units are required for participants in groundfish fisheries. Vessels participating in the directed halibut fishery are only required to have VMS if they are also retaining federally managed groundfish species. In 2021, out of 190 vessels with IPHC permits, 38 vessels did not have VMS and 7 vessels without VMS landed halibut (G. Busch, NMFW-OLE, personal communication, November 2, 2022).

1.3.7. Changes to the Catch Sharing Plan

The framework in the CSP has been in place since 1995. NMFS has approved the CSP and implements management of the fisheries consistent with that framework. PFMC also annually has made changes to the CSP, which NMFS approves and implements management measures consistent with those changes. These annual updates to the CSP have been relatively minor. The types of changes the Council has recommended in the CSP include creating or modifying subareas, limited reapportioning of subarea allocations, changing retention of groundfish bycatch species, modifying bag limits, and changing openings based on in-season management. Most changes, recently, have focused on increasing flexibility for in-season management, as the fisheries have become longer in duration since 2020.

The effects on ESA-listed species from halibut fisheries flow from overall season dates and sector and subarea allocations. Changes to specific dates or days within the season do not influence the general timing of the fishery, and shifts in subarea allocations, or incidental retention, are likely to result in only minimal shifts in the effort or harvest of halibut. In addition, monitoring of the stock is performed on a weekly basis by state agencies, and fishery trends (such as when allocations will be attained or if additional fishing days are needed to reach allocations) are discussed with IPHC and NMFS. Additionally, fishing intensity is unlikely to change because the overall allocation to Area 2A is unlikely to be substantially increased in the near future due to the condition of the halibut stock.

Because these annual changes to the CSP recommended by the Council and implemented through management measures by NMFS are minor (such as days per week fished, bag limits, etc.) they do not change the potential effects on ESA listed species from the fisheries. Information on interactions with ESA-listed species will be obtained annually from agencies and evaluated to determine if reinitiation of consultation is necessary.

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

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species or to 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 reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

NMFS has determined that the Proposed Action will have no effect on southern eulachon or its critical habitats.[1] The proposed action is also not likely to adversely affect marine mammals, sea turtles, or their critical habitats, nor is it likely to adversely affect green sturgeon critical habitat, or those salmonid species listed in Section 2.5.3 Chinook and Coho Salmon. These determinations are documented in Section 2.11 "Not Likely to Adversely Affect" Determinations.

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 each listed species.

This biological opinion also relies on the regulatory 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 designations of critical habitat for species listed above use the term primary constituent element (PCE) or essential features. The 2016 final rule (81 FR 7414; February 11, 2016) that revised the 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 biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

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[1] The action area of the proposed action does not overlap with designated critical habitat of eulachon, and eulachon are not encountered in recreational or commercial fisheries that target halibut.

The ESA Section 7 implementing regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the final rule revising the definition and adding this term (84 FR 44976, 44977; August 27, 2019), that revision 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 critical habitat using an exposure–response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects on 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 each species that is likely to be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status sections also help inform the description of the species' "reproduction, numbers, or distribution" for the jeopardy analysis. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the PBFs that are essential for the conservation of the species.

2.2.1. Status of Listed Species

As discussed in more detail in Section 2.11 "Not Likely to Adversely Affect" Determinations, NMFS concludes that the salmon ESUs likely to be adversely affected by the Proposed Action are Puget Sound Chinook salmon, Lower Columbia River (LCR) Chinook salmon, LCR coho salmon, and Snake River fall Chinook salmon. The discussion of the species status and subsequent sections for salmon is, therefore, limited to those four ESUs.

For Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: spatial structure, diversity, abundance, and productivity (McElhany et al. 2000). These "viable salmonid population" (VSP) criteria encompass the species' "reproduction, numbers, or distribution" as described in 50 C.F.R. § 402.02. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout a species' entire life cycle, and these characteristics, in turn, are influenced by habitat and other environmental conditions.

"Spatial structure" refers both to the spatial distributions of individuals in a population, and the processes that generate that distribution. A population's spatial structure depends fundamentally on habitat quality and spatial configuration, and the dynamics and dispersal characteristics of individuals in the population.

"Diversity" refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation at single genes to complex life history traits (McElhany et al. 2000).

"Abundance" generally refers to the number of naturally produced adults (i.e., the progeny of naturally spawning parents) in the natural environment (e.g., on spawning grounds).

"Productivity," as applied to viability factors, refers to the entire life cycle or portions of a life cycle (i.e., the number of progeny or naturally spawning adults produced per parent). When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents over a period of time (e.g., a generation), the population is declining. McElhany et al. (2000) use the terms "population growth rate" and "productivity" interchangeably when referring to production over the entire life cycle. They also refer to "trend in abundance," which is the manifestation of long-term population growth rate.

For species with multiple populations, once the biological status of a species' populations has been determined, NMFS assesses the status of the entire species using criteria for groups of populations, as described in recovery plans, guidance documents from technical recovery teams, and regional guidance. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and ensuring some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as metapopulations (McElhany et al. 2000).

One factor affecting the status of salmonids, rockfish, and aquatic habitat at large is climate change. The following section describes climate change and other ecosystem effects on the action area.

Climate Change and Other Ecosystem Effects

Changes in global climate affect ESA-listed species and stocks occurring in the action area. This section summarizes such effects, and more detail can be found in the 2017 and 2018 halibut biological opinions (NMFS 2017a, NMFS 2018a).

The best available information suggests that the earth's climate is warming, and that this could significantly impact ocean and freshwater habitat conditions, and thus the survival of species subject to this consultation. Recent evidence suggests that climate and weather is expected to become more extreme, with an increased frequency of drought and flooding (IPCC 2019). Heavier winter rainstorms from warming may lead to increased flooding and high-flow events that result in scouring of riverbeds, smothering salmon redds, and increasing suspended sediment in systems. In the summer, decreased stream flows and increased water temperature can reduce salmon habitat and impede migration (Southern Resident Orca Task Force 2019).

Anthropogenic influences on climate, as well as projections of climate change over the next century, are anticipated to continue. Recent warming bears the signature of rising concentrations of greenhouse gas emissions and it is anticipated that the 30-year average temperature in the Northern Hemisphere is now higher than it has been over the past 1,400 years (IPCC 2013; Melillo et al. 2014). In addition, there is high certainty that ocean acidity has increased with a drop in pH of 0.1 (NWFSC 2015).

Changes in climate and ocean conditions happen on several different time scales and have had a profound influence on distributions and abundances of marine and anadromous fishes, including federally listed species considered in this opinion. Several studies have revealed that climate change has the potential to affect ecosystems in nearly all tributaries throughout the state of Washington (Battin et al. 2007; ISAB 2007). While the intensity of effects will vary by region (ISAB 2007), climate change is generally expected to alter aquatic habitat (water yield, peak flows, and stream temperature). As climate change alters the structure and distribution of rainfall, snowpack, and glaciations, each factor will in turn alter riverine hydrographs.

Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species and the conservation value of designated critical habitats in the Pacific Northwest. These changes will not be spatially homogeneous across the region. The largest hydrologic responses are expected to occur in basins with significant snow accumulation, where warming decreases snow pack, increases winter flows, and advances the timing of spring melt (Mote et al. 2014, Mote et al. 2016). Rain-dominated watersheds and those with significant contributions from groundwater may be less sensitive to predicted changes in climate (Tague et al. 2013, Mote et al. 2014).

During the last century, average regional air temperatures in the Pacific Northwest increased by 1–1.4 °F as an annual average, and up to 2 °F in some seasons (based on average linear increase per decade; Abatzoglou et al. 2014; Kunkel et al. 2013). Warming is likely to continue during the next century as average temperatures are projected to increase another 3–10 °F, with the largest increases predicted to occur in the summer (Mote et al. 2014). Decreases in summer precipitation of as much as 30% by the end of the century are consistently predicted across climate models (Mote et al. 2014). Precipitation is more likely to occur during October through March, less during summer months, and more winter precipitation will be rain than snow (ISAB 2007, Mote et al. 2013, Mote et al. 2014). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB 2007, Mote et al. 2014). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

In addition to changes in freshwater conditions, predicted changes for coastal waters in the Pacific Northwest as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al. 2014). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by 1.0–3.7 °C (1.8–6.7 °F) by the end of the century (IPCC 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences for anadromous, coastal, and marine species in the Pacific Northwest (Tillmann and Siemann 2011; Reeder et al. 2013). Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. Acidification also affects sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al. 2012; Sunda and Cai 2012).

Warming ocean temperatures will likely alter all biological communities in cool or cold ocean regions, making it more difficult for organisms to locate or capture prey (Roemmich and McGowan 1995; Zamon and Welch 2005). Warmer waters could also allow for the northward expansion of predator and competitor ranges (Rexstad and Pikitch 1986; McFarlane et al. 2000; Phillips et al. 2007). A change to a warm-water regime in the ocean creates larger areas of hypoxia or anoxia because warmer water holds less dissolved oxygen. This shifts more species into shallower waters where atmospheric oxygen mixes more freely into the water column (Meyer-Gutbrod et al. 2021) and could have future impacts on predation and feeding in the nearshore environment.

The adaptive ability of threatened and endangered species is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. Without these natural sources of resilience, systematic changes in local and regional climatic conditions will likely reduce long-term viability and sustainability of populations in many species (NWFSC 2015). New stressors generated by climate change, or existing stressors with effects that have been amplified by climate change, may also have synergistic impacts on species and ecosystems (Doney et al. 2012). These conditions will possibly intensify the climate change stressors inhibiting recovery of ESA-listed species in the future.

Rockfish

The impact of climate change on Puget Sound yelloweye and bocaccio rockfish is discussed in detail below.

Green sturgeon

The potential for climate change to increase water temperatures and impact flow rates in freshwater, estuarine, and ocean habitats could affect green sturgeon's spawning and recruitment success, depending on the magnitude and timing of the potential changes. Similar to other sturgeon species, water temperatures and flow rates are important factors influencing green sturgeon spawning and recruitment success. Subadult and adult Southern DPS green sturgeon use ocean habitats for migration and potentially for feeding. Based on their use of coastal bay and estuarine habitats, subadults and adults can occupy habitats with a wide range of temperature, salinity, and dissolved oxygen levels (Kelly et al. 2007; Moser and Lindley 2007). Thus, it is not clear how changing ocean conditions because of climate change may affect Southern DPS green sturgeon and its habitat.

Salmonids

Given the increasing certainty that climate change is occurring and is accelerating (Battin et al. 2007), NMFS anticipates salmonid habitats will be affected and this, in turn, is likely to affect the distribution and productivity of salmon populations in the region (Beechie et al. 2006). Climate and hydrology models project substantial reductions in both total snow pack and low-elevation snow pack in the Pacific Northwest over the next 50 years (Mote and Salathé 2009) – changes that will shrink the extent of the snowmelt-dominated habitat available to salmon. Changes may restrict our ability to conserve diverse salmon and steelhead life histories and make recovery targets for these salmon populations more difficult to achieve.

Warmer streams, ocean acidification, lower summer stream flows, and higher winter stream flows are projected to negatively affect salmonids (Blum et al. 2018). Similar types of effects on salmon may occur in the marine ecosystem including warmer water temperatures, loss of coastal habitat due to sea level rise, ocean acidification, and changes in water quality and freshwater inputs (Mauger et al. 2015; Thorne et al. 2018).

Overall, about one-third of the current cold-water salmonid habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (Mantua et al. 2009). Higher temperatures will reduce the quality of available salmonid habitat for most freshwater life stages (ISAB 2007). Reduced flows will make it more difficult for migrating fish to pass physical and thermal obstructions, limiting their access to available habitat (Mantua et al. 2010; Isaak et al. 2012). Temperature increases shift timing of key life cycle events for salmonids and species forming the base of their aquatic food webs (Crozier et al. 2011; Tillmann and Siemann 2011; Winder and Schindler 2004). Higher stream temperatures will also cause decreases in dissolved oxygen and may also cause earlier onset of stratification and reduced mixing between layers in lakes and reservoirs, which can also result in reduced oxygen (Meyer et al. 1999, Winder and Schindler 2004; Raymondi et al. 2013). Higher temperatures are likely to cause several species to become more susceptible to parasites, disease, and higher predation rates (Crozier et al. 2008; Wainwright and Weitkamp 2013; Raymondi et al. 2013).

As more basins become rain-dominated and prone to more severe winter storms, higher winter stream flows may increase the risk that winter or spring floods in sensitive watersheds will damage spawning redds and wash away incubating eggs (Goode et al. 2013). Earlier peak stream flows will also alter migration timing for salmon smolts, and may flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and reducing smolt survival (McMahon and Hartman 1989; Lawson et al. 2004).

Recent studies have provided evidence that growth and survival rates of salmon in the California Current off the Pacific Northwest can be linked to fluctuations in ocean conditions related to Pacific Decadal Oscillation and the El Nino-Southern Oscillation conditions and events (Peterson et al. 2006; Wells et al. 2008), as well as the recent northeast Pacific marine warming phenomenon (aka “the blob”) (Bond et al. 2015; Cavole et al. 2016). The frequency of 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.

Global sea levels are expected to continue rising throughout this century, likely reaching predicted increases of 10–32 inches by 2081–2100 (IPCC 2014). If realized, these changes will result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Tillmann and Siemann 2011; Reeder et al. 2013). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al. 2007).

Sunflower Sea Stars

From 2013 to 2017, the sunflower sea star experienced a range-wide epidemic of sea star wasting syndrome (SSWS) (Gravem et al. 2021; Hamilton et al. 2021; Lowry et al. 2022). While the cause of this disease remains unknown, prevalence of the outbreak has been linked to a variety of environmental factors, including temperature change, sustained elevated temperature, low dissolved oxygen, and decreased pH (Hewson et al. 2018; Aquino et al. 2021; Heady et al. 2022; Oulhen et al. 2022). As noted above, changes in physiochemical attributes of nearshore waters are expected to change in coming decades as a consequence of anthropogenic climate change, but the specific consequences of such changes on SSWS prevalence and severity are currently impossible to accurately predict.

2.2.1.1. Status of Puget Sound/Georgia Basin Rockfish

Detailed assessments of yelloweye rockfish (*Sebastes ruberrimus*) and bocaccio (*S. paucispinis*) can be found in the recovery plan (NMFS 2017b) and the 5-year status review (Tonnes et al. 2016), and are summarized here. We describe the status of yelloweye rockfish and bocaccio with nomenclature referring to specific areas of Puget Sound and the Strait of Georgia. Though these water bodies, together with the Strait of Juan de Fuca, collectively make up the Georgia Basin, or Salish Sea, we use Puget Sound in the broad sense to refer to all U.S. waters of the listed Distinct Population Segments (DPSs) of bocaccio and yelloweye rockfish (Figures 7 and 8). Using this nomenclature, U.S. waters north of the San Juan Islands are considered part of Puget Sound, despite cartographically being the southern Strait of Georgia.

Puget Sound is the second largest estuary in the United States, located in northwest Washington State and covering an area of about 900 square miles (2,330 square km), including 2,500 miles (4,000 km) of shoreline. We subdivide Puget Sound into five interconnected subbasins defined by the presence of shallow areas called sills, which restrict water flow and prolong flushing rates such that water chemistry and biology vary substantially. These subbasins largely align with MCAs shown in Figure 4, and are defined as: (1) the San Juan/Strait of Juan de Fuca/southern Strait of Georgia Basin, also referred to as "North Sound" (the portion of MCA 6 east of Port Angeles and all of MCA 7); (2) Main Basin (MCAs 9, 10, and 11); (3) Whidbey Basin (MCAs 8–1 and 8–2); (4) South Sound (MCA 13); and (5) Hood Canal (MCA 12). We use the term "Puget Sound proper" to refer collectively to all basins except North Sound.

The Puget Sound/Georgia Basin DPS of yelloweye rockfish is listed under the ESA as threatened, and the Puget Sound/Georgia Basin DPS of bocaccio is listed as endangered (75 FR 22276, April 28, 2010). On January 23, 2017 (82 FR 7711), we extended the yelloweye rockfish DPS, which initially aligned with the DPS of bocaccio, further north in the Johnstone Strait area of Canada, a difference apparent by comparing Figures 7 and 8. This extension was also the result of new genetic analysis of yelloweye rockfish. The DPSs include all yelloweye rockfish and bocaccio found in waters of Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca east of the Victoria Sill (Figures 7 and 8) regardless of their origin.

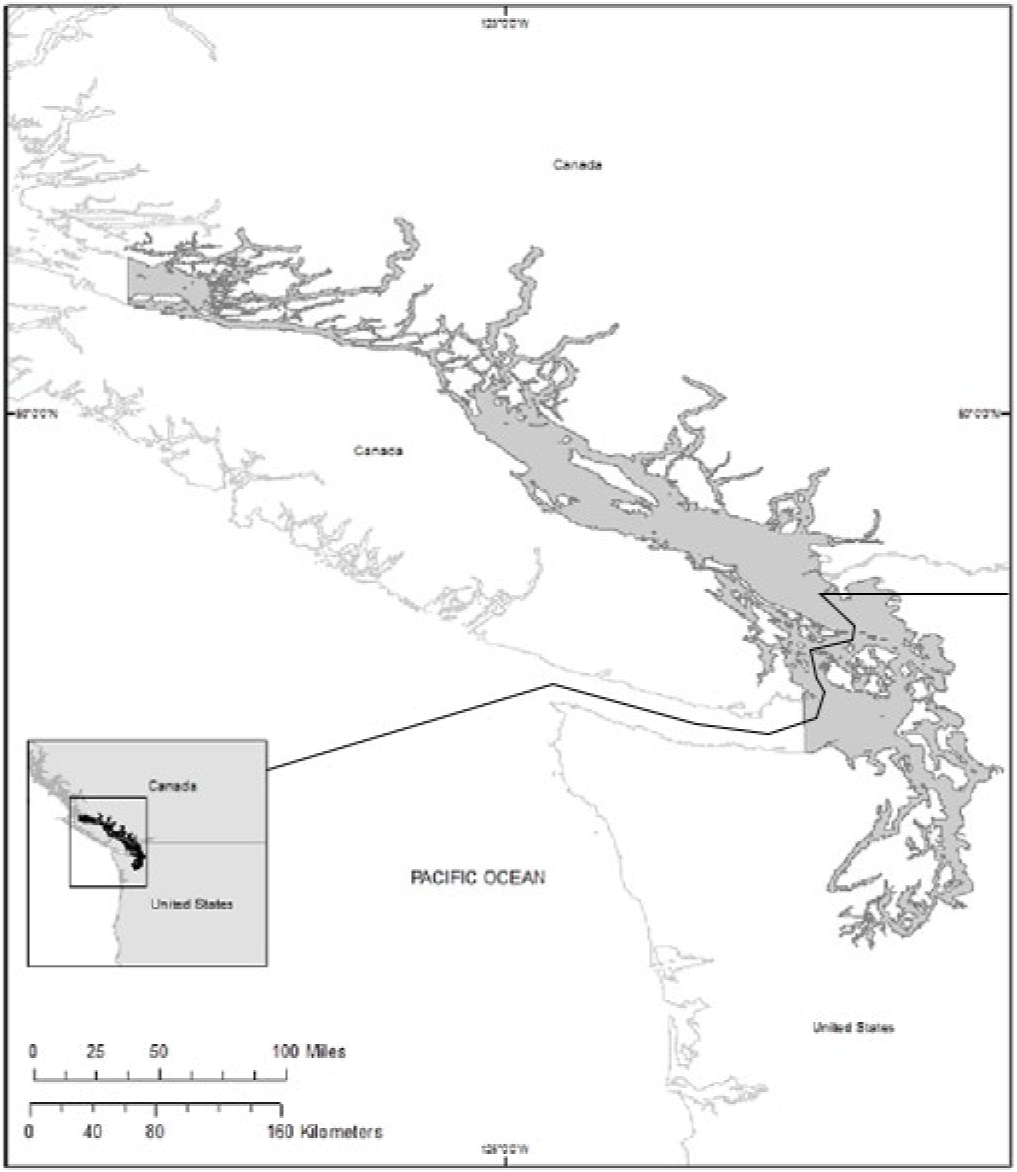

Figure 7. Geographic scope of the yelloweye rockfish distinct population segment (DPS), spanning the U.S.-Canadian border.

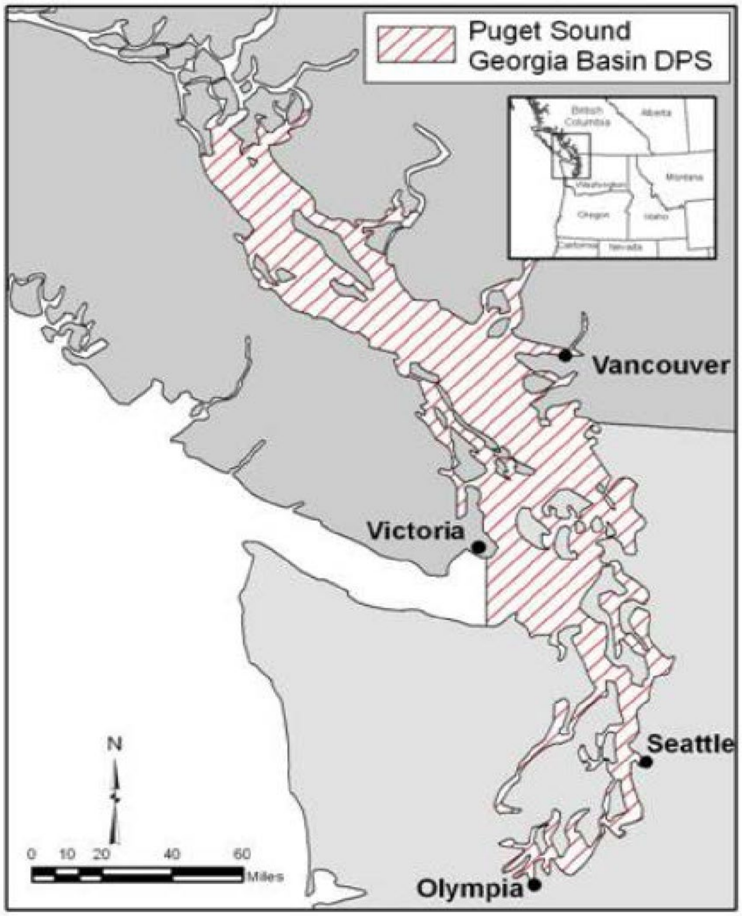

Figure 8. Geographic scope of the yelloweye rockfish distinct population segment (DPS), spanning the U.S.-Canadian border.

The life histories of yelloweye rockfish and bocaccio include a larval/pelagic juvenile stage, followed by demersobenthic juvenile, subadult, and adult stages. Much of the life history and habitat use for these two species is similar, with important differences noted below. All species of rockfish fertilize their eggs internally and the young are extruded as larvae. A mature female yelloweye rockfish or bocaccio can produce from several thousand to well over a million eggs each breeding cycle (Love et al. 2002; Arthur et al. 2022). Breeding cycles tend to occur annually, but skip spawning (i.e., a biennial reproductive cycle for some individuals) has been recorded in various rockfish species (e.g., Nichol and Pikitch 1994; Hannah and Parker 2007; Thompson and Hannah 2010; Lefebvre and Field 2015; Head et al. 2016), including yelloweye (Gertseva and Cope 2017; COSEWIC 2020; Arthur et al. 2022) and bocaccio (He et al. 2015). Larvae can make small local movements to pursue food immediately after birth (Tagal et al. 2002), but are likely initially passively distributed with prevailing currents until they are large enough to progress toward preferred habitats. Larvae and pelagic juveniles of some species, especially splitnose rockfish (*S. diploproa*), have been observed under free-floating algae, seagrass, and detached kelp (Love et al. 2002; Buckley et al. 1995; Shaffer et al. 1995), but are also distributed throughout the water column (Weis 2004). Unique oceanographic conditions within Puget Sound proper result in most larvae staying within the subbasin where they are released (e.g., Hood Canal) rather than being broadly dispersed (Drake et al. 2010), but dispersal patterns are highly variable among subbasin and season of larval release (Andrews et al. 2021). Larvae released in North Sound disperse widely throughout inland waters of the DPSs, as well as offshore waters of Washington and British Columbia, before reaching the end of their planktonic period.

When bocaccio reach sizes of 1–3.5 inches (3–9 cm), or approximately 3–6 months old, they settle onto shallow nearshore waters in rocky or cobble substrates with or without kelp (Love et al. 1991, 2002). These habitat features offer a beneficial mix of warmer temperatures, food, and refuge from predators (Love et al. 1991). Areas with floating and submerged kelp species support the highest densities of most juvenile rockfish (Carr 1983; Halderson and Richards 1987; Hayden-Spear 2006; Matthews 1989). Unlike bocaccio, juvenile yelloweye rockfish do not typically occupy intertidal waters (Love et al. 1991; Studebaker et al. 2009), but settle in 98 to 131 feet (30 to 40 m) of water near the upper depth range of adults (Yamanaka and Lacko 2001).

Subadult and adult yelloweye rockfish and bocaccio typically utilize habitats with moderate to extreme steepness, complex bathymetry, and rock and boulder-cobble complexes (Love et al. 2002). Within the boundaries of the DPSs, both species have been documented in areas of high relief rocky and non-rocky substrates such as sand, mud, and other unconsolidated sediments (Miller and Borton 1980; Washington 1977; Pacunski et al. 2013; 2020; Andrews et al. 2018; Lowry et al. 2022). Yelloweye rockfish remain near the bottom and have small home ranges, while bocaccio have larger home ranges, move long distances, and spend time suspended in the water column (Love et al. 2002). Adults of each species are most commonly found between 131 to 820 feet (40 to 250 m) (Love et al. 2002; Orr et al. 2000).

Yelloweye rockfish are one of the longest-lived of the rockfishes, with some individuals reaching more than 100 years of age (Yamanaka et al. 2006). They reach 50 percent maturity at sizes around 16 to 20 inches (40 to 50 cm) and ages of 15 to 20 years (Rosenthal et al. 1982; Yamanaka and Kronlund 1997). In waters off California, however, they may reach maturity as early as 6 to 8 years of age (Wyllie-Echeverria 1987). Bocaccio are notoriously difficult to age, and their maximum age has been reported as being as high as 57 years (Ralston and Ianelli 1998). Application of advanced techniques, however, places the maximum age closer to 40 years (COSEWIC 2002; Pearson et al. 2015), with evidence that this attribute varies with latitude. Bocaccio reach reproductive maturity between ages 3 and 8 (Wyllie-Echeverria 1987; Love et al. 2002).

In the following section, we summarize the condition of yelloweye rockfish and bocaccio at the DPS level according to the following demographic viability criteria: abundance and productivity, spatial structure/connectivity, and diversity. These viability criteria are outlined in McElhaney et al. (2000) and reflect concepts that are well founded in conservation biology and are generally applicable to a wide variety of species. These criteria describe demographic risks that individually and collectively provide strong indicators of extinction risk (Drake et al. 2010). There are several common risk factors detailed below at the introduction of each of the viability criteria for each listed rockfish species. Habitat- and species-limiting factors can affect abundance, productivity, spatial structure, and diversity parameters, and are described.

Abundance and Productivity

There is no single reliable historical or contemporary population estimate for yelloweye rockfish or bocaccio within the full range of the Puget Sound/Georgia Basin DPSs (Drake et al. 2010; Tonnes et al. 2017). Despite this limitation, there is clear evidence each species' abundance declined dramatically since the 1970s and has not yet rebounded (Drake et al. 2010; Williams et al. 2010; Tonnes et al. 2017; Keppel and Olsen 2019). Analysis of SCUBA surveys, recreational catch, and WDFW trawl surveys indicated total rockfish populations in the Puget Sound region are estimated to have declined between 3.1% and 3.8% per year for the past several decades, which corresponds to a 69% to 76% decline from 1977 to 2014 (Tonnes et al. 2016; Tolimieri et al. 2017). For yelloweye rockfish in the Puget Sound region, models based on recent remotely operated vehicle (ROV) survey data indicate that populations are slowly increasing but still fall well short of recovery goals (Min et al. 2023). For bocaccio, encounter rates within the DPS are now so low that reliably determining a population status trend is impossible.

Catches of yelloweye rockfish and bocaccio declined as a proportion of overall rockfish catch (Drake et al. 2010; Palsson et al. 2009) until fisheries were closed in 2010 in response to the ESA listings. Yelloweye rockfish were 2.4% of the harvest in North Sound during the 1960s, occurred in 2.1% of the harvest during the 1980s, but then decreased to an average of 1% from 1996 to 2002 (Palsson et al. 2009). In Puget Sound proper, yelloweye rockfish were 4.4% of the harvest during the 1960s, only 0.4% during the 1980s, and 1.4% from 1996 to 2002 (Palsson et al. 2009).

Bocaccio made up 8%–9% of the overall rockfish catch in the late 1970s and declined in frequency, relative to other species of rockfish, from the 1970s to the 1990s (Drake et al. 2010). From 1975 to 1979, bocaccio averaged 4.6% of the catch. From 1980 to 1989, they were 0.2% of the 8,430 rockfish identified (Palsson et al. 2009). In the 1990s and early 2000s, bocaccio were not observed by WDFW in the dockside surveys of recreational catch (Drake et al. 2010). Despite concerted efforts to obtain bocaccio specimens for genetic research over the last decade, only a handful of individuals have been observed by the WDFW with their ROV, and even fewer have been successfully captured (Pacunski et al. 2013; 2020; Andrews et al. 2019; Lowry et al. 2022).

Productivity is the measurement of a population's growth rate through all or a portion of its life cycle. Life history traits of yelloweye rockfish and bocaccio suggest generally low levels of inherent productivity because they are long-lived, mature slowly, and have sporadic episodes of successful reproduction (Drake et al. 2010; Tolimieri and Levin 2005). Overfishing can have dramatic impacts on the size or age structure of the population, with effects that can influence ongoing productivity. When the size and age of females decline, there are negative impacts on reproductive success. These impacts, termed maternal effects, are evident in a number of traits. Larger and older females of various rockfish species have a higher weight-specific fecundity (number of larvae per unit of female weight) (Bobko and Berkeley 2004; Boehlert et al. 1982; Sogard et al. 2008). A consistent maternal effect in rockfishes relates to the timing of parturition. The timing of larval birth can be crucial in terms of corresponding with favorable oceanographic conditions because most larvae are released typically once annually, with a few exceptions in southern coastal populations and in yelloweye rockfish in Puget Sound (Washington et al. 1978). Several studies of rockfish species have shown that larger or older females release larvae earlier in the season compared to smaller or younger females (Nichol and Pikitch 1994; Sogard et al.

2008). Larger or older females provide more nutrients to larvae by developing a larger oil globule released at parturition, which provides energy to the developing larvae (Berkeley et al. 2004; Fisher et al. 2007) and, in black rockfish, enhances early growth rates (Berkeley et al. 2004).

Contaminants such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and chlorinated pesticides appear in rockfish collected in urban areas (West et al. 2001; Palsson et al. 2009). While the highest levels of contamination occur in urban areas, toxins can be found in the tissues of fish throughout Puget Sound (West et al. 2001). Although few studies have investigated the effects of toxins on rockfish ecology or physiology, other fish in the Puget Sound region that have been studied show a substantial impact, including reproductive dysfunction of some sole species (Landahl et al. 1997). Reproductive function of rockfish is also likely affected by contaminants (Palsson et al. 2009) and other life history stages may be affected as well (Drake et al. 2010). Larvae may be especially sensitive, given their inability to avoid areas containing high levels of toxic contaminants and the underdeveloped nature of organs, such as the liver, that play a role in detoxification.

Future climate-induced changes to rockfish habitat with the ability to alter their productivity have been identified (Drake et al. 2010). Harvey (2005) created a generic bioenergetic model for rockfish, showing that their productivity is highly influenced by climate conditions. For instance, El Niño-like conditions generally lowered growth rates and increased generation time. The negative effect of the warm water conditions associated with El Niño appear to be common across rockfishes (Moser et al. 2000). Recruitment of all species of rockfish appears to be correlated at large scales. Field and Ralston (2005) hypothesized that such synchrony was the result of large-scale climate forcing. Exactly how climate influences rockfish in Puget Sound is unknown; however, given the general importance of climate to rockfish recruitment, it is likely that climate strongly influences the dynamics of listed rockfish population viability (Drake et al. 2010). The consequences of climate change to rockfish productivity, however, will likely be small.

Yelloweye Rockfish Abundance and Productivity

Yelloweye rockfish within U.S. waters of the Puget Sound/Georgia Basin are very likely most abundant within the San Juan Basin. The San Juan Basin has the most suitable rocky benthic habitat (Palsson et al. 2009; Pacunski et al. et al 2013; 2020; Lowry et al. 2022) and historically was the area in which anglers most frequently encountered, and retained, this species (Moulton and Miller 1987; Olander 1991).

Productivity for yelloweye rockfish is influenced by long generation times that reflect intrinsically low annual reproductive success. Natural mortality rates have been estimated from 2% to 4.6% (Yamanaka and Kronlund 1997; Wallace 2007). Productivity may also be particularly impacted by Allee effects, which occur as adults are removed by fishing and the density and proximity of mature fish decreases. Adult yelloweye rockfish typically occupy relatively small ranges (Love et al. 2002) and it is unknown the extent to which they may move to find suitable mates. Exploratory tagging and focal individual drop-camera survey efforts in Hood Canal have demonstrated that yelloweye rockfish occupy an area of less than 20 sq ft over the course of several weeks (D Lowry, NOAA Fisheries, personal communication).

In Canada, yelloweye rockfish biomass is estimated to have declined 68%–88% between 1918 and 2019, such that it is now 12% of the unfished stock size on the inside waters of Vancouver Island (DFO 2011; COSEWIC 2020). In 2020, the COSEWIC status of this population was changed from Species of Concern to Threatened, acknowledging persistently depressed abundance. There are no analogous biomass estimates in the U.S. portion of the yelloweye rockfish DPS. However, the WDFW has generated several population estimates of yelloweye rockfish in recent years. Remotely operated vehicle (ROV) surveys in the San Juan Island region in 2008 (focused on rocky substrate) and 2010 (across all habitat types) estimated a population of 47,407 ± 11,761 and 114,494 ± 31,036 individuals, respectively (Pacunski et al. 2013; 2020). A 2015 ROV survey of that portion of the DPSs south of the entrance to Admiralty Inlet encountered 35 yelloweye rockfish, producing a preliminary population estimate of 66,998 ± 7,370 individuals (final video review is still under way) (WDFW 2017).

Bocaccio Abundance and Productivity

Bocaccio in the U.S. waters of the Puget Sound/Georgia Basin were historically most common within the South Sound and Main Basin (Drake et al. 2010). Though bocaccio were never a predominant segment of the multi-species rockfish abundance within the Puget Sound/Georgia Basin (Drake et al. 2010), their present-day abundance is likely a small fraction of their pre-contemporary fishery abundance. Bocaccio abundance may be very low in large segments of the Puget Sound/Georgia Basin and, though noting their occasional occurrence in the Strait of Georgia, assessments of the species in Canadian waters do not account for fish occurring in any portion of the DPS (COSEWIC 2013; Fisheries and Oceans Canada 2020). Productivity is driven by high fecundity and episodic recruitment events, largely correlated with environmental conditions. Thus, bocaccio populations do not follow consistent growth trajectories and sporadic recruitment drives population structure (Drake et al. 2010). In 2016, a settlement event that was 44 times normal levels was documented in coastal Canada, dramatically modifying predictions of stock status and fishery potential (Fisheries and Oceans Canada 2020).

Natural annual mortality is estimated to be approximately 8% (Palsson et. al 2009). Tolimieri and Levin (2005) found that the bocaccio population growth rate is around 1.01, indicating a very low intrinsic growth rate for this species. Demographically, this species demonstrates some of the highest recruitment variability among rockfish species, with many years of failed recruitment being the norm (Tolimieri and Levin 2005). It is not yet known how, or if, the dramatic settlement event noted in 2016 on the outer coast may affect populations of bocaccio within the DPS. As a result of modifications made to the definition of the DPS in 2017 (82 FR 7711), individuals born on the outer coast but settling within the boundaries of the DPS would be granted ESA-listed status. Obtaining a genetic profile for the population residing within the DPS prior to this settlement event (i.e., that are too old to be part of the 2016 cohort) will be crucial to evaluating any long-standing genetic differentiation between the coast and inland waters. Given their severely reduced abundance in inland waters, Allee effects may be particularly acute for bocaccio, even considering the propensity of some individuals to move long distances and potentially find mates.

In Canada, the median estimate of bocaccio biomass is 3.5% of its unfished stock size (though this only assessed Canadian waters outside of the boundary of the DPS) (Stanley et al. 2012; COSEWIC 2013). There are no analogous biomass estimates in the U.S. portion of the bocaccio

DPS. However, the ROV survey of the San Juan Islands in 2008 estimated a population of 4,606±4,606 (based on four fish observed along a single transect) (Pacunski et al. 2013), but no estimate could be obtained in the 2010 ROV or 2012-13 survey because this species was not encountered (Pacunski et al. 2020; Lowry et al. 2022). A single bocaccio encountered in the 2015 ROV survey produced a statistically invalid population estimate for that portion of the DPS lying south of the entrance to Admiralty Inlet and east of Deception Pass. A handful of bocaccio have been caught in genetic surveys (Andrews et al. 2018; Dayv Lowry, NOAA Fisheries, personal communication) and by recreational anglers in Puget Sound proper (Eric Kraig, WDFW, personal communication) in the past several years.

In summary, though abundance and productivity data for yelloweye rockfish and bocaccio is relatively imprecise, both abundance and productivity have been reduced largely by fishery removals within the range of each Puget Sound/Georgia Basin DPS. Recent increases in yelloweye abundance have occurred, but data are insufficient to assess changes in abundance for bocaccio.

Spatial Structure and Connectivity

Spatial structure consists of a population's geographic distribution and the processes that generate that distribution (McElhaney et al. 2000). A population's spatial structure depends on habitat quality, spatial configuration, and dynamics, as well as dispersal characteristics of individuals within the population (McElhaney et al. 2000). Prior to contemporary fishery removals from the 1970s through the 1990s, each of the major subbasins in the range of the DPSs likely hosted relatively large populations of yelloweye rockfish and bocaccio (Moulton and Miller 1987; Washington 1977; Washington et al. 1978). This distribution allowed both species to utilize the full suite of available habitats to maximize their abundance and demographic characteristics, thereby enhancing their resilience (Hamilton 2008). This distribution also enabled each species to potentially exploit ephemerally good habitat conditions, and in turn receive protection from smaller-scale and negative environmental fluctuations. These types of fluctuations may change prey abundance for various life stages and/or may change environmental characteristics and water flow parameters that influence the number of annual recruits. Spatial distribution also provides a measure of protection from larger-scale anthropogenic changes that decrease habitat suitability, such as oil spills or hypoxia that may be isolated to a single subbasin. Rockfish population resilience is sensitive to changes in connectivity among various groups of fish (Hamilton 2008). Hydrologic connectivity of the subbasins of Puget Sound is naturally restricted by relatively shallow sills located at Deception Pass, Admiralty Inlet, the Tacoma Narrows, and in Hood Canal (Burns 1985). The Victoria Sill, which marks the western edge of the DPSs, bisects the Strait of Juan de Fuca, runs from east of Port Angeles north to Victoria, and regulates water exchange (Drake et al. 2010). Given that these sills regulate water exchange among subbasins, they also moderate the movement of rockfish larvae (Drake et al. 2010; Andrews et al. 2021). When localized depletion of rockfish occurs, it can reduce stock resiliency (Hamilton 2008; Hilborn et al. 2003). The effects of localized depletions of rockfish are likely exacerbated by the natural hydrologic constrictions within Puget Sound.

Yelloweye Rockfish Spatial Structure and Connectivity

Yelloweye rockfish spatial structure and connectivity is threatened by the reduction of fish within each subbasin, and the naturally sedentary disposition of adults. This reduction is likely most acute within the subbasins of Puget Sound proper, given complex geography and prominent sills that restrict larval transport among subbasins. Yelloweye rockfish are probably most abundant within the San Juan Basin, and transport of larvae to other subbasins is affected by seasonal flow patterns, the exact location of larval release, and the depth of larval release (Andrews et al. 2021). While connectivity may be high at times, distinct genetic traits of at least the portion of the population occupying Hood Canal have arisen (Andrews et al. 2018).

Bocaccio Spatial Structure and Connectivity

Most bocaccio may have been historically spatially limited to several subbasins. They were historically most abundant in the Main Basin and South Sound (Drake et al. 2010) with no documented occurrences in the San Juan Basin until 2008 (WDFW 2011a; Pacunski et al. 2013). Positive signs for spatial structure and connectivity come from the propensity of some adults and pelagic juveniles to migrate long distances, which could re-establish aggregations of fish in formerly occupied habitat (Drake et al. 2010). The apparent reduction of populations of bocaccio in the Main Basin and South Sound represents a further impairment in the historically spatially limited distribution of bocaccio, and adds risk to the viability of the DPS.

In summary, spatial structure and connectivity for each species have been adversely impacted, mostly by fishery removals. These impacts on species viability are likely most acute for yelloweye rockfish because of their sedentary nature as adults.

Diversity

Characteristics of diversity for rockfish include fecundity, timing of the release of larvae and their condition, morphology, age at reproductive maturity, physiology, and molecular genetic characteristics. In spatially and temporally varying environments, there are three general reasons why diversity is important for species and population viability: (1) diversity allows a species to use a wider array of environments; (2) diversity protects a species against short-term spatial and temporal changes in the environment; and (3) genetic diversity provides the raw material for surviving long-term environmental changes.

Yelloweye Rockfish Diversity

Yelloweye rockfish size and age distributions have been truncated, based on recreational fishery encounter rates (Figure 9). Yelloweye rockfish caught in the 1970s spanned a broad range of sizes. By the 2000s, there was some evidence of fewer older fish in the population (Drake et al. 2010). As a result, the reproductive burden may be shifted to younger and smaller fish. This shift could alter the timing and condition of larval release, which may be mismatched with habitat conditions within the range of the DPS, potentially reducing the viability of offspring (Drake et al. 2010). Yelloweye rockfish retention has been prohibited in recreational fisheries since 2010, thus comparable data to estimate size range are not available after this time. Only a handful of adult yelloweye rockfish have been observed within WDFW ROV surveys in U.S. waters of the DPS (Lowry et al. 2022; Dayv Lowry, NOAA Fisheries, pers.comm.), and all observed fish in 2008 and 2010 in the San Juan Basin were less than 8 inches long (20 cm) (Pacunski et al 2013;

2020). Since these fish were observed several years ago, any that have survived will have grown bigger (Pacunski et al. [2013; 2020] did not report a precise size for these fish; thus, we are unable to provide a precise estimate of their likely size now). Size distribution data from more recent surveys in 2015, 2018, and 2020-21 are not yet available (Bob Pacunski, WDFW, pers.comm.).

Recent genetic information for yelloweye rockfish further confirmed the existence of fish genetically differentiated within the Puget Sound/Georgia Basin compared to the outer coast (NMFS 2016a) and that yelloweye rockfish in Hood Canal are genetically divergent from the rest of the DPS. Yelloweye rockfish in Hood Canal are addressed as a separate recovery unit in the recovery plan (NMFS 2017c), and reaching the recovery goal for the DPS at large requires viability of this population unit.

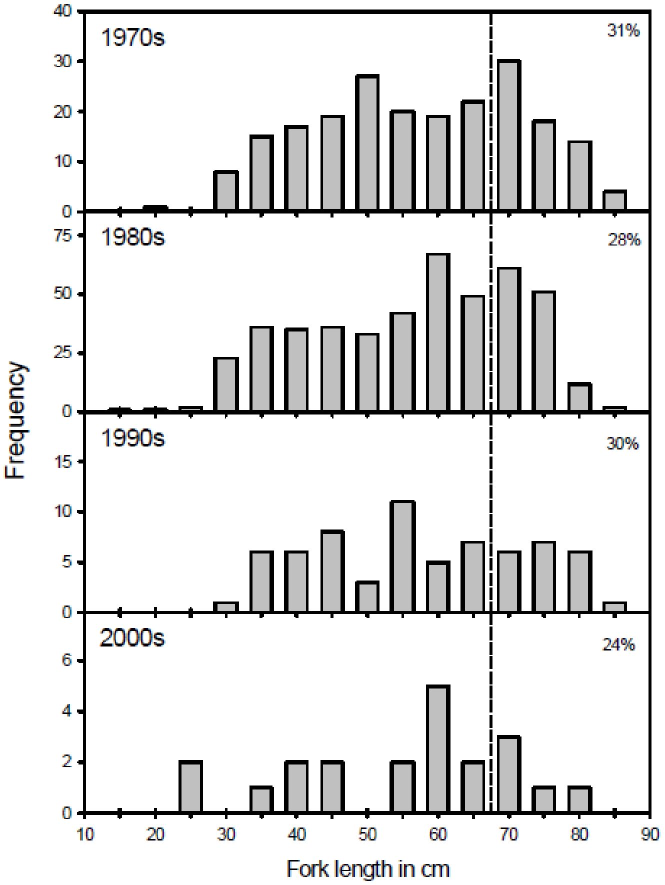

Figure 9. Yelloweye rockfish length frequency distributions (cm) from recreational fisheries binned within four decades. The vertical line depicts the size at which about 30 percent of the population comprised fish larger than the rest of the population in the 1970s, as a reference point for a later decade. Retention of yelloweye rockfish was prohibited in 2010, so no data are available after this.

<ins>Bocaccio Diversity</ins>

Size-frequency distributions for bocaccio in the 1970s indicate a wide range of sizes, and two distinct cohorts, with recreationally caught individuals from 9.8-33.5 inches (25-85 cm) (Figure

10). This size distribution profile indicates a spread of ages, with successful episodic recruitment over many years. A similar range of sizes is also evident in the 1980s catch data, though size truncation at the upper end of the distribution is beginning to be apparent. Through the 1990s encounters with bocaccio became rarer, with larger fish disappearing altogether from the catch data. By the decade of the 2000s, no size distribution data for bocaccio were available due to a nearly complete lack of encounters.

Assessments of bocaccio in Canadian waters recognize occasional occurrences of the species in the Salish Sea, but focus biomass estimation and harvest recommendation efforts on fish occupying coastal waters (Fisheries and Oceans Canada 2020). Bocaccio in the Puget Sound/Georgia Basin may have physiological or behavioral adaptations because of the unique habitat conditions in the range of the DPS. The potential loss of diversity in the bocaccio DPS, in combination with their relatively low productivity, may result in a mismatch with habitat conditions and further reduce population viability (Drake et al. 2010).

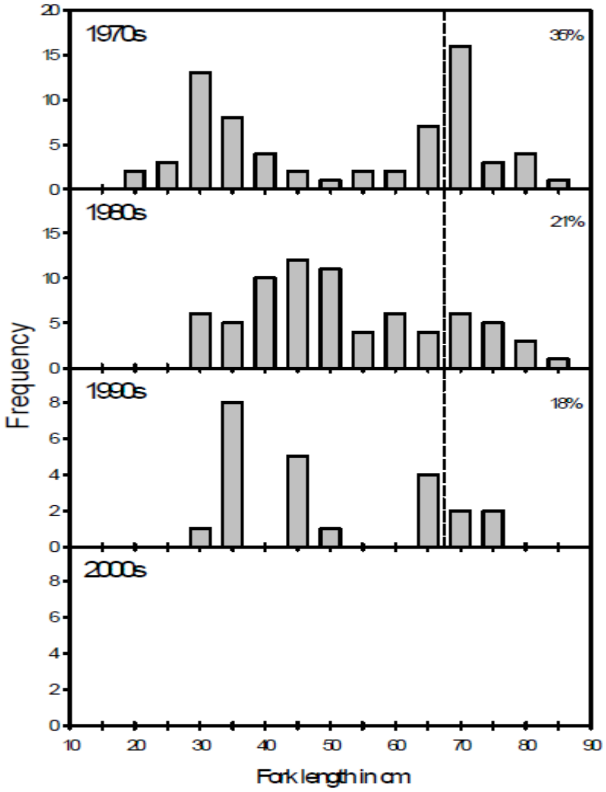

Figure 10. Bocaccio length frequency distributions (cm) from recreational fisheries within four decades. The vertical line depicts the size at which about 30% of the population comprised fish larger than the rest of the population in the 1970s, as a reference point for a later decade. Retention of bocaccio was prohibited in 2010, so no data are available after this.

In summary, diversity for each species has likely been adversely impacted by historical fishery removals, though minimal removals have occurred since 2010 due to harvest prohibitions. In turn, the ability of fish to utilize habitats within the action area, find mates, and perform important ecological roles has been compromised.

Limiting Factors

Climate Change and Other Ecosystem Effects

As reviewed in ISAB (2007), average annual Northwest air temperatures have increased by approximately 1.8°F (1°C) since 1900, which is nearly twice that for the previous 100 years, indicating an increasing rate of change. Summer temperatures, under the A1B emissions scenario (a "medium" warming scenario), are likely to continue during the next century as average temperatures are projected to increase another 3-10°F, with the largest increases predicted to occur in the summer (Mote et al. 2014). This change in surface temperature has already modified, and is likely to continue to modify, marine habitats of listed rockfish. There is still a great deal of uncertainty associated with predicting specific changes in timing, location, and magnitude of future climate change and species-specific impacts on rockfish.

As described in ISAB (2007), climate change effects that have influenced, and will continue to influence, the habitat include: increased ocean temperature; increased stratification of the water column; decreased pH; and intensity and timing changes of coastal upwelling. These continuing changes will alter primary and secondary productivity, shifting marine community structure (Doney et al. 2012). These perturbations may, in turn, alter listed rockfish trophic dynamics, growth, productivity, survival, and habitat usage. Increased concentration of CO_2 (termed Ocean Acidification, or OA) reduces carbonate availability for shell-forming invertebrates. Ocean acidification adversely affects calcification, or the precipitation of dissolved ions into solid calcium carbonate structures, for a number of marine organisms, which alters spatiotemporal prey availability (Feely et al. 2010). Further research is needed to understand the possible implications of OA on trophic functions in Puget Sound to understand how they may affect rockfish. Thus far, studies conducted in other areas have shown that the effects of OA will be variable (Ries et al. 2009) and species-specific (Miller et al. 2009).

In addition to ecological disruptions from OA in marine systems, increased acidity can directly impact the physiology and behavior of individual fish. Munday et al. (2009) demonstrated that larval orange clownfish (*Amphiprion percula*) detect and respond differently to olfactory cues when pH levels are varied over a range (7.6-8.15) predicted to occur in natural systems by 2100. Simpson et al. (2011) later demonstrated that deleterious effects on hearing also occurred in this species, reducing response to reef noise and avoidance of habitats where predation pressure was high. Larval Atlantic herring (*Clupea hargenus*) exposed to elevated carbon dioxide levels during rearing exhibited reduced growth, degraded body condition, and severe tissue damage in several organs (Frommel et al. 2014). While there have been very few studies to date on the direct effect OA may have on rockfish, in a laboratory setting OA has been documented to affect rockfish behavior (Hamilton et al. 2014). After juvenile splitnose rockfish (*Sebastes diploproa*) spent one week under OA conditions projected for the next century in the California shore they spent more time in unlighted environments compared to the control group. Davis et al. (2018) also reported metabolic and behavior changes in juvenile rockfish with regard to predator avoidance; however, they reported that many of the effects were effectively compensated for and adapted to after 3 weeks of exposure. Research conducted to understand adaptive responses to OA on other marine organisms has shown that although some organisms may be able to adjust to OA to some extent, these adaptations may reduce the organism's overall fitness or survival (Wood et al. 2008). Yelloweye rockfish and bocaccio are likely able to adapt to long-term shifts in water chemistry to some degree, but thresholds at which such adaptation becomes unlikely or impossible have not been identified. More research is needed to further understand rockfish-specific responses, and possible adaptations, to OA.

There are natural biological and physical functions in regions of Puget Sound, especially in Hood Canal and South Sound, that cause the water to be corrosive and hypoxic, such as restricted circulation and mixing, respiration, and strong stratification (Newton and Van Voorhis 2002; Feely et al. 2010). However, these natural conditions, typically driven by climate forcing, are exacerbated by anthropogenic sources such as OA, nutrient enrichment, and land-use changes (Feely et al. 2010). By the next century, OA will increasingly reduce pH and saturation states in Puget Sound (Feely et al. 2010). Areas in Puget Sound susceptible to naturally occurring hypoxic and corrosive conditions are also the same areas where low seawater pH occurs, compounding the conditions of these areas (Feely et al. 2010). Given that the population of yelloweye rockfish inhabiting Hood Canal displays a divergent genetic profile from populations elsewhere in the DPS (Andrews et al. 2018), impacts from corrosive water and hypoxia here may substantially impede recovery.

Commercial and Recreational Bycatch

Listed rockfish are encountered as bycatch in some recreational and commercial fisheries in Puget Sound. This bycatch is described in Section 2.4.4.1 Harvest and Bycatch Effects in the Environmental Baseline. In addition, NMFS permits limit take of listed rockfish for scientific research purposes. This take is described in Section 2.7.1, Puget Sound/Georgia Basin Rockfish.

Other Limiting Factors

The yelloweye rockfish DPS abundance is much lower than it was historically, though recent analysis suggests historical estimates were erroneously high and resulted in an unrealistic baseline for comparison (Min et al. 2023). The fish face several threats, including bycatch in some commercial and recreational fisheries, non-native species introductions, chemical contamination, and habitat degradation. NMFS has determined that this DPS is likely to be in danger of extinction in the foreseeable future throughout all of its range.

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

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

2.2.1.2. Status of Southern DPS Green Sturgeon

NMFS listed the Southern DPS of North American green sturgeon (Southern DPS green sturgeon) as threatened under the ESA in 2006 (71 FR 17757, April 7, 2006). In this section, we summarize the status of Southern DPS green sturgeon throughout its range, based on the most recent 5-year status review (NMFS 2021d) and the recovery plan (NMFS 2018c).

Because of the limited information available on the population's historical and current abundance, spatial structure, productivity, and diversity, there is a high level of uncertainty regarding the species' viability. However, the best available information indicates that Southern DPS green sturgeon are at moderate risk of extinction based on the low estimated adult abundance and restriction of spawning to one segment of the mainstem Sacramento River as well as its tributaries, the Yuba, and Feather Rivers (only a portion of the species' potential historical spawning habitat), which have likely also compromised the species' productivity and diversity.

Description and Geographic Range

The green sturgeon is an anadromous, long-lived, and bottom-oriented (demersal) fish species in the family Acipenseridae. The maximum age of adult green sturgeon is likely to range from 60 to 70 years, and adults may exceed 6.5 feet (2 m) in length and 198 pounds (90 kg) in weight.

Based on genetic analyses and spawning site fidelity (Adams et al. 2002; Israel et al. 2004), NMFS determined that the green sturgeon includes at least two DPSs: a northern DPS consisting of populations originating from coastal watersheds northward of and including the Eel River (Northern DPS green sturgeon), with spawning confirmed in the Klamath and Rogue River systems; and a southern DPS consisting of populations originating from coastal watersheds south of the Eel River (Southern DPS green sturgeon), with spawning confirmed in the Sacramento River system. Genetic analysis of samples from five non-juvenile green sturgeon collected in the Eel River confirms the Northern DPS assignment (Anderson et al. 2017). Another study further suggests a spawning population in the Eel River (Stillwater Sciences and Wiyot Tribe Natural Resources Department 2017). In 2006, NMFS listed the Southern DPS green sturgeon as threatened under the ESA, but determined that ESA listing for Northern DPS green sturgeon was not warranted, maintaining the Northern DPS on the NMFS Species of Concern list instead. Because the ESA-listed entity (Southern DPS green sturgeon) and non-ESA listed entity (Northern DPS green sturgeon) co-occur throughout much of their range, most of the information presented here is general to green sturgeon. Where available, we provide information specific to Southern DPS green sturgeon.

Green sturgeon range from the Bering Sea, Alaska, to Ensenada, Mexico, use a diversity of habitat types at different life stages, and are one of the most marine-oriented sturgeons. Subadult green sturgeon (sexually immature fish that have entered coastal marine waters) spend several years at sea before reaching reproductive maturity and returning to fresh water to spawn for the first time (Nakamoto et al. 1995). After migrating out of their natal rivers, subadult green sturgeon move between coastal waters and various estuaries along the U.S. West Coast between San Francisco Bay, California, and Grays Harbor, Washington (Lindley et al. 2008; Lindley et al. 2011). Migration patterns differ among individuals within and among populations (Lindley et al. 2011). Green sturgeon form dense aggregations in multiple rivers and estuaries (e.g., lower Columbia River estuary, Willapa Bay, Grays Harbor) during summer months (Moser and

Lindley 2007). Winter months are generally spent in the coastal ocean, with many green sturgeon migrating to northern waters in the fall. Green sturgeon occur in areas north of Vancouver Island in winter, with Queen Charlotte Sound and Hecate Strait likely destinations based on observed depth and temperature preferences and detections of acoustically tagged green sturgeon at the northern end of Vancouver Island (Lindley et al. 2008; Nelson et al. 2010). Peak migration rates exceeded 31 miles (50 km) per day during the spring southward migration (Lindley et al. 2008).

Relatively little is known about how green sturgeon use habitats in the coastal ocean and in estuaries, or the purpose of their episodic aggregations (Lindley et al. 2008; Lindley et al. 2011). Studies using pop-off archival tags (satellite tags) indicate that, while in the ocean, green sturgeon occur between 0- and 656-foot (0 and 200 m) depths, but spend most of their time between 65 to 262 feet (20 to 80 m) in water temperatures of 9.5 to 16.0°C (Erickson and Hightower 2007; Huff et al. 2011). They are generally demersal, but make occasional forays to surface waters, perhaps to assist their migration (Kelly et al. 2007). Telemetry data in coastal ocean habitats suggest that green sturgeon spent a longer duration in areas with high seafloor complexity, especially where a greater proportion of the substrate consists of boulders (Huff et al. 2011). However, while in estuaries where green sturgeon feed over the bottom on benthic invertebrates (Dumbauld et al. 2008), they do not appear to use hard substrates. Data from feeding pit mapping surveys conducted in Willapa Bay, Washington, showed densities were highest over shallow intertidal mud flats and lowest in subtidal areas over sand and in dense stands of non-indigenous seagrasses (Moser et al. 2017). Telemetry data indicates that, in their natal rivers, mature green sturgeon prefer deep pools, presumably for spawning and conserving/restoring energy (Erickson and Webb 2007; Heublein et al. 2009). In high-current areas, tagged green sturgeon have been shown to swim with the current near the surface and along the bottom in shallow areas, likely to maximize swimming efficiency (Kelly et al. 2020) Similar tracking studies involving juvenile green sturgeon are currently underway (Klimley et al. 2015a).

After maturity is reached at approximately 15 years of age and 150 cm total length, the Southern DPS typically spawns every 3 to 4 years (range 2 to 6 years) (Brown 2007; NMFS 2015c). Adult Southern DPS spawn in the Sacramento River primarily from April through early July, with peaks of activity likely influenced primarily by water flow (Heublein et al. 2009; Poytress et al. 2011, 2015; Steel et al. 2019). Southern DPS spawning primarily occurs in cool sections of the upper mainstem Sacramento River in deep pools containing small to medium sized gravel, cobble, or boulder substrate (Klimley et al. 2015b; Poytress et al. 2015). Eggs primarily adhere to gravel or cobble substrates, or settle into crevices (Van Eenennaam et al. 2001; Poytress et al. 2011). Eggs hatch after 6 to 8 days, and larval feeding begins 10 to 15 days post-hatch; larval development is completed within 45 days at 2.36 to 3.15 inches (60 to 80 mm) total length (TL) (Beamesderfer et al. 2007). After rearing in fresh water or the estuary of their natal river for 1 to 4 years, juvenile green sturgeon transition to the subadult stage and move from estuarine waters into coastal waters. Results from Klimley et al. (2015a) suggest that some individuals in the Southern DPS may enter the ocean and transition to the subadult life stage in their first year, but typical length of fish encountered in the ocean (>600-mm TL) suggests ocean entry occurs at a later age. Mature adults of the Northern DPS enter their natal rivers in the spring and typically leave the river during the subsequent autumn when water temperatures drop below 10 °C and flows increase (Benson et al. 2007; Erickson and Webb 2007). Thereafter, they migrate among the coastal ocean and estuarine habitats before returning again to spawn 2 to 4 years later (Erickson and Webb 2007).

Genetic and acoustic tagging data indicate little migration between spawning areas of the Northern and Southern DPSs, although they co-occur in non-natal marine and estuarine habitats to varying degrees (Israel et al. 2009; Lindley et al. 2011). Southern DPS green sturgeon have been confirmed to occur throughout the coast from Monterey Bay, California, to as far north as Graves Harbor, Alaska (NMFS 2009a). Green sturgeon observed northwest of Graves Harbor, Alaska, and south of Monterey Bay, California, have not been identified as belonging to the Northern DPS or Southern DPS. Genetic analyses indicate that green sturgeon aggregations in the Columbia River estuary and Willapa Bay have a larger proportion of Southern DPS green sturgeon (0.69 to 0.88) than Northern DPS green sturgeon, whereas Grays Harbor has a slightly larger proportion of Northern DPS green sturgeon (0.54 to 0.59) (Israel et al. 2009). A later analysis based on samples collected in 2010 to 2012 shows a similar pattern with the average proportion of Southern DPS being higher in the Columbia River (0.72) and Willapa Bay (0.63) as compared to Grays Harbor (0.40) (Schreier et al. 2016).

Spatial Structure and Diversity

Although the geographic distribution of Southern DPS green sturgeon is broad, the available spawning habitat is limited. In the final rule to list Southern DPS green sturgeon as threatened under the ESA (71 FR 17757, April 7, 2006), NMFS identified the reduction of spawning habitat to a limited area of the Sacramento River as the principal factor for the species' decline. The final rule described a substantial loss of what was likely historical spawning habitat in the upper Sacramento and upper Feather Rivers, because of the construction of impassable barriers (i.e., Keswick Dam and Oroville Dam) that block access to green sturgeon (USFWS 1995, supported by Mora et al. 2009). The final rule also described how the remaining spawning habitat was impaired by habitat alterations (e.g., increased water temperatures and altered flow regimes) and loss of access to habitat associated with impassable barriers (e.g., Red Bluff Diversion Dam (RBDD)), and other threats such as impaired water quality because of agricultural runoff.

Since publication of the final ESA-listing rule, changes have occurred that have likely improved the status of the Southern DPS green sturgeon through improvements to the quality of the habitat in the Sacramento River. These include keeping the RBDD gates open all year (beginning in 2012), allowing fish access to upstream spawning habitat (NMFS 2015a), and measures to improve fish passage at the Fremont Weir in the Yolo Bypass (where green sturgeon have been stranded in the past) (NMFS 2011a). In addition, studies have confirmed that green sturgeon spawn in the lower Feather River (Seesholtz et al. 2015). Spawning was documented in the lower Yuba River in 2018 and 2019 (Beccio 2018, 2019). Spawning habitat for the Southern DPS remains restricted, however, to a limited portion of the species' likely historical spawning habitat, exposing the Southern DPS green sturgeon to catastrophic events. Because of spawning periodicity, only a portion of the adult spawning population would be in the river in any one year. However, a single event could affect a large portion or all of the spawning habitat and thus affect a large proportion of the adult spawning population and a whole year class.

Studies have examined the genetic traits of Southern DPS green sturgeon to allow genetic differentiation from Northern DPS green sturgeon (Israel et al. 2004; Schreier et al. 2016; Anderson et al. 2017). However, little is known regarding how current levels of diversity (e.g., genetic, life history) compare with historical levels. The loss and alteration of available spawning habitat has potentially resulted in a reduction in the species' diversity. This reduction may increase the risk of extinction to the species by limiting the population's ability to withstand short-term environmental changes and to adapt to long-term environmental changes.

Abundance and Productivity

Modeling, genetic, and field-based studies, often targeting other species, have provided information on the Southern DPS green sturgeon population. However, a reliable population estimate, information on long-term trends, and trends needed to evaluate the recovery of Southern DPS green sturgeon are still lacking because data are lacking on egg-to-larva survival, juvenile recruitment, information on juveniles and subadult life stages, and mortality estimates for all life stages. Additionally, sturgeon catch in many areas was not historically reported by species or DPS.

The most useful dataset for examining population trends and inferring abundance comes from Dual Frequency Identification Sonar (DIDSON) surveys, which began in 2010. These surveys have been used to estimate the abundance of Southern DPS adults in the upper Sacramento River (current estimate 2,106 (95% confidence interval [CI] = 1,246-2,966) (Mora 2016; Mora et al. 2018). There are some caveats regarding these estimates. Movement of individual fish in and out of the area throughout the season could affect the estimate. The DIDSON surveys and associated modeling will eventually provide population abundance trends over time.

The proportion of juveniles, subadults, and adults in the Southern DPS population at equilibrium (25% juveniles, 63% subadults, and 12% adults; Beamesderfer et al. 2007) can be used to generate estimates of subadult abundance and the overall population abundance. Based on this equilibrium and the above assumptions, Mora (2018) estimated that the population consists of 11,055 subadults (95% CI = 6,540–15,571) and a total of 17,548 adults, subadults, and juveniles combined (95% confidence interval = 12,614–22,482); the SWFSC updated the total population estimate to 17,723 in 2021 (Dudley 2021).

Because we lack estimates of the historical abundance of green sturgeon for comparison to current estimates, we look to general principles in conservation biology relating population viability to population abundance. In general, an effective population size of 500 or more adults is needed for a population to be naturally self-sustaining, based on the principle that genetic drift is significant when effective population sizes are less than 500 (Franklin 1980; Soulé 1980).

Assuming that the ratio of the census to effective population size is about 0.2 for green sturgeon (based on the ratio for salmonids; green sturgeon-specific information is not available; Waples et al. 2004), the census population size needed for a naturally self-sustaining population would be 2,500 adults. The estimated current abundance of the adult population (2,106; 95% confidence interval = 1,246-2,966) is less than the estimated census population size of 2,500 adults needed for a self-sustaining population. The demographic criteria indicates a population census at or above 3,000 adult Southern DPS green sturgeon for three generations.

Little is known about green sturgeon productivity. Green sturgeon do not mature until they are about 15-17 years of age at a size of about 4.5-7 feet (1.4-2.2 m) in length (Beamesderfer et al. 2007). The length at first maturity is estimated to be 60 inches (152 cm) total length (TL) (14-16 years) for males and 64 inches (162 cm) TL (16-20 years) for females in the Klamath River (Van Eenennaam et al. 2006), and 57 inches (145 cm) TL for males and 65 inches (166 cm) TL for females in the Rogue River (Erickson and Webb 2007).

Productivity and recruitment information for Southern DPS green sturgeon is an area that requires additional research; existing data are too limited to be presented as robust estimates. Incidental catches of larval green sturgeon in the mainstem Sacramento River and of juvenile green sturgeon at the south Sacramento-San Joaquin Delta (Delta) pumping facilities suggest that green sturgeon are successful at spawning, but that annual year class strength may be highly variable (Beamesderfer et al. 2007; Adams et al. 2007). In general, sturgeon year class strength appears to be episodic with overall abundance dependent upon a few successful spawning events (NMFS 2010b). It is unclear if the population is able to consistently replace itself. This is important because the VSP concept requires that a population meeting or exceeding the abundance criteria for viability should, on average, be able to replace itself (McElhany et al. 2000). More research is needed to establish Southern DPS green sturgeon productivity. Productivity is likely reduced because of restriction of spawning to one area in the mainstem Sacramento River and its tributaries, the Yuba and Feather rivers, as well as continuing impacts on the remaining spawning habitat.

Limiting Factors

Commercial and Recreational Harvest and Bycatch

This section focuses on harvest and bycatch impacts in fisheries outside of the action area. Historically, large numbers of green sturgeon were harvested incidentally in white sturgeon commercial and recreational fisheries (Emmett et al. 1991; Adams et al. 2007). Relatively smaller numbers of green sturgeon were harvested as bycatch in the tribal gillnet salmon fisheries in the Columbia and Klamath Rivers. Fishery impacts on green sturgeon have been greatly reduced from historical levels because of increasingly restrictive fishing regulations, including bans on the retention of green sturgeon throughout California, Oregon, Washington, and Canada and revised white sturgeon fishing regulations that were enacted following the ESA listing of the Southern DPS (75 FR 30714, June 2, 2010). However, fisheries throughout the coast continue to incidentally catch green sturgeon.

Table 13 summarizes the estimated annual catch of Southern DPS green sturgeon in several fisheries occurring outside of the action area (i.e., commercial and recreational fisheries in freshwater rivers, coastal estuaries, and coastal marine waters outside of the EEZ off California, Oregon, and Washington), for which data were available. The total estimated annual catch (787 to 933 subadults and/or adults) represents 6-7% of the estimated adult and subadult population (2,106 adults and 11,055 subadults). We note that both our incidental catch and mortality estimates, and population estimates, include a high degree of uncertainty and should be considered with caution. For example, our population estimates may be underestimates because they do not consider the number of spawning adults in the lower Feather River. The incidental catch and mortality estimates may be overestimates, because some are based on historical harvest levels and they do not account for potential recapture of the same fish in multiple fisheries.

Below, we provide a brief description of how the estimates in Table 13 were generated. We do not discuss the Klamath tribal fisheries because the green sturgeon harvested in that fishery belong to the Northern DPS. Catch in fisheries occurring within the action area is discussed in Section 2.4, Environmental Baseline, of this opinion.

Table 13. Summary of estimated incidental catch and mortality of Southern DPS (sDPS) green sturgeon (number of fish) in commercial and recreational fisheries occurring outside of the action area.

Fishery	**Estimated sDPS Incidental Catch**		**Estimated sDPS Mortalities**	
	Low estimate	**High estimate**	**Low estimate**	**High estimate**
Central Valley, CA, recreational fisheries	89	202	3	5
Oregon recreational fisheries	0	33	0	2
Lower Columbia River recreational fisheries	52	52	7	11
Lower Columbia River commercial fisheries	271	271	14	14
Washington State fisheries	375	375	18	18
TOTAL	787	933	42	50

In California, the commercial sturgeon fishery has been closed since 1917 (Pycha 1956), but recreational white sturgeon fisheries exist in the Central Valley (i.e., the Sacramento and lower Feather Rivers, the Delta, and the San Francisco, San Pablo, and Suisun Bays) (Adams et al. 2007). CDFW sturgeon report card data from 2007 through 2016 provide information on incidental catch of green sturgeon, indicating 215 to 311 fish caught per year from 2007 to 2009 and 89 to 202 fish per year in 2010 through 2016, after enactment of sturgeon fishing area closures in 2010 (Gleason et al. 2008; Dubois et al. 2009, 2010, 2011, 2012; Dubois 2013; Dubois and Harris 2015, 2016; Dubois and Danos 2017). We assume that all of the green sturgeon caught and released were Southern DPS green sturgeon, based on genetic and tagging data that indicate only Southern DPS green sturgeon use the Central Valley rivers, bays, and delta (Lindley et al. 2008; Israel et al. 2009). Given continued implementation of the sturgeon fishing area closures, we estimate the fisheries incidentally catch 89 to 202 Southern DPS green sturgeon per year (including subadults and adults) and kill about 3 to 5 fish per year (using an estimated bycatch mortality rate of 2.6% for hook-and-line fisheries) (Robichaud et al. 2006).

In Oregon, green sturgeon were historically harvested in the state-regulated commercial trawl fisheries (part of the federal groundfish fishery, discussed in the Environmental Baseline section of this opinion) and in recreational sturgeon fisheries conducted in coastal estuaries. Harvest of green sturgeon in the recreational fisheries has been reduced compared to historical levels to 6 to 59 fish per year from 2008 through 2015, with no reported green sturgeon catches in 2011 through 2013 (excluding fisheries in the Columbia River) (ODFW 1995–2015). Assuming that 16% to 55% of the green sturgeon caught in Oregon belong to the Southern DPS (based on genetic stock composition analysis) (Israel et al. 2009), we estimate that the recreational fisheries incidentally catch 0 to 33 and kill 0 to 2 Southern DPS green sturgeon per year (using an estimated bycatch mortality rate of 2.6% for hook-and-line fisheries) (Robichaud et al. 2006).

In the lower Columbia River estuary, green sturgeon incidental catch has been much reduced because of management actions implemented to control white sturgeon harvest and prohibitions on the retention of green sturgeon. A recent analysis estimated that recreational fisheries may incidentally catch up to 52 and kill 7 to 11 Southern DPS green sturgeon per year and commercial fisheries may incidentally catch up to 271 and kill up to 14 Southern DPS green sturgeon per year (NMFS 2008a).

In Washington, harvest of green sturgeon primarily occurred in state-regulated commercial and recreational fisheries targeting white sturgeon or salmon in the large coastal estuaries. Estimated incidental catch of green sturgeon was as high as 1,000 to 2,000 fish per year in Grays Harbor and Willapa Bay, but has since been reduced because of management measures (WDFW 2011b). WDFW estimates that state commercial and recreational fisheries (excluding the Columbia River fisheries, which are addressed separately above) may incidentally catch up to 375 and kill up to 18 Southern DPS green sturgeon per year (Kirt Hughes, WDFW, email to Phaedra Doukakis, NMFS, January 30, 2015, regarding revised estimates of Southern DPS green sturgeon). These are conservative estimates (potentially overestimates), based on the maximum historical harvest levels (expanded to include green sturgeon smaller or larger than the legal fishing slot limit) recorded during a time when the salmon and white sturgeon fishing seasons were structured similarly to what is expected in the future (WDFW 2011b).

Bycatch of green sturgeon also occurs in commercial fisheries off British Columbia and Alaska. Canada prohibits retention of green sturgeon in all fisheries. Green sturgeon are encountered in the commercial groundfish trawl fishery in British Columbia. Between 1996 and 2013, 36,156 pounds of green sturgeon were reported as bycatch, with the number of individual sturgeon unknown because bycatch is recorded only by weight (Fisheries and Oceans Canada 2016). Approximately 87% of this bycatch occurred off the northwest coast of Vancouver Island, with the remainder off the west coast of Vancouver Island (9%), and in Hecate Strait and Queen Charlotte Sound (4%). From 2014 to 2016, 1,092 pounds of green sturgeon were discarded from the bottom trawl fishery (A. Keizer, DFO, email to Phaedra Doukakis, NMFS, and Robert Tadey, DFO, January 5, 2017, regarding Pacific halibut and groundfish bottom trawl fisheries). The North Pacific Groundfish Observer Program, which observes federal groundfish fisheries off Alaska, has recorded rare encounters with green sturgeon in trawl fisheries in the Bering Sea, including one fish in 1982; two fish in 1984; one fish in 2005; three fish in 2006; and one fish per year in 2009, 2012, 2013, and 2015 (NPGOP data received April 2015). It is unknown whether the green sturgeon encountered belonged to the Northern or Southern DPS. Green sturgeon are rarely encountered in coastal waters off Baja California, Mexico, and fishery impacts in Mexican waters are likely negligible.

Other Limiting Factors

Green sturgeon face several additional threats in the freshwater, estuarine, and marine environments within which they move throughout their life, including reduction/loss of spawning and rearing habitat, insufficient freshwater flow rates in spawning and rearing habitats, contaminants (e.g., pesticides), potential poaching, entrainment by water projects, vessel strikes, influence of exotic species, small population size, impassable barriers, and elevated water temperatures (Adams et al. 2007; NMFS 2010b; NMFS 2021d). As discussed above, the principal factor in the ESA-listing of Southern DPS green sturgeon was the reduction of its spawning habitat to a single area in the Sacramento River and two of its tributaries because of migration barriers (e.g., dams) and habitat alterations, increasing the vulnerability of the spawning population to catastrophic events and of early life stages to variable environmental conditions within the system. Threats to the single remaining spawning population, coupled with the inability to alleviate those threats using current conservation measures, led to the decision to list the species as threatened.

2.2.1.3. Life-History and Status of the Puget Sound Chinook ESU

This ESU was listed as a threatened species in 1999. Its threatened status was reaffirmed June 28, 2005 (70 FR 37160), and again on April 14, 2014 (79 FR 20802). Critical Habitat for Puget Sound Chinook salmon was designated on September 2, 2005 (70 FR 52629). There are 61 watersheds within the range of this ESU. Habitat areas for this ESU also include 2,216 mi (3,566 km) of stream and 2,376 mi (3,824 km) of nearshore marine areas, which includes that zone from extreme high water out to a depth of 30 meters and adjacent to watersheds occupied by the ESU. The Puget Sound Chinook Salmon ESU includes all naturally spawned populations of Chinook salmon from rivers and streams flowing into Puget Sound including the Strait of Juan de Fuca from the Elwha River, westward, including rivers and streams flowing into Hood Canal, South Sound, North Sound and the Strait of Georgia in Washington (64 FR 14208).

On October 4, 2019 NMFS published notice of NMFS's intent to initiate a new 5-year status review for 28 listed species of Pacific salmon and steelhead and requested updated information from the public to inform the status review (84 FR 53117). The NWFSC finalized its updated biological viability assessment for Northwest Pacific salmon and steelhead listed under the ESA (Ford 2022) in January of 2022. NMFS's WCR is currently preparing the 5-year status review for Puget Sound Chinook salmon.

NMFS adopted the recovery plan for Puget Sound Chinook on January 19, 2007 (72 FR 2493). The recovery plan consists of two documents: the Puget Sound Salmon Recovery Plan prepared by the Shared Strategy for Puget Sound (Puget Sound Salmon Recovery Plan) (SSPS 2007) and Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan (NMFS 2006a). The recovery plan adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT) (PSTRT 2002; Ruckelshaus et al. 2006). The PSTRT's Biological Recovery Criteria will be met when the following conditions are achieved:

1. All watersheds improve from current conditions, resulting in improved status for the species;
2. At least two to four Chinook salmon populations in each of the five biogeographical regions of Puget Sound attain a low risk status over the long-term[2];
3. At least one or more populations from major diversity groups historically present in each of the five Puget Sound regions attain a low risk status;

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[2] The number of populations required to be at low-risk status depends on the number of diversity groups in the region. For example, three of the regions only have two populations generally of one diversity type; the Central Sound Region has two major diversity groups; the Whidbey/Main Region has four major diversity groups.

4. Tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations are functioning in a manner that is sufficient to support an ESU-wide recovery scenario;
5. Production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery.

Spatial Structure and Diversity

The Puget Sound ESU includes all naturally spawned Chinook salmon originating from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound and the Strait of Georgia. The PSTRT determined that 22 of the historical populations within the Puget Sound ESU currently contain Chinook salmon and grouped them into five major geographic regions, based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity (Table 14). Based on genetic and historical evidence reported in the literature, the PSTRT also determined that there were 16 additional spawning aggregations or populations in the Puget Sound Chinook Salmon ESU that are now putatively extinct[3] (Ruckelshaus et al. 2006).

The ESU also includes Chinook salmon from certain artificial propagation programs. Artificial propagation (hatchery) programs (26) were added to the listed Puget Sound Chinook Salmon ESU in 2005, as part of the final listing determinations for 16 ESUs of West Coast Salmon and Final 4(d) Protective Regulations for Threatened Salmonid ESUs (70 FR 37160). In October of 2016, NMFS proposed revisions to the hatchery programs included as part of some Pacific salmon ESUs and steelhead DPSs listed under the ESA (81 FR 72759). NMFS issued its final rule in December of 2020 (85 FR 81822). This final rule includes 25 hatchery programs as part of the listed Puget Sound Chinook Salmon ESU: Kendall Creek Hatchery Program; Marblemount Hatchery Program (spring-run); Marblemount Hatchery Program (summer-run); Brenner Creek Hatchery Program ; Harvey Creek Hatchery Program ; Whitehorse Springs Hatchery Program; Wallace River Hatchery Program (yearlings and subyearlings); Issaquah Creek Hatchery Program; White River Hatchery Program; White River Acclimation Pond Program; Voights Creek Hatchery Program; Clarks Creek Hatchery Program; Clear Creek Hatchery Program; Kalama Creek Hatchery Program; George Adams Hatchery Program; Hamma Hamma Hatchery Program; Dungeness/Hurd Creek Hatchery Program; Elwha Channel Hatchery Program; Skookum Creek Hatchery Spring-run Program; Bernie Kai-Kai Gobin (Tulalip) Hatchery-Cascade Program; North Fork Skokomish River Spring-run Program; Soos Creek Hatchery Program (subyearlings and yearlings); Fish Restoration Facility Program; Bernie Kai-Kai Gobin (Tulalip) Hatchery-Skykomish Program; and Hupp Springs Hatchery-Adult Returns to Minter Creek Program.

Table 14. Extant Puget Sound Chinook salmon populations in each geographic region (Ruckelshaus et al. 2006).

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[3] It was not possible in most cases to determine whether these Chinook salmon spawning groups historically represented independent populations or were distinct spawning aggregations within larger populations.

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

Note: NMFS has determined that the **bolded** populations, in particular, are essential to recovery of the Puget Sound Chinook Salmon ESU. In addition, at least one other population within the Whidbey Basin and Central/South Puget Sound Basin regions would need to be viable for recovery of the ESU. The PSTRT noted that the Nisqually watershed is in comparatively good condition, and thus the certainty that the population could be recovered is among the highest in the Central/South Region. NMFS concluded in its supplement to the Puget Sound Salmon Recovery Plan that protecting the existing habitat and working toward a viable population in the Nisqually watershed would help to buffer the entire region against further risk (NMFS 2006a).

Three of the five regions (Strait of Juan de Fuca, Georgia Basin, and Hood Canal) identified by the PSTRT contain only two populations, both of which must be recovered to viability to recover the ESU (NMFS 2006a). Under the Puget Sound Salmon Recovery Plan, the Suiattle and one each of the early, moderately early, and late run-timing populations in the Whidbey Basin Region, as well as the White and Nisqually (or other late-timed) populations in the Central/South Sound Region must also achieve viability (NMFS 2006a).

The PSTRT did not define the relative roles of the remaining populations in the Whidbey and Central/South Sound Basins for ESU viability. Therefore, NMFS developed additional guidance which considers distinctions in genetic legacy and watershed condition, among other factors, in assessing the risks to survival and recovery of the listed species by the proposed actions across all populations within the Puget Sound Chinook ESU. In assessing these risks, it is important to consider whether the genetic legacy of the particular population is intact or if it is no longer distinct within the ESU, a condition which is usually due to use of non-local stocks in historic hatchery practices. Populations are defined by their relative isolation from each other and by the unique genetic characteristics that evolve, as a result of that isolation, and adaptation to their specific habitats. If these populations still retain their historic genetic legacy, then the appropriate course, to ensure their survival and recovery, is to preserve that genetic legacy and rebuild those populations. Preserving that legacy requires both a sense of urgency and the actions necessary and appropriate to preserve the legacy that remains. However, if the genetic legacy is gone, then the appropriate course is to recover the populations using the individuals that best approximate the genetic legacy of the original population, reduce the effects of the factors that have limited their production, and provide the opportunity for them to readapt to the existing conditions.

In keeping with this approach, NMFS's guidance further classified Puget Sound Chinook salmon populations into three tiers based on a systematic framework that considers the genetic legacy of the population, the population's life history, and production and watershed characteristics (NMFS 2010a) (Figure 11). This framework, termed the *Population Recovery Approach (PRA)*, carries forward the biological viability and delisting criteria described in the Supplement to the Puget Sound Salmon Recovery Plan (PSTRT 2002; NMFS 2006a). The assigned tier indicates the relative role of each of the 22 populations comprising the ESU to the viability of the ESU and its recovery. Tier 1 populations are most important for preservation, restoration, and ESU recovery. Tier 2 populations play a less important role in recovery of the ESU. Tier 3 populations play the least important role. When we analyze proposed actions, we evaluate impacts at the individual population scale for their effects on the viability of the ESU. We expect that impacts on Tier 1 populations would be more likely to affect the viability of the ESU, as a whole, than similar impacts on Tier 2 or 3 populations, because of the relatively greater importance of Tier 1 populations to overall ESU viability and recovery. NMFS has incorporated this and similar approaches in previous ESA section 4(d) determinations and opinions on Puget Sound salmon fisheries and regional recovery planning (NMFS 2005; 2008i; 2008h; 2010a; 2011c; 2013c; 2014b; 2015e; 2016h; 2017b; 2018d; 2019c; 2020d; 2021g; 2022)

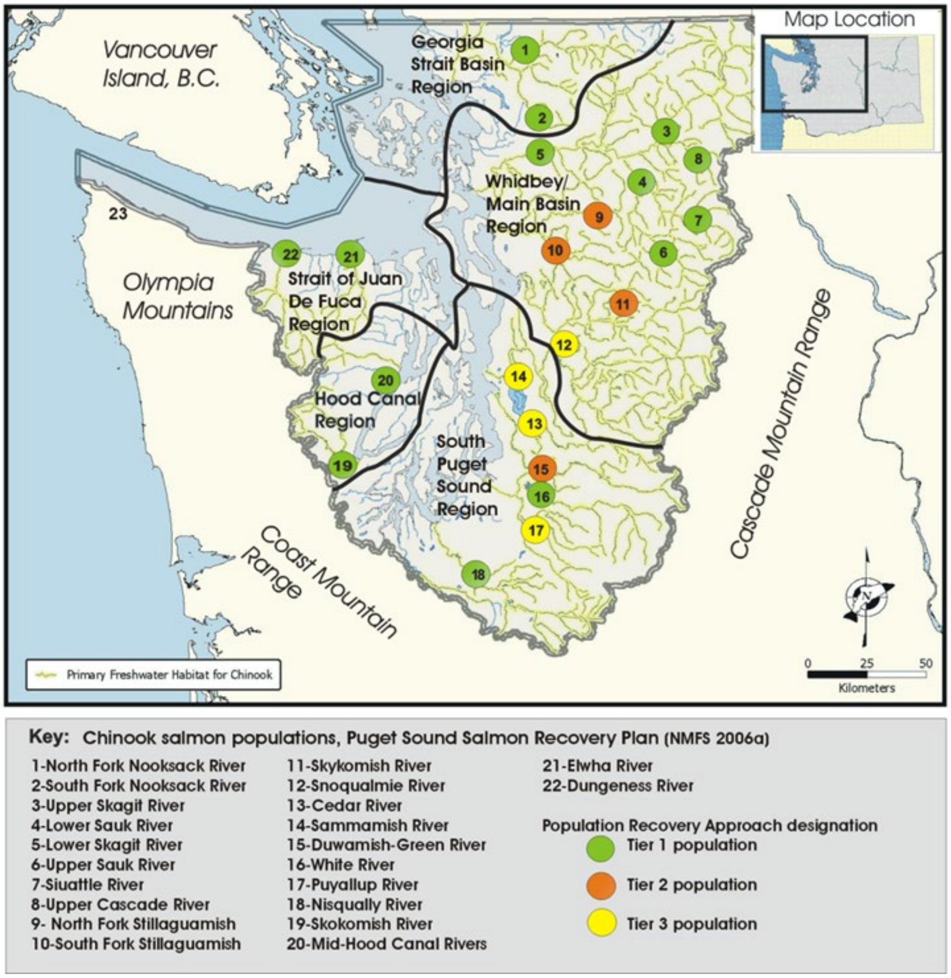

Figure 11. Map of Puget Sound Chinook salmon populations.

Measures of spatial structure and diversity can give some indication of the resilience of a population to sustain itself. Spatial structure can be measured in various ways, but here we assess the proportion of natural-origin spawners (wild fish) vs. hatchery-origin spawners on the spawning grounds (Ford 2022).

Over the long-term (since 1990), there is a general declining trend in the proportion of natural-origin spawners across the ESU (Table 15). While there are several populations that have maintained high levels of natural-origin spawner proportions, mostly in the Skagit and Snohomish basins, many others have continued the trend of high proportions of hatchery-origin spawners in the most recent available period (Table 15). It should be noted that the pre-2005-2009 estimates of mean natural-origin fractions occurred prior to the widespread adoption of mass marking of hatchery produced fish for key populations in Hood Canal and South Puget Sound. Estimates of hatchery and natural-origin proportions of fish since the implementation of mass marking are considered more robust. Several of these populations have long-standing or more recent conservation hatchery programs associated with them — North Fork (NF) and South Fork (SF) Nooksack, NF and SF Stillaguamish, White River, Dungeness, and the Elwha. These conservation programs are in place to maintain or increase the overall abundance of these populations which are in critical status; helping to conserve the diversity and increase the spatial distribution of these populations in the absence of properly functioning habitat. These conservation hatchery programs culture the extant, native Chinook salmon stock in these basins. With the exception of the NF and SF Stillaguamish, the populations included in these conservation programs are identified in NMFS (2006b) as essential for the recovery of the Puget Sound Chinook Salmon ESU (Table 15).

Table 15. Five-year mean of fraction of natural-origin Chinook salmon spawners[4] (sum of all estimates divided by the number of estimates) (Ford 2022).

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

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[4] Estimates of hatchery and natural-origin spawning abundances, prior to the 2005–2009 period are based on pre-mass marking of hatchery-origin fish and, as such, may not be directly comparable to the 2005–2009 forward estimates.

Population	1995–1999	2000–2004	2005–2009	2010–2014	2015–2019
Elwha R. fall*	0.41	0.53	0.35	0.06	0.05

*Denotes populations with conservation hatchery programs in place.

In addition, spatial structure, or geographic distribution, of the White, Skagit, Elwha[5] and Skokomish populations have been substantially reduced or impeded by the loss of access to the upper portions of those tributary basins due to flood control activities and hydropower development. Habitat conditions conducive to salmon survival in most other watersheds have been reduced significantly by the effects of land use, including urbanization, forestry, agriculture, and development (SSPS 2007; NMFS 2008d; 2008e; 2008b). It is likely that genetic and life history diversity has been significantly adversely affected by this habitat loss.

Puget Sound Chinook salmon are harvested in ocean salmon fisheries, in Puget Sound fisheries, and in terminal fisheries in the rivers. They migrate to the north, so for most Puget Sound Chinook salmon populations, the majority of the ocean fishery impacts occur in Canada, and for some populations, additional small to moderate impacts occur in Alaska. The fisheries in these areas are subject to the PST. Some populations are also harvested at lower rates in the coastal fisheries off Washington and Oregon. Chinook salmon populations in Puget Sound generally show a similar pattern: declining ERs in the 1990s, and relatively stable-to-increasing ERs since then (Figures 12 through 14). Long term trends in ER for Puget Sound stocks are available for 1992 through 2018 from recently completed postseason Fishery Regulation Assessment Model (FRAM) model runs (Oct 2022) (pers. comm. J. Carey, NMFS West Coast Region (WCR)). That information is incorporated into the region-specific discussions that follow.

ERs on Strait of Juan de Fuca and Mid-Hood Canal Chinook salmon populations have generally declined since the early 1990s. Total ERs for Strait of Juan de Fuca populations, which averaged 35% from 1992-99, have since decreased to an average of 26% between 2009 and 2018 (Figure 12). Total ERs for the Mid-Hood Canal population averaged 34% between 1992 and 1999 but have since decreased to an average of 25% between 2009 and 2018 (Figure 12). Total ERs for the Skokomish population averaged 42% between 1992 and 1999. After a period of increased harvest from 2000-08 where the ER averaged 5%, the ER on the Skokomish population decreased slightly, and has averaged 56% since 2009 (Figure 12). The distribution of mortality accrued in marine fisheries is described in detail in the Environmental Baseline (Section 2.4)

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

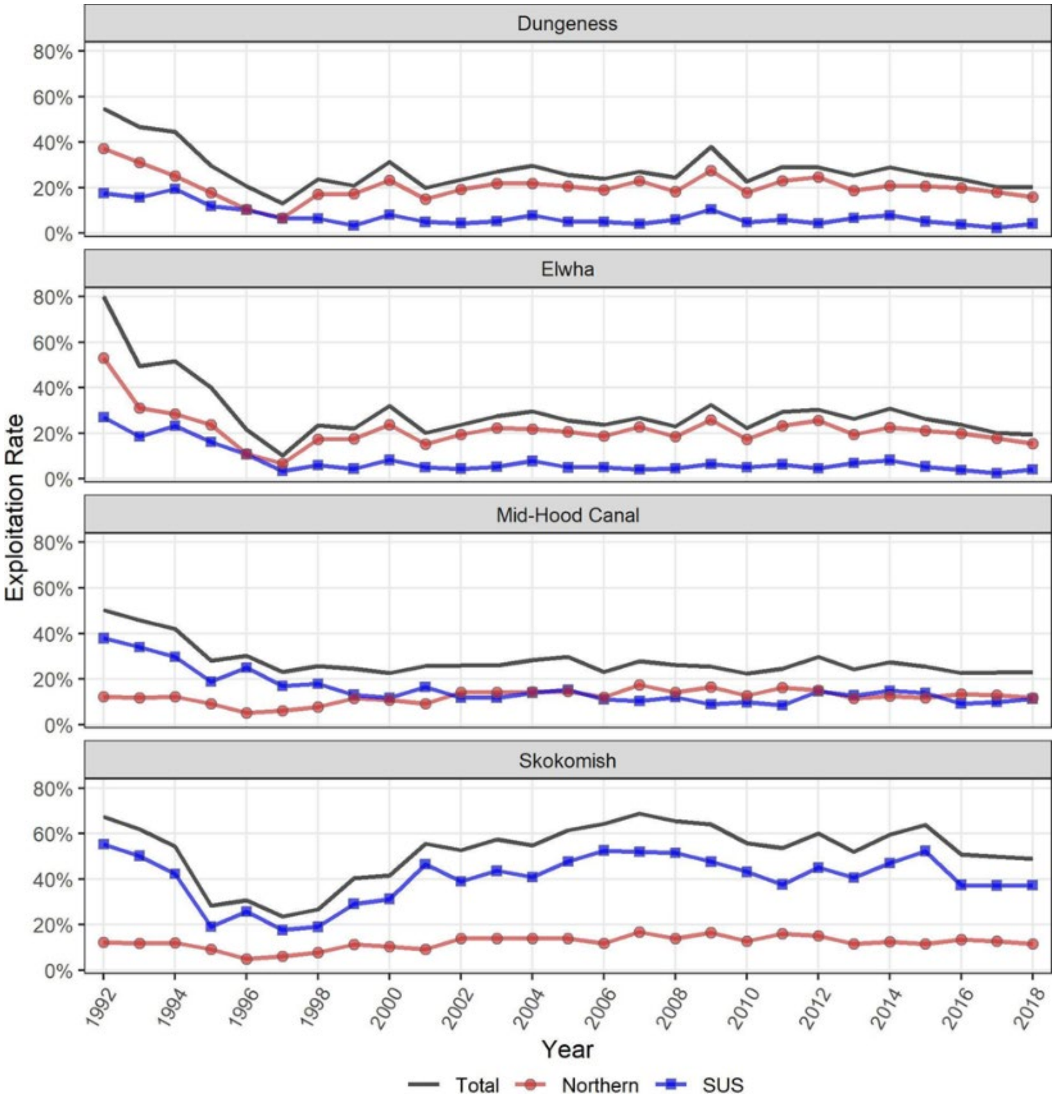

Figure 12. Total harvest exploitation of Hood Canal and Strait of Juan de Fuca Puget Sound Chinook salmon populations from (pers. comm. J. Carey, NMFS WCR). SUS = Southern United States.

ERs on populations in northern Puget Sound have steadily declined since the mid-1980s (Figure 13). From 1992-99 the total ER on Nooksack River spring Chinook salmon averaged 41% (Figure 13). Between 2009 and 2018 the total ER for all fisheries declined to an average of 31% (Figure 13). From 1992 to 1999, average total ERs were 41% for Stillaguamish River Chinook salmon and 45% for Skagit River summer/fall stocks (Figure 13). Between 2009 and 2018, total ERs declined to averages of 31% for Stillaguamish River Chinook salmon and 44% for Skagit River summer/fall stocks (Figure 13) (see Environmental Baseline for geographic distribution of the ERs).

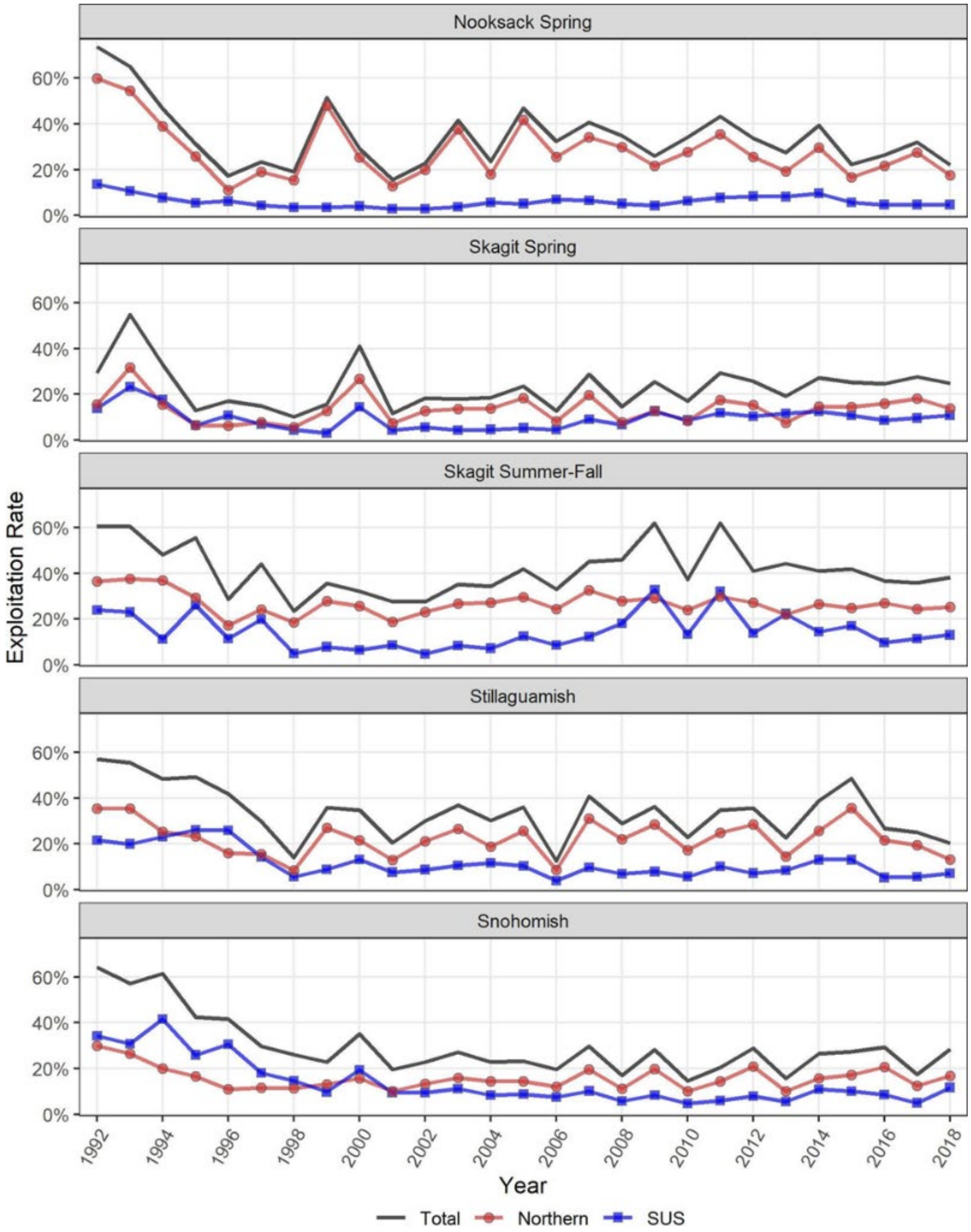

Figure 13. Total harvest exploitation of northern Puget Sound Chinook salmon populations from (pers. comm. J. Carey, NMFS WCR).

ERs on the Puget Sound Chinook salmon populations in Lake Washington and the Duwamish/Green and White rivers have also declined since the early 1990s (Figure 14). From 1992-99, average total ERs ranged from 30% (White River Spring) to 74% (Nisqually). Between 2009 and 2018, total ERs averaged 24% (White River Spring) to 52% (Nisqually) representing a decrease of 28-55% in ERs (Figure 14) (see Environmental Baseline for geographic distribution of the ERs).

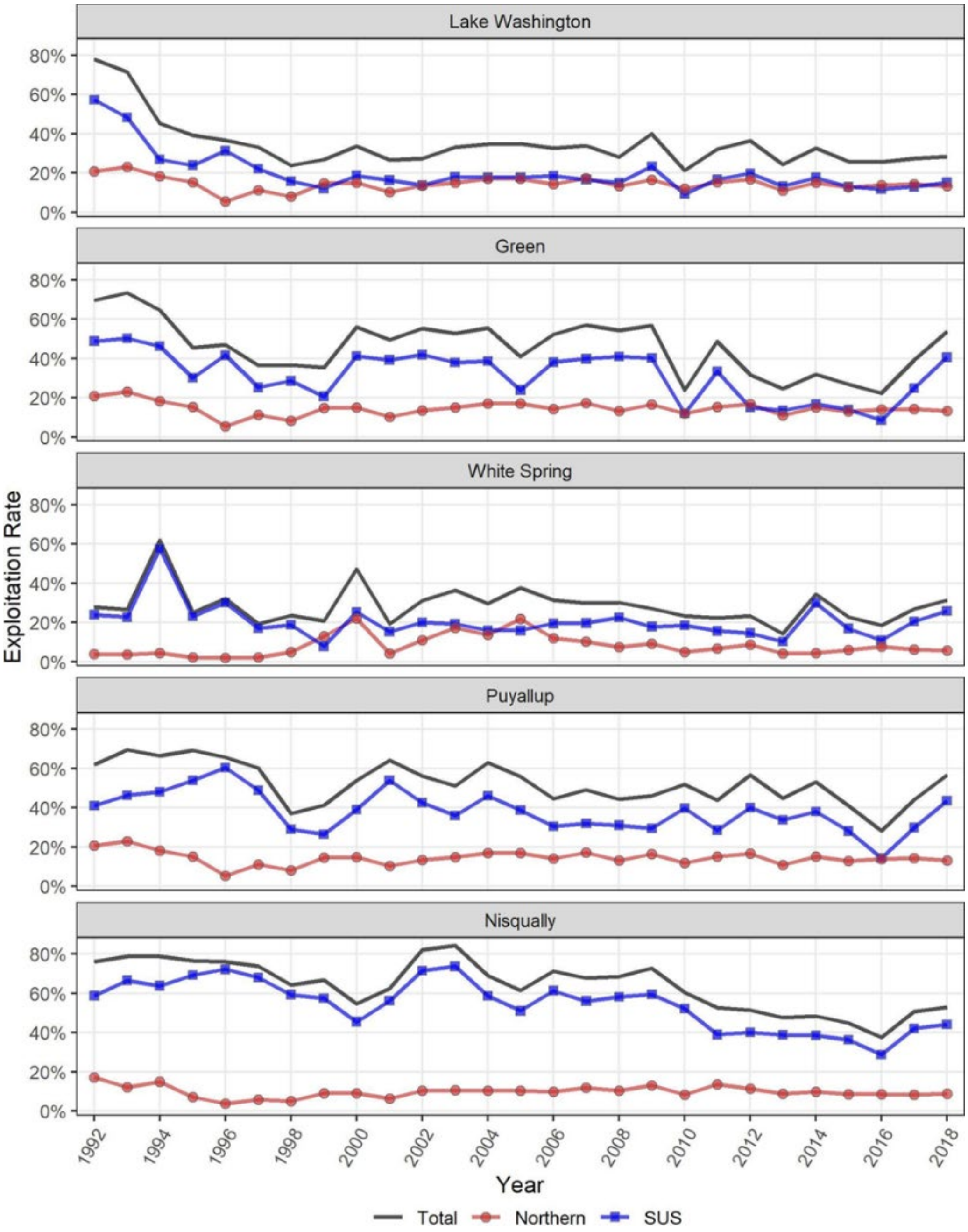

Figure 14. Total harvest exploitation of mid- and south-Puget Sound Chinook salmon populations from (pers. comm. J. Carey, NMFS WCR).

Abundance and Productivity

Total abundance in the ESU over the entire time series shows that trends for individual populations are mixed. Generally, many populations experienced increases in total abundance during the years 2000-08, and more recently in 2015-17, but general declines during 2009-14, and a downturn again in the two most recent years for which data are available, 2018-19 (Figure 15). The downturn in the most recent years was likely associated with the period of anomalously warm sea surface temperatures in the northeast Pacific Ocean that developed in 2013 and continued to persist through much of 2015; this phenomenon was termed “the Blob.” During the persistence of the Blob, distribution of marine species was affected (e.g., tropical and subtropical species were documented far north of their usual ranges), marine mammals and seabirds starved, and a coastwide algal bloom that developed in the summer of 2015 resulted in domoic acid poisoning of animals at various trophic levels, from crustaceans to marine mammals. Chinook salmon returning in 2017 and 2018 would have reached maturation in the ocean during these years, experiencing lower marine survival as a result of the hostile ocean conditions.

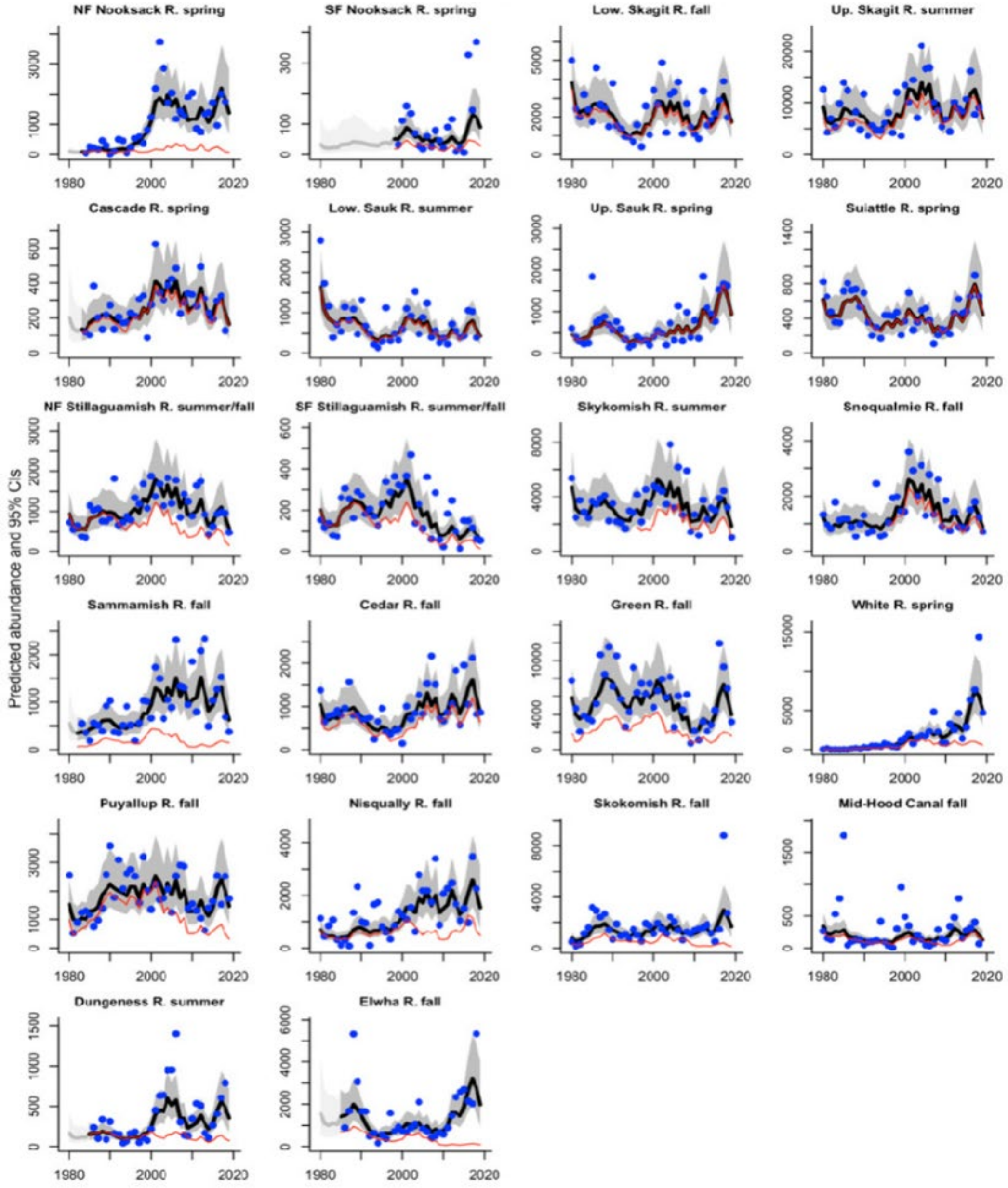

Figure 15. Smoothed trend in estimated total (thick black line) and natural-origin (thin red line) Puget Sound Chinook Salmon ESU individual populations spawning abundance. Points show the annual raw spawning abundance estimates (Ford 2022).

Abundance across the Puget Sound ESU has generally increased since the last status review, with only 2 of the 22 populations (Cascade and North Fork Stillaguamish) showing a negative percent change in the 5-year geometric mean natural-origin spawner abundances compared with the prior status review (Table 16). Several populations (North Fork and South Fork Nooksack, Sammamish, Green, White, Puyallup, Nisqually, Skokomish, Dungeness and Elwha) are dominated by hatchery returns. Fifteen of the remaining 20 populations with positive percent change in the 5-year geometric mean natural-origin spawner abundances since the prior status review have relatively low natural spawning abundances of < 1000 fish, so some of these increases represent small changes in total abundance (Ford 2022). As with the table above (Table 15), showing the 5-year mean proportions of natural-origin spawners, it should be noted again that the pre-2005-09 estimates of mean natural-origin fractions occurred prior to the widespread adoption of mass marking of hatchery produced fish, likely overestimating the proportion of natural-origin spawners. Estimates of hatchery and natural-origin proportions of fish since the implementation of mass marking are considered more robust (NMFS 2022).

Table 16. Five-year geometric mean of raw natural-origin Chinook salmon spawner counts. This is the raw total spawner estimate times the fraction natural-origin estimate, if available. In parentheses, 5-year geometric mean of raw total spawner estimates (i.e., hatchery and natural) are shown. A value only in parentheses means that a total spawner estimate was available but no (or only one) estimate of natural-origin spawners was available. The geometric mean was computed as the product of estimates raised to the power 1 over the number of counts available (2-5). A minimum of 2 values were used to compute the geometric mean. Percent change between the most recent two 5-year periods is shown on the far right (Ford 2022).

Population	Region	1990-94	1995-99	2000-04	2005-09	2010-14	2015-19	Percent Change
NF Nooksack R. spring	Strait of Georgia	51 (102)	95 (471)	229 (2,186)	275 (1,536)	136 (1,205)	137 (1,553)	1 (29)
SF Nooksack R. spring	Strait of Georgia	-	-	44 (87)	22 (41)	13 (35)	42 (106)	223 (203)
Low. Skagit R. fall	Whidbey Basin	1,332 (1,474)	971 (1,035)	2,531 (2,774)	1,916 (2,228)	1,416 (1,541)	2,130 (2,640)	50 (71)
Up. Skagit R. summer	Whidbey Basin	3,970 (5603)	5,641 (6,185)	10,723 (12,410)	8,785 (10,525)	7,072 (7,457)	9,568 (10,521)	35 (41)
Cascade R. spring	Whidbey Basin	151 (188)	209 (213)	340 (371)	302 (342)	298 (317)	185 (223)	-38 (-30)
Low. Sauk R. summer	Whidbey Basin	384 (409)	403 (429)	820 (846)	543 (569)	376 (416)	635 (649)	69 (56)
Up. Sauk R. spring	Whidbey Basin	404 (408)	265 (267)	427 (427)	506 (518)	854 (880)	1,318 (1,330)	54 (51)
Suiattle R. spring	Whidbey Basin	288 (302)	378 (382)	402 (415)	258 (261)	376 (378)	640 (657)	70 (74)
NF	Whidbey	731	677	1,089	493	417	302	-28 (-23)

Stillaguamish R. summer/fall	Basin	(913)	(1,177)	(1,553)	(1,262)	(996)	(762)	
SF Stillaguamish R. summer/fall	Whidbey Basin	148 (185)	176 (305)	196 (280)	51 (131)	34 (68)	37 (96)	9 (41)
Skykomish R. summer	Whidbey Basin	(2,398)	1,497 (3,331)	2,377 (4,849)	2,568 (3,378)	1,689 (2,462)	1,736 (2,806)	3 (14)
Snoqualmie R. fall	Whidbey Basin	(963)	1,427 (1,279)	2,036 (2,477)	1,308 (1,621)	839 (1,082)	856 (1,146)	2 (6)
Sammamish R. fall	Central/ South PS	197 (576)	149 (564)	336 (1,031)	171 (1,278)	82 (1,289)	126 (879)	54 (-32)
Cedar R. fall	Central/ South PS	385 (562)	276 (497)	379 (646)	1,017 (1,249)	699 (914)	889 (1,253)	27 (37)
Green R. fall	Central/ South PS	2,697 (5,420)	3,856 (7,274)	2,800 (6,542)	1,305 (3,149)	785 (2,109)	1,822 (6,373)	132 (202)
White R. spring	Central/ South PS	269 (378)	242 (616)	1,159 (1,461)	839 (2,099)	652 (2,161)	895 (6,244)	37 (189)
Puyallup R. fall	Central/ South PS	2,146 (2,547)	2,034 (2,348)	1,378 (1,794)	1,006 (2,054)	450 (1,134)	577 (1,942)	28 (71)
Nisqually R. fall	Central/ South PS	610 (781)	577 (723)	689 (1,296)	551 (1,899)	481 (1,823)	766 (1,841)	59 (1)
Skokomish R. fall	Hood Canal	505 (993)	478 (1,233)	479 (1,556)	500 (1,216)	136 (1,485)	265 (2,074)	95 (40)
Mid-Hood Canal fall	Hood Canal	94 (120)	78 (103)	169 (217)	47 (88)	80 (295)	196 (222)	145 (-25)
Dungeness R. summer	SJF	117 (117)	104 (104)	99 (520)	151 (374)	66 (279)	114 (476)	73 (71)
Elwha R. fall	SJF	428 (673)	275 (735)	491 (995)	140 (605)	71 (1,349)	134 (2,810)	89 (108)

Since 1999, most Puget Sound Chinook populations have mean natural-origin spawner escapement levels well below levels identified as required for recovery to low extinction risk (Table 17). Long-term, natural-origin mean escapements for eight populations are at or below their critical thresholds[6]. Both populations in three of the five biogeographical regions are below or near their critical threshold: Georgia Strait, Hood Canal and Strait of Juan de Fuca (Table 17). When hatchery spawners are included, aggregate average escapement is over 1,000 for one of the two populations in each of these three regions, reducing the demographic risk to the populations

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[6] After taking into account uncertainty, the critical threshold is defined as a point below which: (1) depensatory processes are likely to reduce the population below replacement; (2) the population is at risk from inbreeding depression or fixation of deleterious mutations; or (3) productivity variation due to demographic stochasticity becomes a substantial source of risk (NMFS 2000b).

in these regions. Additionally, hatchery spawners help two of the remaining three of these populations achieve total spawner abundances above their critical threshold, reducing demographic risk. Nine populations are above their rebuilding thresholds[7], seven of them in the Whidbey/Main Basin Region. In 2018, NMFS and the NWFSC updated the rebuilding thresholds for several key Puget Sound populations. These thresholds represent the MSY estimate of spawners based on available habitat. The new spawner-recruit analyses for several populations indicated a significant reduction in the number of spawners that can be supported by the available habitat when compared to analyses conducted 10-15 years ago. This may be due to further habitat degradation or improved productivity assessment or, more likely, a combination of the two. For example, the updated rebuilding escapement threshold for the Green River is 1,700 spawners compared to the previous rebuilding escapement threshold of 5,523[8] spawners. So, although several populations are above the updated rebuilding thresholds, indicating that escapement is sufficient for the available habitat in many cases, the overall abundance has declined.

Long-term growth rates of natural-origin escapement are generally higher than growth rates of natural-origin recruitment (i.e., abundance prior to fishing) indicating some stabilizing influence on escapement, possibly from past reductions in fishing-related mortality (Table 18). This indicates that, over time, a higher proportion of the natural-origin production from these rivers has been making it to escapement. Since 1990, 13 populations show long-term growth rates that are at or above replacement for natural-origin escapement including populations in four of five regions. Currently, only five populations, in two regions, show long-term neutral to positive growth rates in natural-origin recruitment (Table 18). Additionally, most populations are consistently well below the productivity goals identified in the recovery plan (Table 17). Although long-term trends (1990 forward) vary for individual populations across the ESU, currently 20 populations exhibit a stable or increasing trend in total natural escapement (Table 18). Thirteen of 22 populations show a growth rate in the geometric mean natural-origin spawner escapement that is greater than or equal to 1.00 (Table 18).

Even given some of the incremental increases in natural-origin spawner abundances in the most recent five-year period (Table 16), the long-term trends in both abundance and productivity, in most Puget Sound populations, are well below the levels necessary for recovery (Table 18).

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[7] The rebuilding threshold is defined as the escapement that will achieve MSY under current environmental and habitat conditions (NMFS 2000b), and is based on an updated spawner-recruit assessment in the Puget Sound Chinook Harvest Management Plan, December 1, 2018. Thresholds were based on population-specific data, where available.

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

Table 17. Long-term estimates of escapement and productivity (recruits/spawner) for Puget Sound Chinook populations. Natural origin escapement information is provided where available. Populations at or below their critical escapement threshold are bolded. Populations exceeding their rebuilding natural-origin escapement threshold are underlined.

Region	Population (MU = Management Unit)	1999 to 2018 Run Year Geometric mean Escapement (Spawners)		NMFS Escapement Thresholds		Recovery Planning Abundance Target in Spawners (productivity)	Average % hatchery fish in escapement 1999–2018 (min-max)[5]
		Natural [1]	Natural-Origin (Productivity[2])	Critical[3]	Rebuilding[4]		
Georgia Basin	Nooksack MU	1,798	236	400	500		
	NF Nooksack	1,532	**180** (0.3)	*200*[6]	-	3,800 (3.4)	86 (63-97)
	SF Nooksack	266	**56** (1.9)	*200*[6]	-	2,000 (3.6)	51 (19-82)
Whidbey/Main Basin	Skagit Summer/Fall MU						
	Upper Skagit River	9,349	8,314 (2.7)	738	5,740	5,380 (3.8)	11 (2-36)
	Lower Sauk River	560	531 (3.1)	*200*[6]	371	1,400 (3.0)	5 (0-33)
	Lower Skagit River	2,090	1,845 (2.8)	281	2,131	3,900 (3.0)	9 (0-23)
	Skagit Spring MU						
	Upper Sauk River	633	624 (2.2)	130	470	750 (3.0)	1 (0-5)
	Suiattle River	379	372 (2.0)	170	223	160 (2.8)	2 (0-7)
	Upper Cascade River	289	260 (1.5)	130	148	290 (3.0)	7 (0-25)
	Stillaguamish MU						
	NF Stillaguamish R.	1,029	472 (0.9)	300	550	4,000 (3.4)	51 (25-80)
	SF Stillaguamish R.	122	**58** (1.2)	*200*[6]	300	3,600 (3.3)	48 (9-79)
	Snohomish MU						
	Skykomish River	3,193	2,212 (1.5)	400	1,491	8,700 (3.4)	28 (0-62)
	Snoqualmie River	1,449	1,182 (1.3)	400	816	5,500 (3.6)	18 (0-35)
Central/South Sound	Cedar River	924	659 (2.7)	*200*[6]	*282*[7]	2,000 (3.1)	28 (10-50)
	Sammamish River	1,073	**161** (0.5)	*200*[6]	*1,250*[6]	1,000 (3.0)	80 (36-96)
	Duwamish-Green R.	4,014	1,525 (1.4)	400	1,700	-	59 (27-79)
	White River[9]	1,859	625 (0.8)	*200*[6]	410[7]	-	59 (14-90)
	Puyallup River[10]	1,646	784 (1.2)	*200*[6]	1,170[7]	5,300 (2.3)	54 (19-83)
	Nisqually River	1,670	621 (1.5)	*200*[6]	1,200[8]	3,400 (3.0)	56 (17-87)
Hood Canal	Skokomish River	1,398	**282** (0.8)	452	1,160	-	71 (7-96)
	Mid-Hood Canal Rivers[11]	**187**		*200*[6]	*1,250*[6]	1,300 (3.0)	36[11] (2-87)
Strait of Juan de Fuca	Dungeness River	411	**98**(1.0)	*200*[6]	925[8]	1,200 (3.0)	72 (39-96)
	Elwha River[12]	1,231	**171**(1.02)	*200*[6]	*1,250*[6]	6,900 (4.6)	74 (31-98)

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

[2] Source productivity is Abundance and Productivity Tables from NWFSC database; measured as the mean of observed recruits/observed spawners through brood year 2015, except: SF Nooksack through brood year 2013; and NF and SF Stillaguamish, Sammamish, Cedar, Duwamish-Green, Puyallup, White, Snoqualmie, Skykomish, through brood year 2016. Sammamish productivity estimate has not been revised to include Issaquah Creek. Source for Recovery Planning productivity target is the final supplement to the Puget Sound Salmon Recovery Plan (NMFS 2006a); measured as recruits/spawner associated with the number of spawners at Maximum Sustained Yield under recovered conditions.

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

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

[5] Estimates of the fraction of hatchery fish in natural spawning escapements are from the Abundance and Productivity Tables from NWFSC database; measured as mean and range for 1999-2018. Estimates represent hatchery fraction through 2019 for: NF and SF Stillaguamish, Skykomish, Snoqualmie, Cedar, Duwamish-Green, White, Puyallup, and Elwha)

[6] Based on generic VSP guidance (McElhany et al. 2000; NMFS 2006b).

[7] Based on spawner-recruit assessment (PSIT and WDFW 2022).

[8] Based on alternative habitat assessment.

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

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

[11] The PSTRT considers Chinook salmon spawning in the Dosewallips, Duckabush, and Hamma Hamma rivers to be subpopulations of the same historically independent population; annual counts in those three streams are variable due to inconsistent visibility during spawning ground surveys. Data on the contribution of hatchery fish is very limited; total abundance estimates primarily based on returns to the Hamma Hamma River.

[12] Estimates of natural escapement do not include volitional returns to the hatchery or those hatchery or natural-origin fish gaffed or seined from spawning grounds for supplementation program broodstock collection

[13] Differences in results reported in Tables 5 and 6 from those in the NWFSC Biological Viability Assessment (Ford 2022) (Tables 3 and 4, above) are related to the data source, method, and time period analyzed (e.g., 5-year vs 20-year estimates).

Table 18. Long-term trends[9] in abundance and productivity for Puget Sound Chinook salmon populations. Long-term, reliable data series for natural-origin contribution to escapement are limited in many areas.

Region	**Population**	**Total Natural Escapement Trend[1] (1990–2018)**		**Natural Origin Growth Rate[2] (1990–2018)**	
		NMFS		**Recruitment (Recruits)**	**Escapement (Spawners)**
Georgia Basin	NF Nooksack (early)	1.10	increasing	0.99	1.00
	SF Nooksack (early)	1.06	stable	0.96	0.96
Whidbey/ Main Basin	Upper Skagit River (moderately early)	1.02	stable	1.01	1.00
	Lower Sauk River (moderately early)	1.01	stable	0.99	1.00
	Lower Skagit River (late)	1.02	stable	1.00	1.00
	Upper Sauk River (early)	1.05	increasing	0.97	1.02
	Suiattle River (very early)	1.02	stable	0.96	1.00
	Upper Cascade River (moderately early)	1.01	stable	0.96	1.00
	NF Stillaguamish R. (early)	0.99	stable	0.92	0.98
	SF Stillaguamish R (moderately early)	0.95	**declining**	0.90	0.96
	Skykomish River (late)	1.00	stable	0.99	0.99
	Snoqualmie River (late)	1.00	stable	1.00	1.00
Central/South Sound	Cedar River (late)	1.04	increasing	0.99	1.00
	Sammamish River[3] (late)	1.03	increasing	1.01	0.99
	Duwamish-Green R. (late)	0.98	stable	0.98	1.00
	White River[4] (early)	1.10	increasing	1.07	1.07
	Puyallup River (late)	0.98	stable	0.96	0.98
	Nisqually River (late)	1.05	increasing	0.97	1.00
Hood Canal	Skokomish River (late)	1.02	stable	0.93	0.97
	Mid-Hood Canal Rivers (late)	1.05	increasing	0.98	1.04
Strait of Juan de Fuca	Dungeness River (early)	1.05	increasing	0.96	0.98
	Elwha River (late)	1.05	increasing	0.89	0.92

[1] Total natural escapement Trend is calculated based on all spawners (i.e., including both natural origin spawners and hatchery-origin fish spawning naturally) to assess the total number of spawning in each river system. Directions of trends defined by statistical tests. Trends for NF and SF Stillaguamish, Skykomish, Snoqualmie, Cedar, Sammamish, Duwamish-Green, White, Puyallup, and Elwha are from 1999 to 2019.

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

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

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

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[9] Differences in results reported in Tables 17 and 18 from those in the NWFSC Biological Viability Assessment (Ford 2022) (Tables 15 and 16) are related to the data source, method, and time period analyzed (e.g., 5-year vs 20-year estimates).

Limiting factors and other areas of concern

Limiting factors described in SSPS (2007) and reiterated in NMFS (2016b) relate to present or threatened set of conditions within certain habitat parameters that inhibit the viability of salmon as defined by the VSP criteria, including:

- Degraded nearshore and estuarine habitat: Residential and commercial development has reduced the amount of functioning nearshore and estuarine habitat available for salmon rearing and migration. The loss of mudflats, eelgrass meadows, and macroalgae further limits salmon foraging and rearing opportunities in nearshore and estuarine areas.
- Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, impaired passage conditions and water quality have been degraded for adult spawning, embryo incubation, and rearing as a result of cumulative impacts of agriculture, forestry, and development. Some improvements have occurred over the last decade for water quality and removal of forest road barriers.

Additional factors affecting Puget Sound Chinook salmon viability:

- Anadromous salmonid hatchery programs: Salmon and steelhead released from Puget Sound hatcheries operated for harvest augmentation purposes pose ecological, genetic, and demographic risks to natural-origin Chinook salmon populations. The risk to the species' persistence that may be attributable to hatchery-related effects has decreased since the last Status Review, based on hatchery risk reduction measures that have been implemented (NWFSC 2015). Improvements in hatchery operations associated with on-going ESA review and determination processes are expected to further reduce hatchery-related risks.
- Salmon harvest management: Total fishery ERs on most Puget Sound Chinook salmon populations have decreased substantially since the late 1990s when compared to years prior to listing — 1992–1998 (average reduction: –21%, range: –49 to +33%; FRAM base period validation results, version 7.1.1) but weak natural-origin Chinook salmon populations in Puget Sound still require enhanced protective measures to reduce the risk of overharvest. The risk to the species' persistence because of harvest remains the same since the last status review, meaning that for some of the populations with minimal abundance, even low rates of harvest impact can pose demographic and genetic risks. However, there has been greater uncertainty associated with this threat due to shorter term harvest plans (uncertainty about future harvest plans) and exceedance of Rebuilding Exploitation Rates (RERs) for many Chinook salmon populations essential to recovery.
- Concerns regarding existing regulatory mechanisms, including: lack of documentation or analysis of the effectiveness of land-use regulatory mechanisms and land-use management plans, lack of reporting and enforcement for some regulatory programs, certain federal, state, and local land and water use decisions continue to occur without the benefit of ESA review. State and local decisions have no federal nexus to trigger the ESA Section 7 consultation requirement, and thus require other regulatory mechanisms (such as ESA section 10 permits) to address direct and indirect species take and/or adverse habitat effects.

2.2.1.4. Life-History and Status of Lower Columbia River (LCR) Chinook ESU

On March 24, 1999, NMFS listed the LCR Chinook Salmon ESU as a threatened species (64 FR 14308). The threatened status was reaffirmed on June 28, 2005 (70 FR 37159) and on April 14, 2014 (79 FR 20802). Critical Habitat for LCR Chinook salmon was designated on September 2, 2005 (70 FR 52706).

On February 6, 2015, we announced the initiation of 5-year reviews for 17 ESUs of salmon and 11 DPSs of steelhead in Oregon, California, Idaho, and Washington (80 FR 6695). We requested that the public submit new information on these species that has become available since our original listing determinations or since the species' status was last updated. In response to our request, we received information from Federal and state agencies, Native American Tribes, conservation groups, fishing groups, and individuals. We considered this information, as well as information routinely collected by our agency, to complete these 5-year reviews. The most recent 5-year status review of the LCR Chinook Salmon ESU was released October 21, 2022 (NMFS 2022d), and this section summarizes the current findings of that viability assessment.

The LCR Chinook Salmon ESU includes natural populations in Oregon and Washington from the ocean upstream to, and including, the White Salmon River (river mile 167.5) in Washington and Hood River (river mile 169.5) in Oregon, except for salmon in the Willamette River (which enters the Columbia River at river mile 101). Within the Willamette River Chinook salmon are listed separately as the Upper Willamette River Salmon ESU, and not as part of the LCR Chinook Salmon ESU.

Thirty-two historical populations, within six Major Population Groups (MPGs), comprise the LCR Chinook Salmon ESU. These are distributed through three ecological zones[10]. A combination of life-history types, based on run timing and ecological zones, result in six MPGs, some of which are considered extirpated or nearly extirpated (Table 19). The run timing distributions across the 32 historical populations are: nine spring populations, 21 early-fall populations, and two late-fall populations (Table 20; Figures 16 and 17).

Within the geographic range of the LCR Chinook Salmon ESU, during the interim since the 2015 status review update, there have been a number of changes in both the quality and quantity of hatchery production in the lower Columbia River (NWFSC 2022). Currently 19 of these hatchery programs are included in the ESU (Table 19), while the remaining programs are excluded (70 FR 37159; NMFS 2022d). Genetic resources that represent the ecological and genetic diversity of a species can reside in a hatchery program. "Hatchery programs with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU are considered part of the ESU and will be included in any listing of the ESU"

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[10] There are a number of methods of classifying freshwater, terrestrial, and climatic regions. The WLC TRT used the term ecological zone as a reference, in combination with an understanding of the ecological features relevant to salmon, to designate four ecological areas in the domain: (1) Coast Range zone, (2) Cascade zone, (3) Columbia Gorge zone, and (4) Willamette zone. This concept provides geographic structure to ESUs in the domain. Maintaining each life-history type across the ecological zones reduces the probability of shared catastrophic risks. Additionally, ecological differences among zones reduce the impact of climate events across entire ESUs (Myers et al. 2003).

(NMFS 2005). For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see NMFS (2005).

Table 19. LCR Chinook Salmon ESU description and MPGs (NMFS 2022; NWFSC 2022).

ESU Description[1]	
Threatened	Listed under ESA in 1999; updated in 2014.
6 major population groups	32 historical populations
Major Population Group	***Populations***
Cascade Spring	Upper Cowlitz (C,G), Cispus (C), Tilton, Toutle, Kalama, NF Lewis (C), Sandy (C,G)
Gorge Spring	(Big) White Salmon (C), Hood
Coast Fall	Grays/Chinook, Elochoman (C), Mill Creek, Youngs Bay, Big Creek (C), Clatskanie, Scappoose
Cascade Fall	Lower Cowlitz (C), Upper Cowlitz, Toutle (C), Coweeman (G), Kalama, EF Lewis (G), Salmon Creek, Washougal, Clackamas (C), Sandy River early
Gorge Fall	Lower Gorge, Upper Gorge (C), (Big) White Salmon (C), Hood
Cascade Late Fall	North Fork Lewis (C,G), Sandy (C,G)
Artificial production	
Hatchery programs included in ESU (18)	Big Creek Tule Fall Chinook; Astoria High School Salmon-Trout Enhancement Program (STEP) Tule Chinook Program; Warrenton High School (STEP) Tule Chinook Program; Cowlitz Tule Chinook Program; North Fork Toutle Tule Chinook Program; Kalama Tule Chinook Program; Washougal River Tule Chinook Program; Spring Creek National Fish Hatchery (NFH) Tule Chinook Program; Cowlitz Spring Chinook Program in the Upper Cowlitz River and in the Cispus River; Friends of the Cowlitz Spring Chinook Program; Kalama River Spring Chinook Program; Lewis River Spring Chinook Program; Fish First Spring Chinook Program; Sandy River Hatchery Program; Deep River Net Pens-Washougal Program; Klaskanine Hatchery Program; Bonneville Hatchery Program; and the Cathlamet Channel Net Pens Program.
Hatchery programs not included in ESU (12)	Clatsop County Fisheries (CCF) Select Area Brights Program Fall Chinook, CCF Spring Chinook salmon Program, Carson NFH Spring Chinook salmon Program, Little White Salmon NFH Tule Fall Chinook salmon Program, Bonneville Hatchery Tule Fall Chinook salmon Program, Hood River Spring Chinook salmon Program*, Deep River Net Pens Tule Fall Chinook, Klaskanine Hatchery Tule Fall Chinook, Bonneville Hatchery Fall Chinook, Little White Salmon NFH Tule Fall Chinook, Cathlamet Channel Net Pens Spring Chinook, Little White Salmon NFH Spring Chinook

[1] The designations "(C)" and "(G)" identify Core and Genetic Legacy populations, respectively.[11]

*The ongoing Hood River Spring Chinook Salmon Program is currently integrating returning natural-origin spring Chinook salmon into the broodstock. The program had been using only spring Chinook salmon returning to the Hood River for broodstock since the release year 2013 when the last release of out-of-basin Deschutes River spring Chinook salmon occurred (NMFS 2022). NMFS will continue to monitor the status of the natural-origin population to determine if the Hood River spring Chinook salmon artificially propagated stock is no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (70 FR 37204, June 28, 2005).

Table 20. LCR Chinook salmon populations and recommended status under the recovery scenario (NMFS 2013a).

Major Population Group	Population (State)	Contribution[2]	Recovery Scenario[1]	
			Target Persistence Probability	**Abundance Target[3]**
Cascade Spring	Upper Cowlitz (WA)	Primary	H+	1,800
	Cispus (WA)	Primary	H+	1,800
	Tilton (WA)	Stabilizing	VL	100
	Toutle (WA)	Contributing	M	1,100
	Kalama (WA)	Contributing	L	300
	North Fork Lewis (WA)	Primary	H	1,500
	Sandy (OR)	Primary	H	1,230
Gorge Spring	White Salmon (WA)	Contributing	L+	500
	Hood (OR)	Primary[4]	VH[4]	1,493
Coast Fall	Youngs Bay (OR)	Stabilizing	L	505
	Grays/Chinook (WA)	Contributing	M+	1,000
	Big Creek (OR)	Contributing	L	577
	Elochoman/Skamokawa (WA)	Primary	H	1,500
	Clatskanie (OR)	Primary	H	1,277
	Mill/Aber/Germ (WA)	Primary	H	900
	Scappoose (OR)	Primary	H	1,222
Cascade Fall	Lower Cowlitz (WA)	Contributing	M+	3,000

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[11] Core populations are defined as those that, historically, represented a substantial portion of the species' abundance. Genetic legacy populations are defined as those that have had minimal influence from nonendemic fish due to artificial propagation activities, or may exhibit important life-history characteristics that are no longer found throughout the ESU (McElhany et al. 2003).

Major Population Group	Population (State)	Contribution[2]	Recovery Scenario[1]	
			Target Persistence Probability	Abundance Target[3]
	Upper Cowlitz (WA)	Stabilizing	VL	--
	Toutle (WA)	Primary	H+	4,000
	Coweeman (WA)	Primary	H+	900
	Kalama (WA)	Contributing	M	500
	Lewis (WA)	Primary	H+	1,500
	Salmon (WA)	Stabilizing	VL	--
	Clackamas (OR)	Contributing	M	1,551
	Sandy (OR)	Contributing	M	1,031
	Washougal (WA)	Primary	H+	1,200
Gorge Fall	Lower Gorge (WA/OR)	Contributing	M	1,200
	Upper Gorge (WA/OR)	Contributing	M	1,200
	White Salmon (WA)	Contributing	M	500
	Hood (OR)	Primary[4]	H[4]	1,245
Cascade Late Fall	North Fork Lewis (WA)	Primary	VH	7,300
	Sandy (OR)	Primary	VH	3,561

[1] overall persistence probability of the population under the delisting scenario to achieve Viable Salmonid Populations (VSP) criteria, including abundance target. VL =very low, L = low, M = moderate, H = high, VH = very high. These are adopted in the recovery plan (NMFS 2013a).

[2] Primary, contributing, and stabilizing designations reflect the relative contribution of a population to recovery goals and delisting criteria. Primary populations are targeted for restoration to a high or very high persistence probability. Contributing populations are targeted for medium or medium-plus viability. Stabilizing populations are those that will be maintained at current levels (generally low to very low viability), which is likely to require substantive recovery actions to avoid further degradation.

[3] Abundance objectives account for related goals for productivity (NMFS 2013a).

[4] Oregon analysis indicates a low probability of meeting the delisting objectives for these populations.

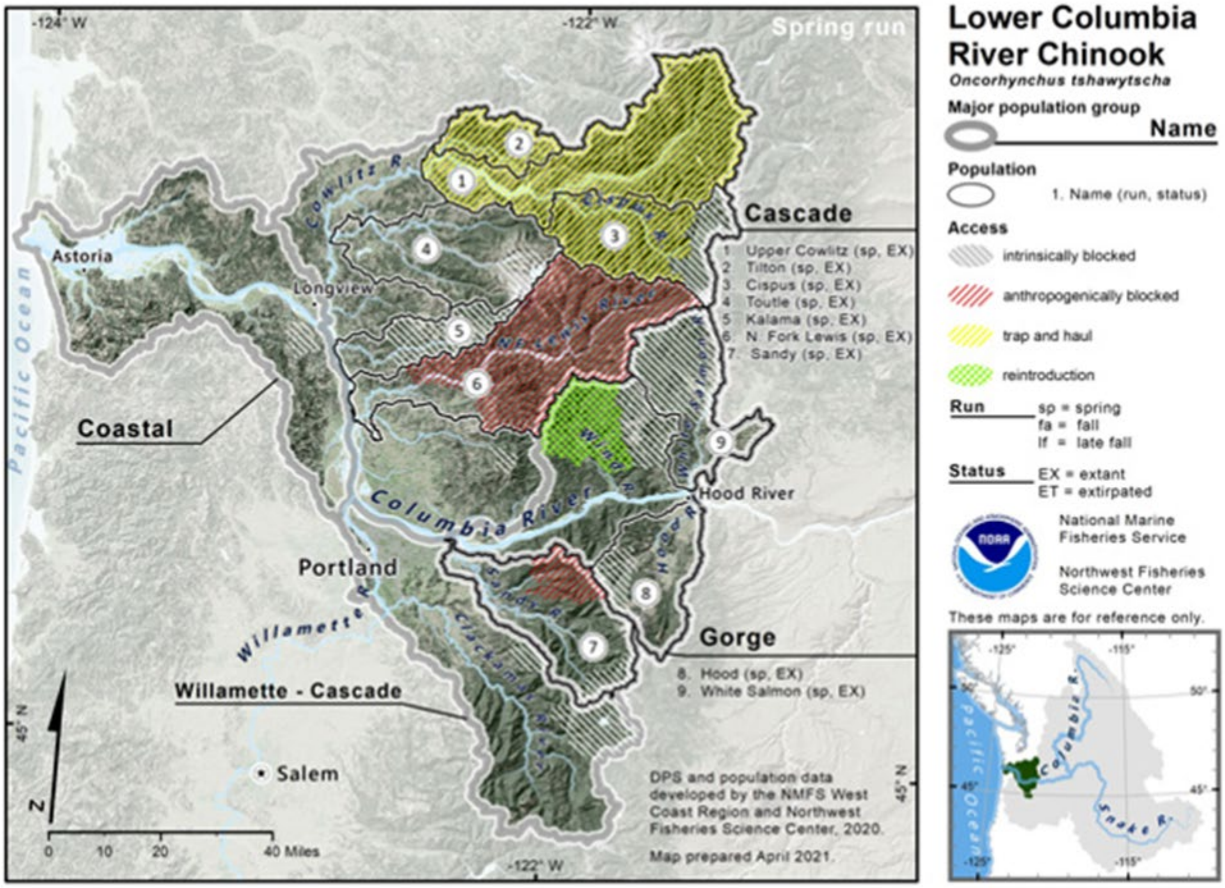

Figure 16. Map of the LCR Chinook Salmon ESU's spawning and rearing areas for spring Chinook salmon Demographically Independent Populations (DIPs or "populations"), illustrating populations and MPGs. Several watersheds contain or historically contained both fall and spring runs; only the spring-run populations are illustrated here (NWFSC 2022).

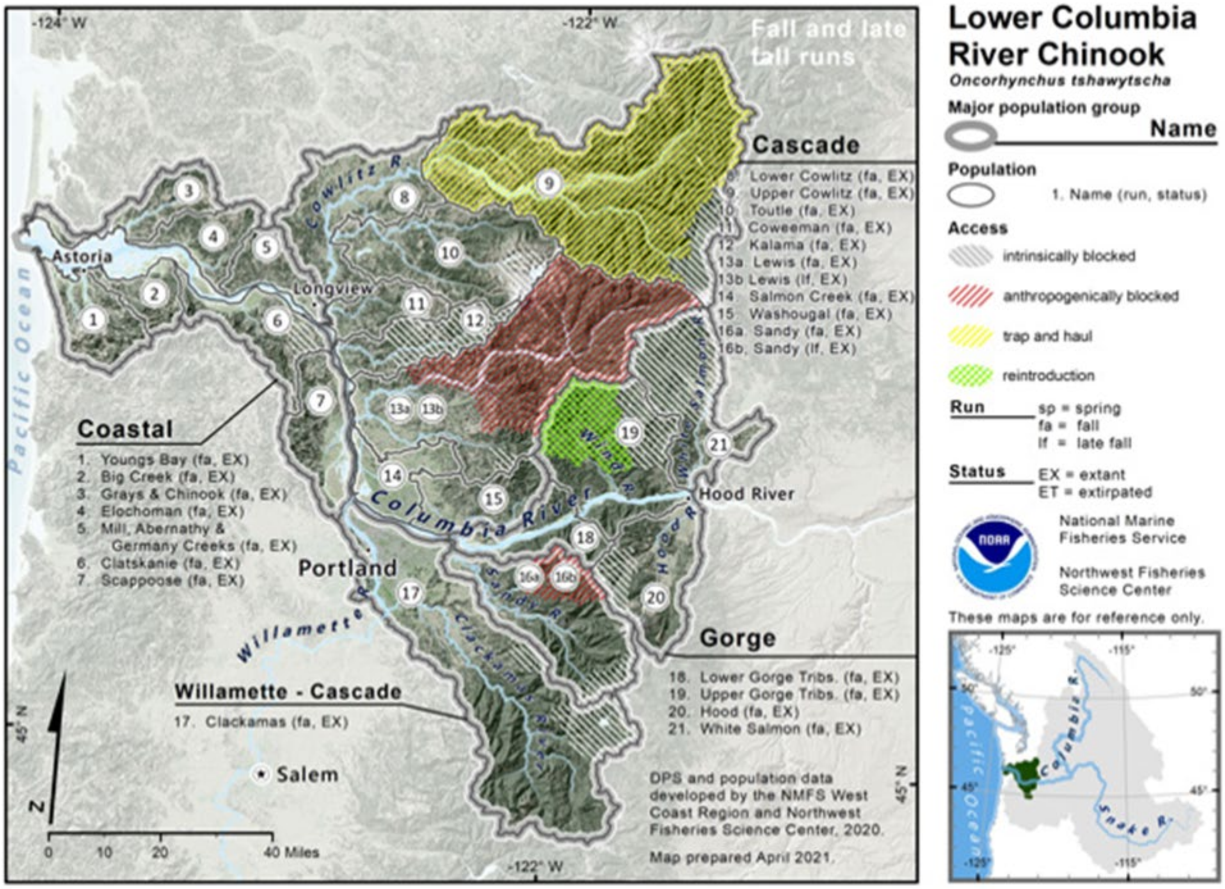

Figure 17. Map of the LCR Chinook Salmon ESU's spawning and rearing areas for fall Chinook salmon populations, illustrating populations and MPGs. Several watersheds contain or historically contained both fall and spring runs; only the fall-run populations are illustrated here (NWFSC 2022).

Chinook salmon have a wide variety of life-history patterns that include: variation in age at seaward migration; length of freshwater, estuarine, and oceanic residence; ocean distribution; ocean migratory patterns; and age and season of spawning migration. Two distinct races of Chinook salmon are generally recognized: "stream-type" and "ocean-type" (Healey 1991; Myers et al. 1998). Ocean-type Chinook salmon reside in coastal ocean waters for three to four years before returning to freshwater and exhibit extensive offshore ocean migrations, compared to stream-type Chinook salmon that spend two to three years in coastal ocean waters. The ocean-type also enter freshwater to return for spawning later (May and June) than the stream-type (February through April). Ocean-type Chinook salmon use different areas in the river — they spawn and rear in lower elevation mainstem rivers, and typically reside in freshwater for no more than three months compared to stream-type Chinook salmon that spawn and rear high in the watershed and reside in freshwater for a year.

LCR Chinook salmon are classified into three life-history types including spring runs, early-fall runs ("tules"), and late-fall runs ("brights") based on when adults return to freshwater (Table 21). LCR spring Chinook salmon are stream-type, while LCR early-fall and late-fall Chinook salmon are ocean-type. Other life-history differences among run types include the timing of: spawning, incubation, emergence in freshwater, migration to the ocean, maturation, and return to freshwater. This life-history diversity allows different runs of Chinook salmon to use streams as small as 10 feet wide and rivers as large as the mainstem Columbia (NMFS 2013a). Stream characteristics determine the distribution of run types among LCR streams. Depending on run type, Chinook salmon may rear anywhere from a few months to a year or more in freshwater streams, rivers, or the estuary before migrating to the ocean in spring, summer, or fall. All runs migrate far into the north Pacific on a multi-year journey along the continental shelf to Alaska before circling back to their river of origin. The spawning run typically includes three or more age classes. Adult Chinook salmon are the largest of the salmon species, and LCR fish can reach sizes of up to 25 kilograms (55 pounds). Chinook salmon require clean gravels for spawning, and pool and side-channel habitats for rearing. All Chinook salmon die after spawning once (NMFS 2013a).

Table 21. Life-history and population characteristics of LCR Chinook salmon.

Characteristic	**Life-History Features**		
	Spring	**Early-fall (tule)**	**Late-fall (bright)**
Number of extant populations	9	21	2
Life-history type	Stream	Ocean	Ocean
River entry timing	March–June	August–September	August–October
Spawn timing	August–September	September–November	November–January
Spawning habitat type	Headwater large tributaries	mainstem large tributaries	mainstem large tributaries
Emergence timing	December–January	January–April	March–May
Duration in freshwater	Usually 12–14 months	1–4 months, a few up to 12 months	1–4 months, a few up to 12 months
Rearing habitat	Tributaries and mainstem	mainstem, tributaries, sloughs, estuary	mainstem, tributaries, sloughs, estuary
Estuarine use	A few days to weeks	Several weeks up to several months	Several weeks up to several months
Ocean migration	As far north as Alaska	As far north as Alaska	As far north as Alaska
Age at return	4–5 years	3–5 years	3–5 years
Recent natural spawners	800	6,500	9,000
Recent hatchery adults	12,600 (1999–2000)	37,000 (1991–1995)	NA

Fall Chinook salmon (tules and brights) historically were found throughout the entire range, while spring Chinook salmon historically were only found in the upper portions of basins with snowmelt driven flow regimes (western Cascade Crest and Columbia Gorge tributaries) (NMFS 2013a). Bright Chinook salmon were identified in only two basins in the western Cascade Crest tributaries. In general, bright Chinook salmon mature at an older average age than either LCR spring or tule Chinook salmon, and have a more northern oceanic distribution. Currently, the abundance of all fall Chinook salmon greatly exceeds that of the spring component (NWFSC 2022).

Harvest rates for populations with different run timings share similar ER patterns, but differ in absolute harvest rates. With each run timing, tributary-specific harvest rates may differ. All populations saw a drop in ERs in the early 1990s in response to decreases in abundance. There has been a modest increase since then (Figure 18). Ocean fishery impact rates have been relatively stable in the past few years, with the exception of the bright (late fall) component of the ESU. The different MPGs are subject to different in-river fisheries (mainstem and tributary) because of differences in life histories and therefore river entry timing, but share relatively similar ocean distributions.

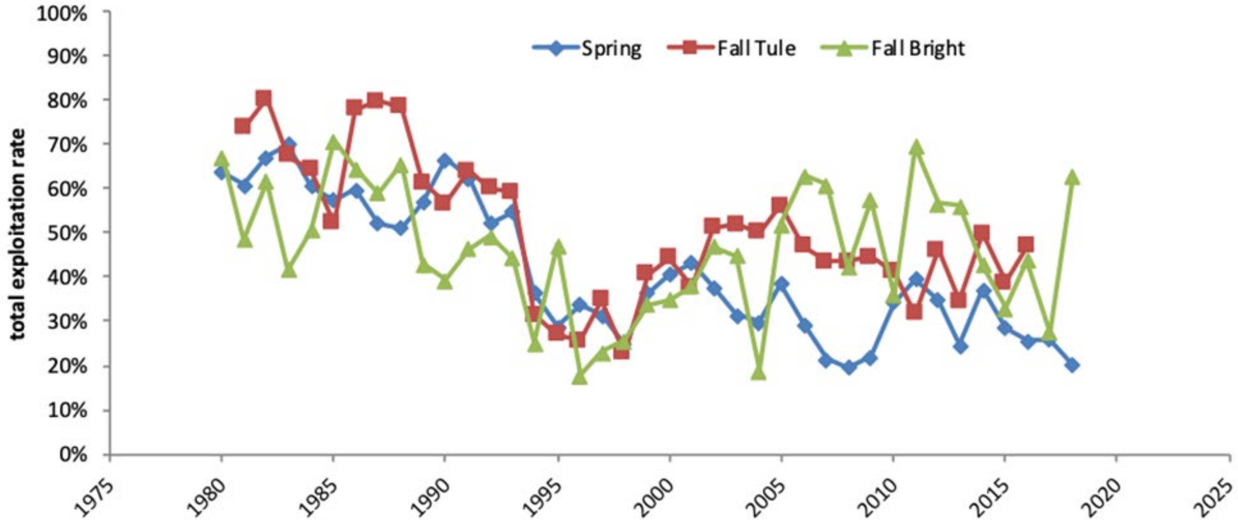

Figure 18. Total ERs on the three components of the Lower Columbia River Chinook salmon ESU (NWFSC 2022) (see environmental baseline for geographic distribution of the ERs).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Each LCR Chinook salmon natural population target persistence probability level is summarized in Table 20. Additionally, Table 20 provides the target abundance for each population that would be consistent with delisting. Persistence probability is measured over a 100-year time period and ranges from very low (probability < 40%) to very high (probability >99%).

The Willamette-Lower Columbia Technical Recovery Team (WLC TRT) established recovery criteria as two primary populations with high target persistence probability in each MPG to achieve ESU viability. If the recovery scenario in Table 20 were achieved, it would exceed the WLC TRT's MPG-level viability criteria for the Coast and Cascade fall MPGs, the Cascade spring MPG, and the Cascade late-fall MPG. However, the recovery scenario in Table 20 for the Gorge spring and Gorge MPGs does not meet WLC TRT criteria. Within each of these MPGs, the scenario targets only one population (the Hood) for high persistence probability because Bonneville Dam spans the Gorge fall and spring MPGs affecting passage of fish to these areas. Exceeding the WLC TRT criteria, particularly in the Cascade fall and Cascade spring Chinook salmon MPG, was intentional on the part of recovery planners to compensate for uncertainties about meeting the WLC TRT's criteria in the Gorge fall and spring MPGs. In addition, multiple spring Chinook salmon natural populations are prioritized for aggressive recovery efforts to balance risks associated with the uncertainty of success in reintroducing spring Chinook salmon populations above tributary dams in the Cowlitz and Lewis systems.

NMFS (2013) commented on the uncertainties and practical limits to achieving high viability for the spring and tule populations in the Gorge MPGs. Recovery opportunities in the Gorge were limited by the small numbers of natural populations and the high uncertainty related to restoration, due to Bonneville Dam passage and inundation of historically productive habitats. NMFS also recognized the uncertainty regarding the TRT's MPG delineations between the Gorge and Cascade MPG populations, and that several Chinook salmon populations downstream from Bonneville Dam may be quite similar to those upstream of Bonneville Dam. As a result, the recovery plan recommends that additional natural populations in the Coast and Cascade MPGs achieve recovery status, as it will help to offset the anticipated shortcomings for the Gorge MPGs. This was considered a more precautionary approach to recovery than merely assuming that efforts related to the Gorge MPG would be successful. The information provided by the WLC TRT and the management unit recovery planners led NMFS to conclude in the recovery plan that the recovery scenario (Table 20) represents one of multiple possible scenarios that would meet biological criteria for delisting. The similarities between the Gorge and Cascade MPG, coupled with compensation in the other strata for not meeting TRT criteria in the Gorge stratum, would provide an ESU no longer likely to become endangered.

Expanded spawner surveys begun after the 2010 review, especially in regard to abundance time series and hatchery contribution to the naturally spawning adults. Presently, there is some level of monitoring for all Chinook salmon populations except those that are functionally extinct (NWFSC 2022). Table 22 captures the geometric mean of natural spawner counts available, indicating that more recent years have more populations being monitored.

Table 22. Five-year geometric mean of raw natural spawner counts (NWFSC 2022). SP = spring-run, FA = fall-run, LFR = late fall-run. In parentheses, 5-year geometric mean of raw total spawner counts is shown. A value only in parentheses means that a total spawner count was available but no or only one estimate of natural spawners available.

Population	MPG	1990–1994	1995–1999	2000–2004	2005–2009	2010–2014	2015–2019	% change
Upper Cowlitz/Cispus Rivers SP	Spring-run Cascade	—	—	—	—	—	171 (5,435)	—
Kalama River SP	Spring-run Cascade	(121)	(127)	(337)	57 (405)	82 (82)	43 (43)	–48 (–48)
North Fork Lewis River SP	Spring-run Cascade	(1,127)	(308)	(556)	(130)	(145)	(112)	(–23)
Sandy River SP	Spring-run Cascade	—	—	—	—	1,778 (2,000)	3,359 (3,667)	89 (83)
Big White Salmon River SP	Spring-run Gorge	—	—	—	—	18 (138)	8 (50)	–56 (–64)
Grays River Tule FA	Fall-run Coastal	(53)	(81)	(214)	83 (188)	79 (448)	228 (579)	189 (29)
Youngs Bay FA	Fall-run Coastal	—	—	—	—	201 (5,105)	145 (1,635)	–28 (–68)
Big Creek FA	Fall-run Coastal	—	—	—	—	0 (1,389)	0 (2,206)	(59)
Elochoman River/ Skamokawa Tule FA	Fall-run Coastal	(530)	(661)	(2771)	(778)	91 (612)	95 (238)	4 (–61)
Clatskanie River FA	Fall-run Coastal	—	—	27 (273)	13 (91)	8 (82)	3 (76)	–62 (–7)
Mill/Abernathy/Germany Creeks Tule FA	Fall-run Coastal	(1,160)	(602)	(2,416)	(727)	67 (688)	28 (151)	–58 (–78)
Lower Cowlitz River Tule FA	Fall-run Cascade	(2,492)	(1,827)	(5,818)	(2,367)	2,562 (3,711)	3,208 (4,161)	25 (12)
Coweeman River Tule FA	Fall-run Cascade	(877)	(796)	(805)	(526)	683 (840)	543 (595)	–20 (–29)
Toutle River Tule FA	Fall-run Cascade	(211)	(788)	(4,689)	(1,826)	330 (1,290)	280 (514)	–15 (–60)
Upper Cowlitz River Tule FA	Fall-run Cascade		(42)	(724)	(2,485)	2,646 (7,779)	1,761 (2,188)	–33 (–72)
Kalama River Tule FA	Fall-run Cascade	(2,714)	(4,192)	(6,911)	(6,156)	540 (7,529)	2,142 (3,808)	297 (–49)
Lewis River Tule FA	Fall-run Cascade	—	(1,423)	(3,487)	(1,599)	1,521 (2,256)	2,003 (3,637)	32 (61)
Clackamas River FA	Fall-run Cascade	—	—	—	—	144 (292)	236 (366)	64 (25)
Sandy River FA	Fall-run Cascade	—	—	—	—	(1,176)	(2,074)	(76)
Washougal River Tule FA	Fall-run Cascade	(2,932)	(3,227)	(4,391)	(2,355)	609 (2,486)	914 (1,643)	50 (–34)
Lower Gorge Tributaries Tule FA	Fall-run Gorge	—	(1,822)	(1,157)	(941)	928 (1,048)	4,528 (4,708)	388 (349)
Upper Gorge Tributaries Tule FA	Fall-run Gorge	—	(277)	(916)	(621)	561 (1,563)	537 (999)	–4 (–36)
Big White Salmon River Tule FA	Fall-run Gorge	(127)	(151)	(2,129)	(939)	759 (962)	283 (502)	–63 (–48)
Lewis River Bright LFR	Late fall-run Cascade	(8,353)	(6,647)	(11,694)	(5,758)	11,671	(8,353)	(6,647)
Sandy River Bright LFR	Late fall-run Cascade	852 (3,594)	815 (3,440)	555 (2,340)	1,097 (4,629)	—	—	—

In 2017, NMFS adopted a Record of Decision ("Mitchell Act ROD") that would be used to guide NMFS' decision on the distribution of funds for hatchery production under the Mitchell Act (16

US CFR 755 757), which NMFS administers. NMFS' continued funding of Mitchell Act hatchery programs, under the Mitchell Act ROD, was analyzed under the ESA and found not likely to jeopardize the continued existence of any species in the Columbia Basin (NMFS 2017). The Mitchell Act ROD directs NMFS to strengthen performance goals to all Mitchell Act-funded, Columbia River Basin, hatchery programs that affect ESA-listed primary and contributing salmon and steelhead populations. These stronger performance goals reduced the risks of hatchery programs to natural-origin salmon and steelhead populations, including the LCR Chinook Salmon ESU, and primarily to the tule Chinook salmon MPGs. It required integrated hatchery programs to be better integrated and isolated hatchery programs to be better isolated than was the practice at the time. While this action is expected to decrease multiple MPGs high relative dominance of hatchery-origin spawners (Table 23), this will take some time to occur, and is not likely to show up in the data until the middle of this decade (mid 2020s at the earliest).

Table 23. Five-year mean of fraction natural-origin spawners (sum of all estimates divided by the number of estimates) for Lower Columbia River Chinook salmon ESU populations (NWFSC 2022).

Population	MPG	1995–1999	2000–2004	2005–2009	2010–2014	2015–2019
Upper Cowlitz/Cispus Rivers SP	Spring-run Cascade	—	—	—	0.08	0.06
Kalama River SP	Spring-run Cascade	—	—	—	1.00	1.00
North Fork Lewis River SP	Spring-run Cascade	—	—	—	—	—
Sandy River SP	Spring-run Cascade	—	—	—	0.89	0.92
Big White Salmon River SP	Spring-run Gorge	—	—	—	0.13	0.18
Grays River Tule FA	Fall-run Coastal	—	—	0.36	0.22	0.43
Youngs Bay FA	Fall-run Coastal	—	—	—	0.04	0.14
Big Creek FA	Fall-run Coastal	—	—	—	0.03	0.04
Elochoman River/ Skamokawa Tule FA	Fall-run Coastal	—	—	—	0.17	0.45
Clatskanie River FA	Fall-run Coastal	—	0.10	0.19	0.09	0.05
Mill/Abernathy/Germany Creeks Tule FA	Fall-run Coastal	—	—	—	0.11	0.22
Lower Cowlitz River Tule FA	Fall-run Cascade	—	—	—	0.70	0.77
Coweeman River Tule FA	Fall-run Cascade	—	—	—	0.82	0.91
Toutle River Tule FA	Fall-run Cascade	—	—	—	0.31	0.55

Population	MPG	1995–1999	2000–2004	2005–2009	2010–2014	2015–2019
Upper Cowlitz River Tule FA	Fall-run Cascade	—	—	—	0.35	0.82
Kalama River Tule FA	Fall-run Cascade	—	—	—	0.08	0.57
Lewis River Tule FA	Fall-run Cascade	—	—	—	0.67	0.56
Clackamas River FA	Fall-run Cascade	—	—	—	0.60	0.68
Sandy River FA	Fall-run Cascade	—	—	—	—	—
Washougal River Tule FA	Fall-run Cascade	—	—	—	0.30	0.58
Lower Gorge Tributaries Tule FA	Fall-run Gorge	—	—	—	0.89	0.96
Upper Gorge Tributaries Tule FA	Fall-run Gorge	—	—	—	0.40	0.58
Big White Salmon River Tule FA	Fall-run Gorge	—	—	—	0.80	0.57
Lewis River Bright LFR	Late fall-run Cascade	—	—	—	1.00	1.00
Sandy River Bright LFR	Late fall-run Cascade	0.24	0.24	0.24	—	—

The information presented in the following section is a review of updated status information available for each MPG from the most recent status review (NMFS 2022d).

Cascade Spring-run MPG

LCR spring Chinook salmon natural populations occur in both the Gorge and Cascade MPGs (Table 20). There are seven LCR spring Chinook salmon populations in the Cascade MPG. Of the seven spring-run populations in this MPG, there are only abundance estimates for five populations, the Upper Cowlitz/Cispus Rivers (two populations combined), Kalama River, North Fork Lewis River, and Sandy River populations. Of these, only the Sandy River population appears to be sustaining natural-origin abundance at near-recovery levels based on the most recent data. The most recent 5-year geomean abundance for the Sandy River was 3,359, which represents an 89% increase over 2010–2014 (Table 22). The removal of Marmot Dam on the Sandy River in 2007, in conjunction with other restoration efforts including reductions in the contribution of hatchery-origin fish, has facilitated the improved natural-origin abundance of spring-run Chinook salmon in that basin, an impressive result given the poor ocean conditions experienced during the period examined in the most recent status review (NMFS 2022d). This abundance is greater than the recovery target of 1,230 listed in Table 20.

Elsewhere in this MPG natural-origin abundances for spring-run Chinook salmon were very low, with negative trends. The combined estimate for the Upper Cowlitz/Cispus River of 171 fish for the last 5-year geomean (Table 22) is much lower than the independent recovery target of 1,800 for either population (Table 20). The North Fork Lewis River recent 5-year geomean of 112 and corresponding Kalama River estimate of 43 fish are also much lower than their respective recovery abundance targets of 1,500 and 300. For the Upper Cowlitz/Cispus Rivers, Kalama River, and North Fork Lewis River populations, hatchery returns currently constitute the vast majority of fish returning to the river (NWFSC 2022d). The Cowlitz and Lewis populations are currently managed for hatchery production since most of the historical spawning habitat has been inaccessible due to hydro development in the upper basin (NMFS 2013a).

The Cowlitz, Lewis, Sandy and Kalama river systems have all met their hatchery's escapement objectives in recent years, with a few exceptions based on the goals established in their respective Hatchery Genetic and Management Plan (HGMPs; Table 24). Escapement for the Lewis River hatchery has fallen short in recent years, but additional harvest management measures have been taken to help offset the projected shortfalls. Escapement to the Cowlitz, Lewis, and Sandy river hatcheries are essential for recovery, given each population is designated a primary population. This, particularly in case of the Cowlitz and Lewis River hatcheries because passage for the populations within those systems is still a limiting factor, ensures that what remains of the genetic legacy of these natural populations is preserved and can be used to advance recovery. The existence of these hatchery programs reduces extinction risk in the short-term.

The historical significance of the Kalama population to the overall LCR Chinook Salmon ESU was likely limited as habitat there was probably not as productive for spring Chinook salmon as other spring Chinook salmon populations in the ESU (NMFS 2013a). In the recovery scenario, the Kalama spring Chinook salmon population is designated as a contributing population targeted for a relatively lower persistence probability, as again habitat there was likely not as productive historically for spring Chinook salmon (Table 20; NMFS 2013a).

Table 24. Hatchery escapement for LCR spring Chinook populations (TAC 2017).

Year	Cowlitz	Kalama	Lewis	Sandy
	Hatchery Escapement (rack return goal: 1,337)[1]	Hatchery Escapement (rack return goal: 300)[2]	Hatchery Escapement (rack return goal: 1,380)[3]	Hatchery Escapement (rack return goal: 150 adults)
1997	1,298	576	2,245	n/a
1998	812	408	1,148	n/a
1999	1,321	794	845	n/a
2000	1,408	1,256	776	n/a
2001	1,306	952	1,193	n/a
2002	2,713	1,374	1,865	n/a
2003	10,481	3,802	3,056	n/a
2004	12,596	3,421	4,235	2,950
2005	7,503	2,825	2,219	1,830
2006	5,379	4,313	4,130	981
2007	3,089	4,748	3,897	28

Year	Cowlitz	Kalama	Lewis	Sandy
	Hatchery Escapement (rack return goal: 1,337)[1]	Hatchery Escapement (rack return goal: 300)[2]	Hatchery Escapement (rack return goal: 1,380)[3]	Hatchery Escapement (rack return goal: 150 adults)
2008	1,895	940	1,386	163
2009	3,604	170	1,068	261
2010	5,920	467	1,896	652
2011	1,992	275	1,101	635
2012	5,589	285	1,294	424
2013	3,762	732	1,785	730
2014	4,591	709	1,009	1,016
2015	17,600	2,642	908	365
2016	15,003	2,682	442	123
2017	8,867	2,057	2,418	335
2018	2,745	1,263	2,343	80
2019	1,295	724	1,780	112
2020	841	937	2,743	472
2021	3,223	1,343	3,602	381

[1] Cowlitz River Spring Chinook salmon brood origin hatchery returns are collected on-station at the Cowlitz Salmon Hatchery.

[2] Kalama River Spring Chinook salmon brood origin hatchery returns are collected on-station at the Kalama Falls Hatchery.

[3] Lewis River Spring Chinook salmon brood origin hatchery returns are collected at the Merwin Dam Fish Collection Facility, and on-station at the Lewis River Hatchery.

A reintroduction program is now being implemented on the Cowlitz River that involves trap and haul of adults and juveniles. The reintroduction program for the upper Cowlitz and Cispus Rivers above Cowlitz Falls Dam is consistent with the recommendations of the recovery plan, and constitutes the initial steps in a more comprehensive recovery strategy. However, the program is currently limited by low collection efficiency of out-migrating juveniles at Cowlitz Falls Dam, and by lack of productivity in the Tilton basin because of relatively poor habitat quality. Some unmarked adults, meaning unknown origin (hatchery or natural), return voluntarily to the hatchery intake. However, for the time being, the reintroduction program relies primarily on the use of surplus hatchery adults. (Information on the hatchery program and associated Settlement Agreement with Tacoma Power can be found at: https://www.mytpu.org/tacomapower/fish-wildlife-environment/cowlitz-river-project/cowlitz-fisheries-programs/). The reintroduction program facilitates the use of otherwise vacant habitat, but cannot be self-sustaining until low juvenile collection problems are solved and other limiting factors are addressed. Efforts are underway to improve juvenile collection facilities. Given the current circumstances, the first priority of fish returning to these areas, both natural-origin and hatchery-origin, is to achieve the integrated hatchery escapement goals, and thereby preserve the genetic heritage of the population. Preservation of genetic heritage reduces the extinction risk of the population should the passage problems continue, and acts as a safety valve for the eventual recovery of the Cowlitz population.

In the Upper Cowlitz River, surplus hatchery-origin fish are transported around the dams to contribute to reintroduction of fish above the dams, whereas in the Kalama and Lewis Rivers, hatchery fish are intercepted at Lower Kalama River Falls and Merwin Dam, respectively to maximize hatchery production. The reintroduction efforts in the Upper Cowlitz River facilitate the use of otherwise vacant habitat, but cannot be self-sustaining until downstream juvenile collection problems are solved. Efforts are underway to improve juvenile collection facilities to achieve 95% juvenile outmigrant survival, which was last estimated for passage survival probability for juvenile Chinook salmon as 83% in 2013–2014 (Liedtke et al. 2018). Currently, downstream passage has not attained sufficient efficiencies for the populations to sustain themselves, although considerable progress has been made in recent years (PacifiCorp 2021). Given the circumstances, fisheries are managed to achieve the hatchery escapement goals and thereby preserve the genetic heritage of the populations, maintain use of the habitat, and retain the option for the reintroduction program and eventual recovery of these populations. Reintroduction efforts have not yet begun to reestablish spring-run Chinook salmon in the Tilton River population.

Legacy effects of the 1980 Mount St. Helens eruption are still a fundamental limiting factor for the Toutle spring Chinook salmon natural population (NMFS 2013a). The North Fork Toutle was the area most affected by the blast, and resulting sedimentation from the eruption. Because of the eruption, a sediment retention structure was constructed to manage the ongoing input of fine sediments into the lower river. Nonetheless, the sediment retention structure is a continuing source of fine sediment and blocks passage to the upper river. A trap and haul system was implemented and operates annually from September to May to transport adult fish above the SRS. The transport program provides access to 50 miles of anadromous fish habitat located above the structure (NMFS 2013a), but that habitat is still in very poor condition. WDFW does not recognize the continued existence of the Toutle River spring-run DIP, and adult spawner surveys are not undertaken (NWFSC 2022). There is relatively little known about current natural spring Chinook salmon production in this basin. The Toutle population has been designated a contributing population targeted for medium persistence probability under the recovery scenario (Table 20).

In summary: in this MPG, only the Sandy River Chinook salmon DIP has attained moderate abundance levels (Table 3); three other populations have very low abundances, and the remaining three have few if any naturally spawning individuals, although the populations may persist as hatchery stocks in some cases (NWFSC 2022).

<u>Gorge Spring-run MPG</u>

The Hood River and White Salmon natural populations are the only populations in the Gorge Spring MPG. The 2005 Biological Review Team (BRT) described the Hood River spring run as “extirpated or nearly so” (Good et al. 2005), and the 2005 ODFW Native Fish Status report describes the population as extinct (ODFW 2005). NMFS reaffirmed its conclusion that Hood River spring Chinook salmon are in the Gorge Spring MPG in the prior status review (NWFSC

2015). Additionally, the White Salmon River population is considered extirpated (NMFS 2013a, Appendix C).

Most of the habitat that was historically available to spring Chinook salmon in the Hood River is still accessible. Due to the apparent extirpation of the population, Oregon initiated a reintroduction program using spring Chinook salmon from the Deschutes River. The nearest natural population of spring Chinook salmon is the Deschutes River population, but the population is part of a different ESU, the Middle Columbia River (MCR) Chinook Salmon ESU. The delisting persistence probability target is listed as very high, but NMFS (2013a) believes that the prospects for meeting that target are uncertain. The only data we have are for estimates of spring Chinook salmon returning to the Hood River are in Table 25, indicating a declining trend in the proportion of presumed natural-origin returns as time went on with the reintroduction program. With the removal of Powerdale Dam, it has not been possible to estimate the abundance of returning adults with any certainty. Earlier reports of unmarked spring-run Chinook salmon returning to the Hood River (NWFSC 2015) may suggest the persistence of some native fish, but there is no verification of this. The last estimate of natural abundance, 18 adults, was in 2017 (NWFSC 2022).

Table 25. Total, hatchery, and natural-origin spring Chinook returns to the Hood River (TAC 2017, Table 2.1.11).

Year	Total Run Size [1]	Clipped Hatchery Run Size	Unclipped Presumed Natural-origin Run Size	Proportion Presumed Natural-origin
2001	602	560	42	7.0%
2002	170	101	69	40.6%
2003	400	338	62	15.5%
2004	242	98	144	59.5%
2005	696	589	107	15.4%
2006	1,236	939	297	24.0%
2007	460	327	133	28.9%
2008	997	936	61	6.1%
2009	1,314	1,248	66	5.0%
2010	635	507	128	20.2%
2011	1,377	1,377	n/a	n/a
2012	1,114	1,114	n/a	n/a
2013	860	820	40	4.7%
2014	1,111	1,086	25	2.3%
2015	2,331	2,223	108	4.6%
2016	1,996	1,846	150	7.5%
5 yr. avg.	1,482	1,418	81	3.8%

[1] Run Size from Oregon Department of Fish and Wildlife (ODFW). Powerdale dam counts prior to 2010.

The White Salmon River natural population is considered extirpated. Condit Dam was completed in 1913 with no juvenile or adult fish passage, thus precluding access to all essential habitat. The breaching of Condit Dam in 2011 provided an option for recovery planning in the White Salmon River. The recovery plan calls for monitoring escapement in the basin for four to five years to see if natural recolonization occurs (abundance estimates prior to 2012 reflected fish spawning below Condit Dam during the spring run temporal spawning window) (NWFSC 2015). Although some spring-run fish have spawned in the basin subsequent to the dam removal, the origin of those fish is not known and spawner surveys have been limited (NWFSC 2022). The most recent 5-year data indicate substantial fish abundance has not yet become established. The current 5-year geomean is only eight fish (Table 22) compared to the recovery target of 500 (Table 20). The recovery scenario described in the recovery plan identifies the White Salmon spring population as a contributing population with a low plus persistence probability target (Table 20).

In summary: there is considerable uncertainty whether this MPG now persists, and whether the low abundances observed represent native natural-origin abundances (NWFSC 2022).

Coast Fall-run MPG

There are seven natural populations in the Coast Fall Chinook salmon MPG. None are considered genetic legacy populations, but all of the populations are targeted for improved persistence probability in the recovery scenario. The Elochoman/Skamokawa, Clatskanie, Mill/Abernathy/Germany (M/A/G), and Scappoose populations are targeted for high persistence, while the Grays River is targeted for medium plus persistence probability. The Big Creek and Youngs Bay populations are targeted for low persistence probability (Table 20).

Populations in this MPG are subject to significant levels of hatchery straying (Table 23). Only in the Grays River Tule population was there a considerable increase in five-year and longer-term abundance, from 79 to 228 (Table 22), although hatchery-origin fish still constitute the majority of natural spawners (Table 23). There was a Chinook salmon hatchery on the Grays River, but that program was closed in 1997 with the last hatchery returns from that facility to the river in 2002. A temporary weir was installed for the first time on the Grays River in 2008 to quantify escapement and to help control the number of hatchery strays from hatchery programs outside the Grays River. As it turns out, a large number of out-of-ESU Rogue River brights from the Youngs Bay net pen programs were observed at the weir, and by 2010 the weir was functionally able to begin removing hatchery strays. The weir, however, is no longer functional and current levels strays from the out-of-ESU Rogue River brights have decreased due to the program downsizing its release size.

The Elochoman River/Skamokawa Tule population was largely stable, with a 5-year geomean abundance of 95 (Table 22). The tule hatchery program operating in the Elochoman River was closed in 2009 (NMFS 2013a). The last returns of these hatchery fish were likely in 2014. Closure of the hatchery program is consistent with the overall transition and hatchery reform strategy for tule Chinook salmon. This population has experienced a slight uptick in the abundance geomean (Table 22), but it is very small, and the last 5-year geomean of spawning abundance of 95 fish is still far short of the recovery plan's recovery target of 1,500 fish.

Of the remaining populations, downward trends were observed in the Youngs Bay, Clatskanie River, and M/A/G Creeks Tule populations, all of which have low abundances (Table 22). Spawning surveys for Youngs Bay and Big Creek are incomplete. The most recent data for the Youngs Bay population indicate a negative trend with the recent 5-year geomean of 145 fish falling short of the 505 abundance expected under the delisting scenario (Table 20). Big Creek surveys are not done every year, and returns are dominated by returns to the hatchery. Presently, unmarked fall-run Chinook salmon are passed over the Big Creek weir to spawn naturally in the upper basin, as there is limited spawning habitat below the weir; the most recent estimate for natural-origin spawners was 118 in 2018. The Big Creek and Youngs Bay natural populations are both proximate to large net pen rearing and release programs designed to provide for a localized, terminal fishery in Youngs Bay. The number of fish released at the Big Creek hatchery has been reduced with additional changes in hatchery practices to help reduce straying into the Clatskanie and other neighboring systems. These are examples of actions the states have taken as part of a comprehensive program of hatchery reform to address the effects of hatcheries.

The Clatskanie River surveys are strongly influenced by large numbers of hatchery-origin fish being attracted to Plympton Creek, whereas the mainstem Clatskanie River has a few natural-origin spawners (>10), but almost no hatchery fish (Tables 22 and 23). The most recent data indicates very low numbers of fish in the Clatskanie River populations, as the 5-year geomeans for the last two 5-year periods indicate less than ten fish versus the delisting scenario expecting annual abundances of over 1,200 (Table 20).

In summary: the populations in this MPG are dominated by hatchery-origin spawners from one of the many large production hatcheries in the area. The abundance of naturally produced adults is low to very low for all populations, and overall productivity estimates were negative (NWFSC 2022).

Cascade Fall-run MPG

There are ten natural populations of fall Chinook salmon in the Cascade MPG. The Lower Cowlitz, Kalama, Clackamas, and Sandy populations are targeted for medium persistence probability (Table 20). The Toutle, Coweeman, Lewis, and Washougal populations are targeted for high-plus persistence probability in the ESA recovery plan (Table 20). Of these, only the Coweeman and Lewis are considered genetic legacy populations. The target persistence probability for the other two populations is very low: Salmon Creek, a population within a highly urbanized subbasin with limited habitat recovery potential, and Upper Cowlitz, a population with reintroduction of spring Chinook salmon as the main recovery effort (NMFS 2013a) (Table 20).

Within this MPG, six of the nine populations show short-term positive trends (Table 22). Natural-origin spawner abundances were in the high hundreds to low thousands of fish, with the majority of the fish on the spawning grounds being natural-origin, except for the Toutle, Kalama, and Washougal Rivers, where hatchery programs strongly influence the composition of naturally-spawning fish (Table 23). The Lower Cowlitz River Tule population had the highest five-year abundance (3,208), a 25% increase over the previous period (Table 22) and is above the delisting abundance goal of 3,200 (Table 20).

Annual variability in the proportion of hatchery-origin spawners is very high in the Clackamas River (Table 23), although only a few years of data are available. Recent improvements in natural adult returns to the Tilton River (part of the Upper Cowlitz River Tule population) suggest that the trap-and-haul program at Mayfield Dam has been successful (NWFSC 2022). The Coweeman and Lewis populations do not have in-basin hatchery programs and are generally subject to less straying. Broodstock management practices for hatcheries are being revised to reduce the level of straying and the resulting effects when straying occurs. Weirs are being operated on the Kalama River to assist with broodstock management, and on the Coweeman and Washougal Rivers to further assess and control hatchery straying in each system. These are examples of actions the states have taken as part of a comprehensive program of hatchery reform to address the effects of hatcheries.

In summary: the majority of the populations in this MPG have exhibited stable or slightly positive natural-origin abundance trends. Overall, most of the fall-run populations in this MPG are improving, even approaching recovery levels in some cases, and while the level of hatchery contribution to naturally spawning adults is relatively better than in other MPGs in this ESU, most populations are still far above the hatchery contribution target of 10% identified in NMFS's lower Columbia River recovery plan (NMFS 2013a).

Gorge Fall-run MPG

There are four natural populations of tule Chinook salmon in the Gorge Fall Chinook salmon MPG: Lower Gorge, Upper Gorge, White Salmon, and Hood. The recovery plan targets the White Salmon and Lower and Upper Gorge populations for medium persistence probability, and the Hood River population for high persistence. However, as discussed earlier in this subsection, it is unlikely that the high viability objective can be met (Table 20). There is some uncertainty regarding the historical role of the Gorge populations in the ESU, and whether they truly functioned historically as populations (NMFS 2013a). This is accounted for in the recovery scenario presented in the recovery plan.

Natural populations in the Gorge Fall MPG have been subject to the effects of a high incidence of hatchery fish straying, and spawning naturally. The White Salmon population, for example, was limited by Condit Dam (as discussed above regarding Gorge Spring MPG) and natural spawning occurred in the river below the dam (NMFS 2013a, Appendix C). Natural-origin returns for most populations are in the hundreds of fish, with decreases in abundance noted for those populations for which we have abundance estimates. Recent five-year geomean for the Big White Salmon River was 282, a 63% decline in abundance (Table 22), compared to the delisting goal of 500 (Table 20). However, spawning is dominated by tule Chinook salmon strays from the neighboring Spring Creek Hatchery and upriver bright Chinook salmon from the production program in the adjoining Little White Salmon River[12]. The Spring Creek Hatchery, which is located immediately downstream from the Little White Salmon River mouth, is the largest tule Chinook salmon production program in the Columbia basin, releasing approximately 10 million smolts annually. The White Salmon River was the original source for the hatchery broodstock, so whatever remains of the genetic heritage of the population is contained in the mix of hatchery

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[12] These fish are not part of the LCR Chinook Salmon ESU.

and natural spawners. There is relatively little known about current natural-origin fall Chinook salmon production in this basin, but it is presumed to be low.

There is relatively little specific or recent information on the abundance of tule Chinook salmon for the other natural populations in the Gorge Fall MPG. Stray hatchery fish are presumed to be decreasing contributors towards the spawning populations in these tributaries due to recent reductions in overall Gorge MPG hatchery releases, including the recent discontinuation of tule Chinook salmon releases from the Little White Salmon Hatchery. Hatchery strays still contribute to the escapement to the Lower Gorge, Upper Gorge, and Hood River populations on the Oregon side of the river (NWFSC 2022). These populations are mostly influenced by hatchery strays from the Bonneville Hatchery located immediately below Bonneville Dam, and the Spring Creek Hatchery located just above Bonneville Dam. The natural-origin abundance of returning Chinook salmon of the Lower Gorge populations has been steadily increasing in recent years (Table 4). The tributaries in the Gorge on the Washington side of the river are similarly affected by hatchery strays, which the recent past five years of monitoring show stable pHOS levels (Table 5). As a consequence, hatchery-origin fish contribution to spawning levels varies in all of the Gorge area tributaries, but actual estimates are unknown for areas like Eagle Creek, Tanner Creek and Herman Creek.

In summary: Natural-origin returns for most populations are in the hundreds of fish, with many of the populations in this MPG having limited spawning habitat available, either because of inundation of historical habitat in the upper gorge or the loss of access.

Cascade Late Fall-run MPG

There are two late-fall, “bright,” Chinook salmon natural populations in the LCR Chinook Salmon ESU in the Sandy and Lewis Rivers. Both populations are in the Cascade MPG (Table 20). Both populations are targeted for very high persistence probability under the recovery scenario (Table 20).

The Lewis River population is the principal indicator stock for management within the Cascade Late Fall-run MPG. It is a natural-origin population with little or no hatchery influence. The escapement goal, based on estimates of maximum sustainable yield (MSY), is 5,700 (McIssac 1990). The natural-origin abundance mean is 8,725 (Table 22) over the last five years and has generally exceeded the goal by a wide margin since at least 1980. While the pattern shows a slight negative trend, the shortfall is consistent with a pattern of low escapements for other far-north migrating stocks in the region, and can likely be attributed to poor ocean conditions. NMFS (2013) identifies an abundance target under the recovery scenario of 7,300 natural-origin fish (Table 20), which is 1,600 more fish than the currently managed-for escapement goal. The recovery target abundance is estimated from population viability simulations, and is assessed as a median abundance over any successive 12-year period. The median escapement over the last five years therefore is exceeding the abundance objective in the recovery plan. Escapement of bright Chinook salmon to the Lewis River is expected to vary from year to year as it has in the past, but generally remain high relative to the population’s escapement objectives, which suggests that the population is near capacity.

The Sandy River bright run is no longer directly monitored with the removal of Marmot Dam in 2007 as a counting station; the most recent estimate was 373 spawners in 2010 (NWFSC 2022). It is unclear if the value is composed of only natural-origin fish; however, there is no hatchery program operated in the tributary for tule or bright Chinook salmon. Abundance estimates for Sandy River fall-run (tule) and bright-run Chinook salmon are combined by ODFW into a single Sandy River fall-run data series, which increased during the recent review period (5-year geomean = 2,074, a 76% increase) (NWFSC 2022). The abundance target for delisting is 3,747 natural-origin fish (Table 20), and although there is some uncertainty to the exact status of the Sandy River bright run, the population currently appears to be at relatively low risk.

In summary: this MPG is the most viable in the ESU. The Lewis River bright DIP is sustaining abundances above its recovery target, and both populations in this MPG maintain their abundances with no hatchery supplementation.

Summary

Spatial structure and diversity are VSP attributes that are evaluated for the LCR Chinook Salmon ESU using a mix of qualitative and quantitative metrics. There have been a number of large-scale efforts to improve accessibility, one of the primary metrics for spatial structure, in this ESU. Passage efforts on the Cowlitz River at Cowlitz Falls began in 1996 for Chinook salmon and other salmonids (NWFSC 2022). In addition, the collection of juvenile fall-run Chinook salmon from the Tilton River at Mayfield Dam appears to be relatively successful, with increasing numbers of fall-run Chinook salmon returning in the last few years. Spring-run reintroductions are not planned for the Tilton River. As explained above, the sediment retention structure remains an impediment to fish passage in the North Fork Toutle River. On the Hood River, Powerdale Dam was removed in 2010, and while this dam previously allowed fish passage, removal of the dam is thought to have eliminated passage delays and injuries. Condit Dam, on the White Salmon River, was removed in 2011, providing access to previously inaccessible habitat. Spawner surveys of the White Salmon River indicate that both hatchery-origin and unmarked (presumed natural-origin) Chinook salmon are colonizing the newly accessible habitat (NWFSC 2022). Fish passage operations for spring-run Chinook salmon (trap-and-haul) were begun on the Lewis River in 2012, reestablishing access to historically occupied habitat above Swift Dam (River Kilometer (RKM) 77.1). These efforts are anticipated to improve spatial structure for each of these respective populations, and by opening up access to blocked spawning habitat increase future abundances.

Figure 19 provides recently updated information about the productivity for each population within the LCR Chinook Salmon ESU. Low abundance, past broodstock transfers, other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among LCR Chinook salmon populations. Hatchery-origin fish spawning naturally may also have reduced population productivity (LCFRB 2010; ODFW 2010). Releases of out-of-ESU upper Willamette River spring-run Chinook salmon into Oregon tributaries near the mouth of the Columbia River may not pose a long-term genetic risk, due to the absence of spring-run spawning habitat in the Coastal stratum, but may pose a risk to natural-origin juveniles due to competition and predation (NWFSC 2022). There have been some reductions in the number of fall-run Chinook salmon in an effort to decrease the contribution of hatchery-origin fish to naturally spawning adults. Spring-run Chinook salmon production has continued, in part, due to the inaccessibility of historical spring-run spawning and rearing habitat, particularly in subbasins like the Cowlitz and Lewis rivers to preserve this life history. The termination of the non-native late fall-run Chinook salmon below Bonneville Dam has decreased the risk of introgression between native natural- and hatchery-origin fish (NWFSC 2022). The estimated proportion of hatchery-origin spawners is still well in excess of the limits set in the recovery plan for many of the primary populations throughout the ESU (Table 23).

Out of the 32 populations that make up this ESU, only seven populations are at or near the recovery viability goals (Table 26) set in the recovery plan (refer above to Table 20). Six of these seven populations were located in the Cascade stratum; most of the populations in the Coastal and Gorge strata are doing rather poorly (NWFSC 2022).

Overall, there has been modest change since the last status review in the biological status of Chinook salmon populations in the Lower Columbia River Chinook salmon ESU (NWFSC 2022). Increases in abundance were noted in about half of the fall-run populations, and in 75% of the spring- run populations for which data were available. Decreases in hatchery contribution were also noted for several populations. Relative to baseline VSP levels identified in the recovery plan (NMFS 2013a), there has been an overall improvement in the status of a number of spring and fall-run populations (Table 26), although most are still far from the recovery plan goals

Many of the populations in this ESU remain at “high risk,” with low natural-origin abundance levels. Hatchery contributions remain high for a number of populations (Table 24), and it is likely that many returning unmarked adults are the progeny of hatchery-origin parents, especially where large hatchery programs operate. While overall hatchery production has been reduced slightly, hatchery-produced fish still represent a majority of fish returning to the ESU. Although many of the populations in this ESU are at “high” risk, it is important to note that poor ocean and freshwater conditions existed during the 2015–2019 period and, despite these conditions, the status of a number of populations improved, some remarkably so from the previous status review (Grays River Tule, Lower Cowlitz River Tule, and Kalama River Tule fall runs) (NWFSC 2022). Overall, the viability of the LCR Chinook salmon ESU has increased since the last status review, although the ESU remains at “moderate” risk of extinction.

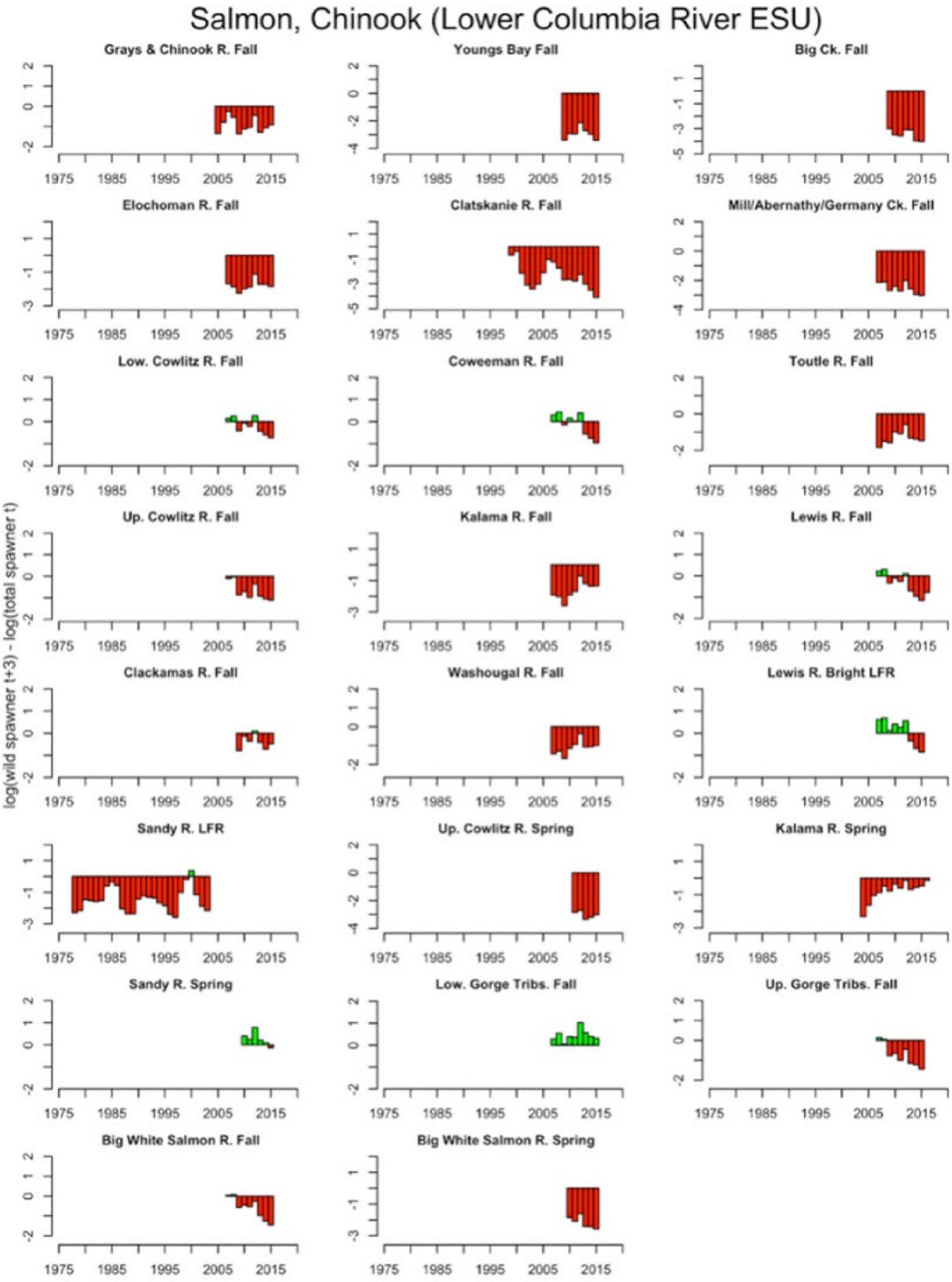

Figure 19. Trends in population productivity, estimated as the log of the smoothed natural spawning abundance in year t minus the smoothed natural spawning abundance in year (t – 4). Spawning years on x-axis (NWFSC 2022).

Table 26. Current 5-year geometric mean of raw natural-origin spawner abundances compared to the recovery scenario presented in the recovery plan (NMFS 2013a) for LCR Chinook salmon populations (NWFSC 2022).

		Abundance	
MPG	**Population**	**2015–2019**	**Recovery Target**
Coastal	Grays River Tule FA (WA)	228	1,000
	Youngs Bay FA (OR)	145	505
	Big Creek FA (OR)	0	577
	Elochoman River/Skamokawa Tule FA (WA)	95	1,500
	Clatskanie River FA (OR)	3	1,277
	Mill/Abernathy/Germany Creeks Tule FA (WA)	28	900
	Scappoose Creek FA (OR)	n/a	1,222
Cascade	Upper Cowlitz/Cispus Rivers SP (WA)	171	1,800
	Kalama River SP (WA)	43	300
	North Fork Lewis River SP (WA)	-112	1,500
	Sandy River SP (OR)	3,359	1,230
	Toutle River SP (WA)	n/a	1,100
	Cispus River SP (WA)	n/a	1,800
	Tilton River SP (WA)	n/a	100
	Lower Cowlitz River Tule FA (WA)	3,208	3,000
	Coweeman River Tule FA (WA)	543	900
	Toutle River Tule FA (WA)	280	4,000
	Upper Cowlitz River Tule FA (WA)	1,761	n/a
	Kalama River Tule FA (WA)	2,142	500
	Lewis River Tule FA (WA)	2,003	1,500
	Clackamas River FA (OR)	236	1,551
	Sandy River FA (OR)	-2,074	1,031
	Washougal River Tule FA (WA)	914	1,200
	Salmon Creek FA (WA)	n/a	n/a
	Lewis River Bright LFR (WA)	8,725	7,300
	Sandy River Bright LFR (OR)	n/a	3,561
Gorge	Big White Salmon River SP (WA)	8	500
	Hood River SP (OR)	n/a	1,493
	Lower Gorge Tributaries Tule FA (WA & OR)	4,528	1,200
	Upper Gorge Tributaries Tule FA (WA & OR)	537	1,200
	Big White Salmon River Tule FA (WA)	283	500
	Hood River FA (OR)	n/a	1,245

Colors indicate the relative proportion of the recovery target currently obtained: red: <10%, orange: 10% < x < 50%, yellow: 50% < x < 100%, green: >100%

Limiting Factors

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the LCR Chinook Salmon ESU. Understanding the factors that limit the ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. LCR Chinook salmon populations began to decline by the early 1900s because of habitat alterations and harvest rates that were unsustainable, particularly given these changing habitat conditions. Human impacts and limiting factors come from multiple sources, including hydropower development on the Columbia River and its tributaries, habitat degradation, hatchery effects, fishery management and harvest decisions, and ecological factors, including predation and environmental variability. The recovery plan consolidates available information regarding limiting factors and threats for the LCR Chinook Salmon ESU (NMFS 2013a).

The recovery plan provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 4 of the recovery plan (NMFS 2013a) describes limiting factors on a regional scale, and how they apply to the four ESA-listed species from the LCR considered in the plan, including the LCR Chinook Salmon ESU. Chapter 4 (NMFS 2013a) includes details on large scale issues including:

- Ecological interactions,
- Climate change, and
- Human population growth.

Chapter 7 of the recovery plan discusses the limiting factors that pertain to LCR Chinook salmon spring, fall, and late fall natural populations and the MPGs in which they reside. The discussion of limiting factors in Chapter 7 (NMFS 2013a) is organized to address:

- Tributary habitat,
- Estuary habitat,
- Hydropower,
- Hatcheries,
- Harvest, and
- Predation.

Rather than repeating the extensive discussion from the recovery plan, it is incorporated here by reference.

In our recent five-year status review (NMFS 2022), based on Section 4(a)(1) of the ESA, we determine if the listed species listing factors have changed. While there have been improvements in the abundance of some populations, we found that the overall viability trends remain low, and well below abundance recovery objectives for LCR Chinook Salmon ESU. Some improvements have been made in listing factors, though slight increases in risk in some listing factors are contemporaneous with restoration work and some regulatory improvements, and the recent improvements (particularly habitat restoration work) require time to manifest measurable increases in population viability. The risk from predation and disease to LCR Chinook Salmon ESU remains. For harvest, the risk is increasing for LCR Chinook salmon due to modest upward trend in harvest impacts on fall and bright fall-run components of the ESU (NMFS 2022). Additionally, the risk to the species persistence from climate change is an increasing concern (NMFS 2022).

As mentioned above, the continuing high proportions of hatchery-origin fish in spawning populations has been purposeful in some areas, e.g. for reintroduction purposes in the Hood, Cowlitz, and Lewis subbasins. However, the recent biological opinion on the majority of hatchery production affecting this ESU (NMFS 2017) expects Federal funding guidelines to require reductions in limiting factors relative to hatchery effects over the course of the next decade.

Accordingly, when all listing factors and current viability are considered, specific to the LCR Chinook Salmon ESU, our recent 5-year status review indicates that the collective risk to the persistence of the LCR Chinook Salmon ESU has not changed significantly since our listing determination in 2006 and should remain listed as threatened (NMFS 2022d).

2.2.1.5. Status of Lower Columbia River (LCR) Coho Salmon

On June 28, 2005, NMFS listed the LCR Coho Salmon ESU as a threatened species (70 FR 37160). The threatened status was reaffirmed on April 14, 2014. Critical Habitat was originally proposed January 14, 2013 and was finalized on January 24, 2016 (81 FR 9252). The most recent status review was published in 2022 (NMFS 2022d) and the recovery plan in 2013 (NMFS 2013a).

Inside the geographic range of the ESU, 24 hatchery coho salmon programs are currently operational (Table 27). Up through 2008, 25 hatchery programs produced coho salmon considered to be part of the ESU. Genetic resources can be housed in a hatchery program but for a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see NMFS (2005). In 2009, the Elochoman Type-S and Type-N programs were discontinued. Table 27 lists the 23 hatchery programs currently included in the ESU and the one excluded program (Jones Jr. 2015). LCR coho salmon are primarily limited to the tributaries downstream of Bonneville Dam (Figure 20). Coho salmon in the Willamette River spawning above Willamette Falls are not considered part of the LCR Coho Salmon ESU (70 FR 37160).

Table 27. LCR Coho Salmon ESU description and MPGs (NMFS 2013a; Jones Jr. 2015).[1]

ESU Description	
Threatened	Listed under ESA in 2005; updated in 2014.
3 major population groups	24 historical populations
Major Population Group	***Population***
Coast	Youngs Bay, Grays/Chinook, Big Creek, Elochoman/Skamokawa, Clatskanie, Mill/Abernathy/Germany Creeks, Scappoose
Cascade	Lower Cowlitz, Upper Cowlitz, Cispus, Tilton, South Fork Toutle, North Fork Toutle, Coweeman, Kalama, North Fork Lewis, East Fork Lewis, Salmon Creek, Clackamas, Sandy, Washougal
Gorge	Lower Gorge, Upper Gorge/White Salmon, Upper Gorge/Hood

Artificial production	
Hatchery programs included in ESU (23)	Grays River (Type-S), Sea Resources (Type-S), Peterson Coho Salmon Project (Type-S), Big Creek Hatchery (ODFW stock #13), Astoria High School (STEP) Coho Salmon Program, Warrenton High School (STEP) Coho Salmon Program, Cathlamet High School FFA Type-N Coho Salmon Program, Cowlitz Type-N Coho Salmon Program (Upper and Lower Cowlitz programs), Cowlitz Game and Anglers Coho Salmon Program, Friends of the Cowlitz Coho Salmon Program, North Fork Toutle River Hatchery (type-S), Kalama River Type-N Coho Salmon Program, Kalama River Type-S Coho Salmon Program, Lewis River Type-N Coho Salmon Program, Lewis River Type-S Coho Salmon Program, Fish First Wild Coho Salmon Program, Fish First Type- N Coho Salmon Program, Syverson Project Type-N Coho Salmon Program, Washougal River Type-N Coho Salmon Program, Eagle Creek NFH, Sandy Hatchery (ODFW stock #11), Bonneville/Cascade/Oxbow Complex (ODFW stock #14)
Hatchery programs not included in ESU (1)	CCF Coho Salmon Program (Klaskanine River origin) *The Elochoman Type-S and Type-N coho salmon hatchery programs have been discontinued and NMFS has recommended removed them from the ESU (Jones Jrno 2015)

[1] Because NMFS had not yet listed this ESU in 2003 when the WLC TRT designated core and genetic legacy populations for other ESUs, there are no such designations for LCR coho salmon.

Twenty-four historical populations within three MPGs comprise the LCR Coho Salmon ESU with generally low baseline persistence probabilities (Table 28). The ESU includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries from the mouth of the Columbia River up to and including the White Salmon and Hood Rivers (Figure 20).

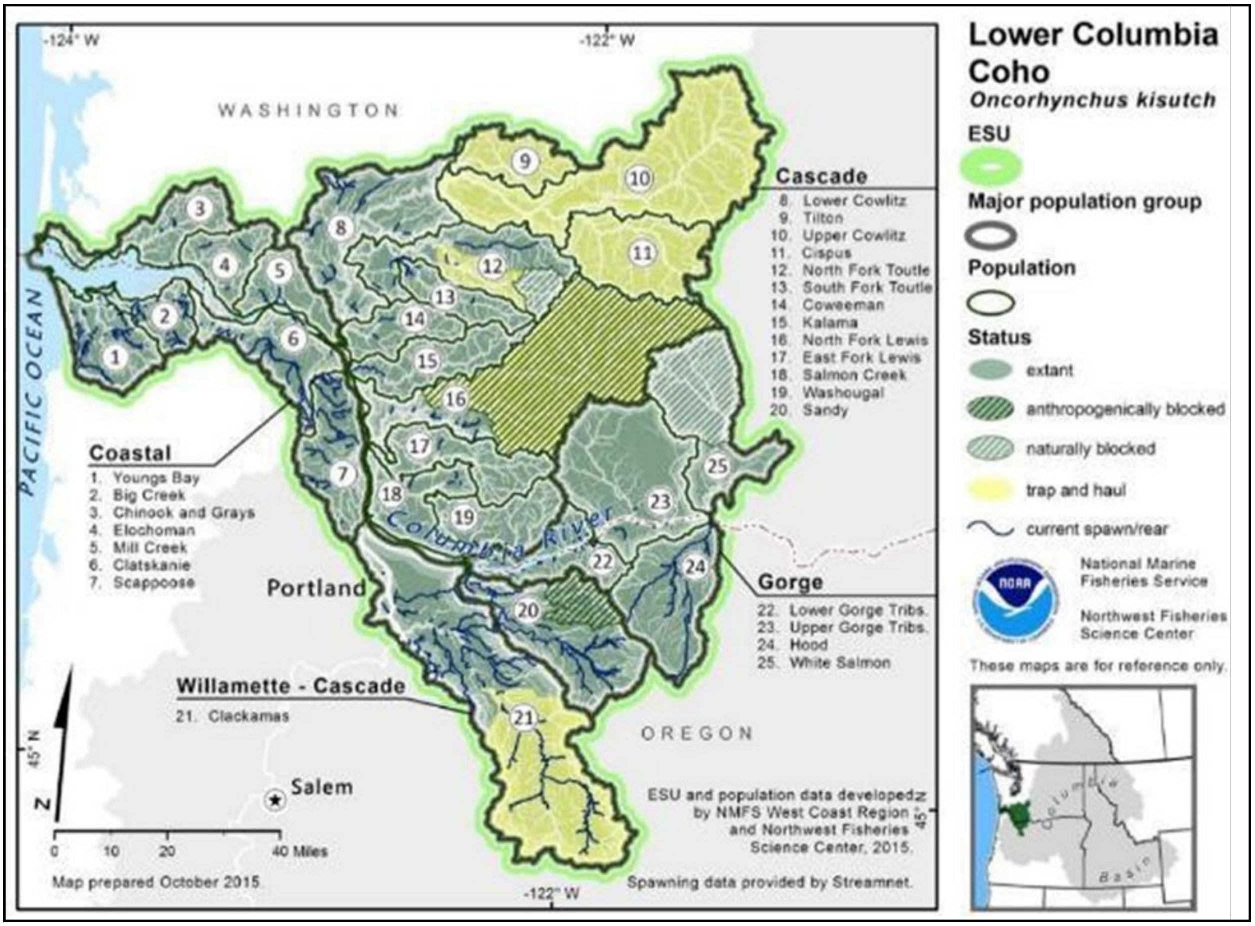

Figure 20. Map of the LCR Coho Salmon ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2015).

Table 28. Current status for LCR coho salmon populations and recommended status under the recovery scenario (NMFS 2013a).

		Status Assessment		**Recovery Scenario**	
Major Population Group	**Population (State)**	**Baseline Persistence Probability**[1]	**Contribution**[2]	**Target Persistence Probability**	**Abundance Target**[3]
Coast	Youngs Bay (OR) - *Late*	VL	Stabilizing	VL	7
	Grays/Chinook (WA) - *Late*	VL	Primary	H	2,400
	Big Creek (OR) - *Late*	VL	Stabilizing	VL	12
	Elochoman/Skamokawa (WA) – *Late*	VL	Primary	H	2,400
	Clatskanie (OR) - *Late*	L	Primary	H	3,201
	Mill/Aber/Germ (WA) - *Late*	VL	Contributing	M	1,800
	Scappoose (OR) - *Late*	M	Primary	VH	3,208
Cascade	Lower Cowlitz (WA) - *Late*	VL	Primary	H	3,700
	Upper Cowlitz (WA) - *Early, late*	VL	Primary	H	2,000
	Cispus (WA) - *Early, late*	VL	Primary	H	2,000
	Tilton (WA) - *Early, late*	VL	Stabilizing	VL	--
	South Fork Toutle (WA) - *Early, late*	VL	Primary	H	1,900
	North Fork Toutle (WA) - *Early, late*	VL	Primary	H	1,900
	Coweeman (WA) - *Late*	VL	Primary	H	1,200
	Kalama (WA) - *Late*	VL	Contributing	L	500
	North Fork Lewis (WA) - *Early, late*	VL	Contributing	L	500
	East Fork Lewis (WA) - *Early, late*	VL	primary	H	2,000
	Salmon Creek (WA) - *Late*	VL	Stabilizing	VL	--
	Clackamas (OR) - *Early, late*	M	Primary	VH	11,232
	Sandy (OR) - *Early, late*	VL	Primary	H	5,685
	Washougal (WA) - *Late*	VL	Contributing	M+	1,500
Gorge	Lower Gorge (WA/OR) - *Late*	VL	Primary	H	1,900
	Upper Gorge/White Salmon (WA) - *Late*	VL	Primary	H	1,900
	Upper Gorge/Hood (OR) - *Early*	VL	Primary	H*	5,162

[1] VL = very low, L = low, M = moderate, H = high, VH = very high. These are adopted in the recovery plan

[2] Primary, contributing, and stabilizing designations reflect the relative contribution of a population to recovery goals and delisting criteria. Primary populations are targeted for restoration to a high or very high persistence probability. Contributing populations are targeted for medium or medium-plus viability. Stabilizing populations are those that will be maintained at current levels (generally low to very low viability), which is likely to require substantive recovery actions to avoid further degradation.

[3] Abundance objectives account for related goals for productivity.

* Oregon's analysis indicates a low probability of meeting the delisting objective of high persistence probability for this population.

Although run time variation is considered inherent to overall coho salmon life- history, LCR coho salmon typically display one of two major life-history types, either early or late returning freshwater entry. Freshwater entry timing for this ESU is also associated with ocean migration patterns (Table 28) based on the recovery of CWT hatchery fish north or south of the Columbia River (Myers et al. 2006). Early returning (Type-S) coho salmon generally migrate south of the Columbia River once they reach the ocean, returning to freshwater in mid-August and to the spawning tributaries in early September. Spawning peaks from mid-October to early November. Late returning (Type-N) coho salmon have a northern distribution in the ocean, returning to the LCR from late September through December and enter the tributaries from October through January. Most of the spawning for Type-N occurs from November through January, but some spawning occurs in February and as late as March (NMFS 2013a). In general, early returning fish (Type-S) spawn further upstream than later migrating fish (Type-N), although Type-N fish enter rivers in a more advanced state of sexual maturity (Table 29) (Sandercock 1991).

Table 29. Life-History and population characteristics of LCR coho salmon.

	Life-History Features	
Characteristic	**Early-returning (Type-S)**	**Late-returning (Type-N)**
Number of extant population	10	23
Life-history type	Stream	Stream
River entry timing	August–September	September–December
Spawn timing	October–November	November–January
Spawning habitat type	Higher tributaries	Lower tributaries
Emergence timing	January–April	January–April
Duration in freshwater	Usually 12–15 months	Usually 12–15 months
Rearing habitat	Smaller tributaries, river edges, sloughs, off-channel ponds	Smaller tributaries, river edges, sloughs, off-channel ponds
Estuarine use	A few days to weeks	A few days to weeks
Ocean migration	South of the Columbia River, as far south as northern California	North of the Columbia River, as far north as British Columbia
Age at return	2–3 years	2–3 years
Recent natural spawners	6,000	
Recent hatchery adults	5,000 – 90,000	12,000 – 180,000

In contrast to Chinook salmon and steelhead, LCR coho salmon run timing was not used to establish differences between MPGs. Some tributaries historically supported spawning by both run types; therefore Myers et al. (2006) indicated that, regardless of whether run timing is an element of diversity on a subpopulation or population level, the run timing was a factor that needed consideration in recovery planning for LCR coho salmon. NMFS' recovery plan took this into consideration by identifying each LCR coho salmon population's proposed life-history component(s).

Regardless of adult freshwater entry timing, coho salmon fry move to shallow, low velocity rearing areas after emergence, primarily along the stream edges and in side channels. All coho salmon juveniles remain in freshwater rearing areas for a full year after emerging from the gravel. Most juvenile coho salmon migrate seaward as one-year smolts from April to June. Salmon with stream-type life-histories, like coho salmon, typically do not linger for extended periods in the Columbia River estuary, but the estuary is critical habitat used for foraging during the physiological adjustment to the marine environment (NMFS 2013a). Coho salmon typically spend 18 months in the ocean before returning to freshwater to spawn. Jacks (i.e., precocial males) spend five to seven months in the ocean before returning to freshwater to spawn.

In 2017, NMFS adopted a Record of Decision ("Mitchell Act ROD") for a policy direction that would be used to guide NMFS' decision on the distribution of funds for hatchery production under the Mitchell Act (16 US CFR 755 757), which NMFS administers. NMFS' continued funding of Mitchell Act hatchery programs, under the Mitchell Act ROD, was analyzed under the ESA and was found to not likely to jeopardize the continued existence of any species in the Columbia Basin (NMFS 2017j). The Mitchell Act ROD directs NMFS to apply stronger performance goals to all Mitchell Act-funded, Columbia River Basin hatchery programs that affect ESA-listed primary and contributing salmon and steelhead populations. These stronger performance goals reduced the risks of hatchery programs on natural-origin salmon and steelhead populations, including the LCR Coho Salmon ESU. It required integrated hatchery programs to be better integrated and isolated hatchery programs to be better isolated. While the following information presented is a review of updated status information available, NMFS expects the prevalence of hatchery-origin coho salmon spawning contribution to decrease over the course of the 2018 Agreement due to the ITS limits and terms and conditions required by the opinion (NMFS 2017j).

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations. Best available information indicates that the species, in this case the LCR Coho Salmon ESU, is at high risk and remains at threatened status. Each population's baseline and target persistence probabilities are summarized in Table 28, along with target abundance for each population that would be consistent with delisting the species. Persistence probability is measured over a 100-year time period and ranges from very low (probability of less than 40%) to very high (probability of greater than 99%).

NMFS conducted status reviews of the LCR Coho Salmon ESU in 1996 (NMFS 1996a), in 2001 (NMFS 2001), in 2005 (Good et al. 2005), in 2011 (Ford 2011), and most recently in 2015 (NWFSC 2015). In 1996, the BRT concluded that they could not identify any remaining natural populations of coho salmon in the LCR (excluding the Clackamas River) or along the Washington coast south of Point Grenville that warrant protection under the ESA, although this conclusion would warrant reconsideration if new information becomes available. In the 2001 review, the BRT was concerned that the vast majority (more than 90%) of the historical natural populations in the ESU were either extirpated or nearly so. The two populations with any significant production (Sandy and Clackamas River populations) were at appreciable risk because of low abundance, declining trends, and failure of the populations to improve after a dramatic reduction in harvest. The large number of hatchery coho salmon in the ESU was also considered an important risk factor. The majority of BRT members in 2001 believed that the species was "at risk of extinction," with a small number of members believing that the species was "likely to become endangered." An updated status evaluation was conducted in 2005, also with a majority of BRT votes for "at risk of extinction" and a substantial minority for "likely to become endangered."

Five evaluations of LCR coho salmon status, all based on WLC-TRT criteria, have been conducted since the last BRT status update in 2005 (Ford 2011; LCFRB 2010; McElhany et al. 2007; ODFW 2010; WLC-TRT 2003). McElhany et al. (2007) concluded that the ESU is currently at high risk of extinction. ODFW (2010) concluded that the Oregon portion of the ESU is currently at very high risk. The (LCFRB 2010) does not provide a statement on ESU-level status, but describes the high fraction of populations in the ESU that are at high or very high risk. According to Ford (2011), of the 27 historical populations in the ESU, 24 are considered at very high risk. The latest status review (NWFSC 2015) relied on data available through 2014. According to the NWFSC, the status of a number of coho salmon populations have changed since previous reviews, mostly due to the improved level of monitoring (and subsequent understanding of status) in Washington tributaries, rather than a true change in status over time. Furthermore, the NWFSC (2015) determined that while recovery efforts have likely improved the status of a number of coho salmon populations, abundance is still at low levels and the majority of DIPs remain at moderate or high risk.

For LCR coho salmon, poor data quality prevented precise quantification of abundance and productivity. Data quality has been poor because of inadequate spawning surveys and, until recently, the presence of unmarked hatchery-origin spawners. Mass marking of hatchery-origin LCR coho salmon began in 1999 (LCFRB 2010) which generally allows assessment of what portion of escapement consists of hatchery-origin spawners and greatly improves the ability to assess the status of populations.

Hatchery production dominates the Washington side of this ESU and no populations are thought to be naturally self-sustaining because the majority of spawners are believed to be hatchery strays. Washington did not collect adult escapement estimates until recently. The state's monitoring strategy has instead relied primarily on a smolt monitoring program. Similar to the Washington populations, natural productivity on the Oregon side of the LCR Coho Salmon ESU is also believed to have decreased due to legacy effects of hatchery fish. While total hatchery production has been reduced from a peak in the 1980s most populations are still believed to have very low abundance of natural-origin spawners (NMFS 2013a; NWFSC 2015).[13]

In general, hatchery-origin fish comprise the large majority of LCR coho salmon annual adult returns (Tables 30 and 31). Numbers can vary substantially from year-to-year because coho salmon encounter and are affected by the widely-varying conditions for marine survival related to environmental conditions particularly in the coastal upwelling zone. Until recently, no population was thought to be naturally self-sustaining, with the majority of spawners believed to be hatchery strays. Moreover, it is likely that hatchery effects have also decreased population

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[13] An average of approximately 10-17 million hatchery coho salmon since 2005 have continued to be released annually in the LCR.

productivity. New and added hatchery releases of coho salmon in areas upstream of the LCR may be impacting natural-origin LCR coho salmon through straying, competition, and predation in the lower mainstem and estuary.

Information that has recently become available indicates that the frequency of hatchery fish straying onto natural spawning grounds is actually quite low for several natural coho salmon populations, which are thought to be self-sustaining. Table 31 presents escapement of LCR coho salmon in selected Oregon and Washington tributaries (2002–2015). New information about escapement of LCR coho salmon in Oregon and Washington that was not available in prior status reviews (Tables 30 and 31) suggests that there has been an increase in the wild fraction of natural-origin coho salmon in their relative abundances. Additionally, hatchery-fish straying into Oregon populations within the LCR Coho Salmon ESU has decreased while pockets of natural production, such as with the Scappoose and Clackamas populations, are also now increasing in their contribution to the overall Oregon coho salmon abundance.

Tables 30 and 31 provide estimates of escapement for tributaries on the Oregon and Washington sides of the lower Gorge population, respectively. It is unclear how comprehensive the surveys are or if the estimates are intended to be expanded estimates for the population as a whole. On the Washington side, the estimates are characterized as cumulative fish per mile index counts. This information, although limited, indicates there are several hundred spawners in these tributaries that collectively make up the population and that hatchery fractions are actually relatively low.

Table 30. Natural-origin spawning escapement numbers and the proportion of natural spawners composed of hatchery-origin fish (pHOS[1]) on the spawning grounds for LCR coho salmon populations in Oregon from 2002 through 2015*.

Major Population Group	Oregon Populations	Origin	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Coast	Youngs Bay	Natural	411	113	149	79	74	21	82	26	68	161	129	n/a	n/a	n/a
		pHOS	86%	86%	86%	75%	84%	40%	22%	92%	61%	66%	46%	n/a	n/a	n/a
	Big Creek	Natural	98	435	112	219	225	212	360	792	279	160	409	n/a	n/a	n/a
		pHOS	90%	40%	70%	36%	50%	15%	54%	30%	52%	21%	18%	n/a	n/a	n/a
	Clatskanie	Natural	167	563	398	494	421	927	995	1,195	1,686	1,546	619	611	3,246	240
		pHOS	22%	0%	0%	1%	10%	4%	0%	1%	3%	1%	11%	11%	4%	4%
	Scappoose	Natural	502	336	755	348	719	375	292	778	1,960	298	210	979	1,587	487
		pHOS	0%	10%	8%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Cascade	Clackamas	Natural	1,981	2,507	2,874	1,301	3,464	3,608	1,694	7,982	1,757	2,254	1,580	3,202	10,670	1,784
		pHOS	57%	10%	16%	28%	76%	14%	45%	27%	57%	10%	10%	2%	14%	11%
	Sandy	Natural	382	1,348	1,213	856	923	687	1,277	1,493	901	3,494	1,165	667	5,942	443
		pHOS	57%	0%	9%	0%	n/a	9%	0%	10%	12%	8%	3%	12%	3%	5%
Gorge	Lower Gorge	Natural	338	n/a	n/a	263	226	126	223	468	920	216	96	151	362	30
		pHOS	17%	n/a	n/a	85%	70%	67%	46%	29%	7%	54%	56%	6%	51%	38%
	Upper Gorge/Hood	Natural	147	41	126	1,262	373	170	69	65	223	232	169	561	42	4
		pHOS	60%	n/a	n/a	45%	48%	45%	29%	0%	85%	69%	78%	65%	76%	64%

[1] For example, Clatskanie in 2007 had 927 natural-origin spawners and 4% hatchery spawners.
To calculate hatchery-origin numbers: [927/(1 – 0.04)] – 583 = 39 hatchery-origin spawners.

*http://www.odfwrecoverytracker.org/summary/#/species=1&run=2&esu=159/esu=159&metric=1&level=3/filter=160&start_year=1992&end_year=2017 Date accessed: October 4, 2017.

Table 31. Natural-origin spawning escapement numbers and the proportion of all natural spawners composed of hatchery-origin fish (pHOS1) on the spawning grounds for LCR coho salmon populations in Washington from 2002 through 2015 (https://fortress.wa.gov/dfw/score/score/species/coho.jsp?species=Coho)*.

Major Population group	Washington populations	Origin	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Coast	Gray's/Chinook	Natural	-	-	-	-	-	-	-	-	388	152	795	1,212	3,700	86
		pHOS	-	-	-	-	-	-	-	-	81%	97%	22%	65%	32%	80%
	Elochoman / Skamokawa	Natural	-	-	-	-	-	-	-	-	834	851	505	721	4,158	168
		pHOS	-	-	-	-	-	-	-	-	73%	56%	29%	43%	34%	50%
	Mill Creek	Natural	-	-	-	-	-	-	-	-	859	576	207	101	932	-
		pHOS	-	-	-	-	-	-	-	-	12%	21%	2%	-	12%	-
	Abernathy	Natural	-	-	-	-	-	-	-	-	490	183	256	384	832	-
		pHOS	-	-	-	-	-	-	-	-	12%	21%	2%	-	12%	-
	Germany	Natural	-	-	-	-	-	-	-	-	322	48	122	149	475	-
		pHOS	-	-	-	-	-	-	-	-	12%	21%	2%	-	12%	-
Cascade	Lower Cowlitz	Natural	-	-	-	-	-	-	-	-	6,274	3,394	-	1,565	12,661	5,132
		pHOS	-	-	-	-	-	-	-	-	15%	8%	-	-	5%	8%
	Upper Cowlitz/Cispus	Natural	54,188	20,695	28,665	22,329	25,574	5,691	13,805	16,162	18,905	7,326	2,397	7,941	25,147	1,012
		pHOS	13%	28%	14%	21%	18%	40%	26%	26%	13%	51%	40%	0%	22%	-
	Tilton	Natural	1,732	601	722	1,332	738	827	1,006	1,305	929	2,025	1,301	2,744	9,074	-
		pHOS	91%	92%	95%	85%	69%	66%	64%	70%	80%	75%	79%	67%	39%	-
	SF Toutle	Natural	-	-	-	-	-	-	-	-	1,518	490	2,063	3,349	10,960	1,537
		pHOS	-	-	-	-	-	-	-	-	21%	22%	14%	-	19%	53%
	NF Toutle[2]	Natural	-	-	-	-	-	-	-	-	1,454	365	1,425	3,497	6,597	868
		pHOS	-	-	-	-	-	-	-	-	60%	30%	24%	-	32%	65%
	Coweeman	Natural	-	-	-	-	-	-	-	-	3,528	2,436	2,964	4,047	5,021	767
		pHOS	-	-	-	-	-	-	-	-	10%	6%	5%	-	17%	25%
	Kalama	Natural	-	-	-	-	-	-	-	-	5	-	69	64	99	18
		pHOS	-	-	-	-	-	-	-	-	99%	-	78%	-	91%	90%
	NF Lewis[3]	Natural	-	-	-	-	-	-	-	-	700	604	827	-	-	-
		pHOS	-	-	-	-	-	-	-	-	1%	3%	11%	-	100%	75%
	EF Lewis	Natural	-	-	-	-	-	-	-	-	1,363	1,025	3,681	3,251	2,531	389
		pHOS	-	-	-	-	-	-	-	-	32%	6%	9%	-	20%	17%

Major Population group	Washington populations	Origin	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
	Salmon Creek	Natural	-	-	-	-	-	-	-	-	-	1,248	1,897	2,693	4,257	1,348
		pHOS	-	-	-	-	-	-	-	-	-	20%	22%	-	0%	0%
	Washougal	Natural	-	-	-	-	-	-	-	-	795	562	531	604	737	101
		pHOS	-	-	-	-	-	-	-	-	44%	8%	13%	-	65%	67%
Gorge	Lower Gorge	Natural	-	-	-	-	28	-	-	-	385	504	524	1,125	704	650
		pHOS	-	-	-	-	0%	-	-	-	29%	13%	20%	-	35%	11%
	Upper Gorge/ Hood	Natural	147	41	126	1,262	373	170	69	65	223	232	169	561	42	4
		pHOS	-	-	-	-	-	-	-	-	-	-	-	-	23%	24%

[1] For example, Mill Creek in 2010 had 859 natural-origin spawners and 12% hatchery spawners. To calculate hatchery-origin numbers multiply (859/(1-.12))- 859 = 117 hatchery-origin spawners.

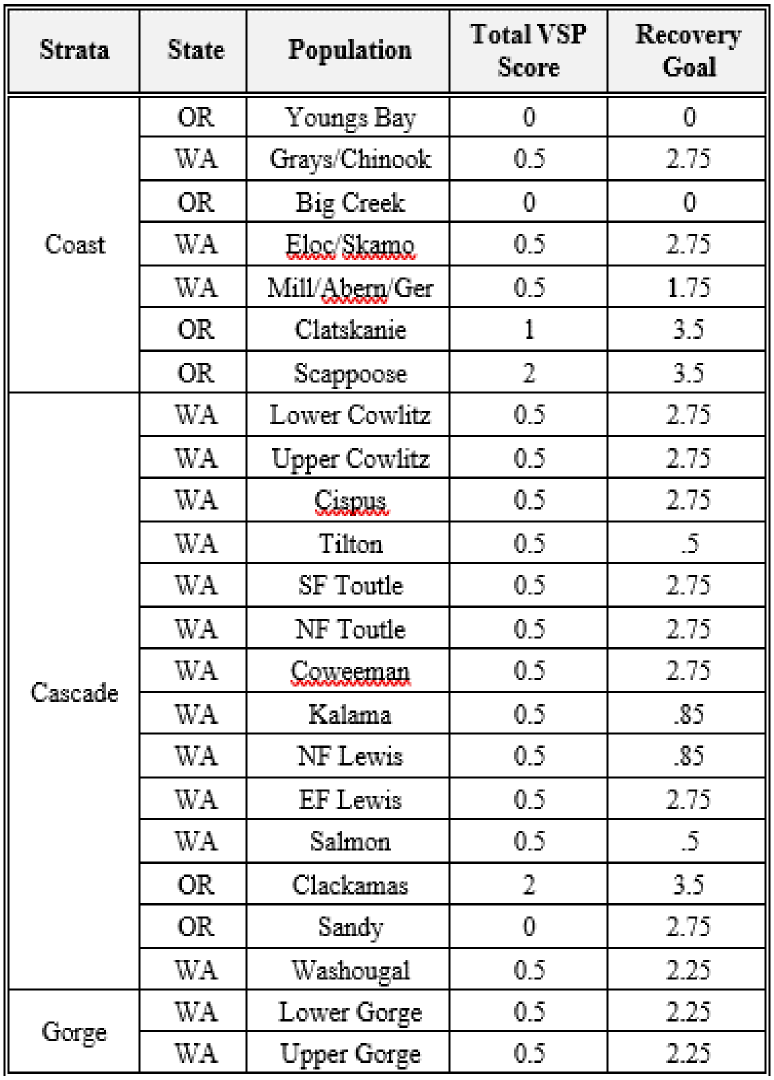
[2] Natural-origin escapement numbers and proportion of hatchery-origin fish combines the Green River (NF Toutle) coho salmon, the North Fork Toutle River coho salmon, and trap count data.

[3] Natural-origin escapement numbers and proportion of hatchery-origin fish combines the Cedar Creek (NF Lewis) coho salmon and the North Fork Lewis River Mainstem coho salmon.

* Date accessed: October 4, 2017.

Any changes in VSP score for coho salmon populations from the previous status review (see Table 32) reflect improvements in abundance, spatial structure, and diversity, as well as in monitoring (NWFSC 2015). Table 33 shows an overall summary of the abundance, productivity, spatial structure, and diversity ratings for each natural population within this ESU. Previous status reviews lacked adequate quantitative data on abundance and hatchery contribution for a number of populations whereas recent surveys provide a more accurate understanding of the status of these populations. However, with only two or three years of data, it is not possible to determine whether there has been a true improvement in status, though it is evident that the contribution of natural-origin fish is much higher than previously thought (NWFSC 2015).

Table 32. Summary of VSP scores and recovery goals for LCR coho salmon populations (NWFSC 2015).*



Strata	State	Population	Total VSP Score	Recovery Goal
Coast	OR	Youngs Bay	0	0
	WA	Grays/Chinook	0.5	2.75
	OR	Big Creek	0	0
	WA	Eloc/Skamo	0.5	2.75
	WA	Mill/Abern/Ger	0.5	1.75
	OR	Clatskanie	1	3.5
	OR	Scappoose	2	3.5
Cascade	WA	Lower Cowlitz	0.5	2.75
	WA	Upper Cowlitz	0.5	2.75
	WA	Cispus	0.5	2.75
	WA	Tilton	0.5	.5
	WA	SF Toutle	0.5	2.75
	WA	NF Toutle	0.5	2.75
	WA	Coweeman	0.5	2.75
	WA	Kalama	0.5	.85
	WA	NF Lewis	0.5	.85
	WA	EF Lewis	0.5	2.75
	WA	Salmon	0.5	.5
	OR	Clackamas	2	3.5
	OR	Sandy	0	2.75
	WA	Washougal	0.5	2.25
Gorge	WA	Lower Gorge	0.5	2.25
	WA	Upper Gorge	0.5	2.25

*Summaries taken directly from Figure 69 in NWFSC (2015). All are on a 4 point scale, with 4 being the lowest risk and 0 being the highest risk. Viable Salmon Population scores represent a combined assessment of population abundance and productivity, spatial structure and diversity (McElhany et al. 2006).

Table 33. LCR Coho Salmon ESU populations and scores for the key elements (abundance/productivity [A/P], spatial structure, and diversity) used to determine current overall net persistence probability of the population (NMFS 2013a)[1].

Ecological Subregions	**Population (Watershed)**	**A/P**	**Spatial Structure**	**Diversity**	**Overall Persistence Probability**
Coast Range	Youngs Bay (OR)	VL	VH	VL	VL
	Grays/Chinook rivers (WA)	VL	H	VL	VL
	Big Creek (OR)	VL	H	L	VL
	Elochoman/Skamokawa creeks (WA)	VL	H	VL	VL
	Clatskanie River (OR)	L	VH	M	L
	Mill, Germany, and Abernathy creeks (WA)	VL	H	L	VL
	Scappoose River (OR)	M	H	M	M
Cascade Range	Lower Cowlitz River (WA)	VL	M	M	VL
	Upper Cowlitz River (WA)	VL	M	L	VL
	Cispus River (WA)	VL	M	L	VL
	Tilton River (WA)	VL	M	L	VL
	South Fork Toutle River (WA)	VL	H	M	VL
	North Fork Toutle River (WA)	VL	M	L	VL
	Coweeman River (WA)	VL	H	M	VL
	Kalama River (WA)	VL	H	L	VL
	North Fork Lewis River (WA)	VL	L	L	VL
	East Fork Lewis River (WA)	VL	H	M	VL
	Salmon Creek (WA)	VL	M	VL	VL
	Clackamas River (OR)	M	VH	H	M
	Sandy River (OR)	VL	H	M	VL
	Washougal River (WA)	VL	H	L	VL
Columbia Gorge	Lower Gorge Tributaries (WA & OR)	VL	M	VL	VL
	Upper Gorge/White Salmon (WA)[7]	VL	M	VL	VL
	Upper Gorge Tributaries/Hood (OR)	VL	VH	L	VL

[1] Ratings range from very low (VL), low (L), moderate (M), high (H), to very high (VH) (NWFSC 2015).

[7] The White Salmon population was limited by Condit Dam, as discussed above regarding Gorge Fall Run Lower Columbia River Chinook salmon. This population is re-establishing itself following removal of Condit Dam in 2011.

Figure 21 displays the extinction risk ratings for all four VSP parameters for Oregon natural populations (ODFW 2010). This figure was updated in 2010 using data available through 2008. The results indicate low to moderate extinction risk for spatial structure for most LCR coho salmon populations in Oregon, but high risk for diversity for all but two populations (the Sandy and Clackamas River populations). The assessments of spatial structure are combined with those of abundance and productivity to give an assessment of the overall status of LCR populations in Oregon. Extinction risk is rated as high or very high in overall status for all populations except the Scappoose and Clackamas river populations (Figure 21). In Figure 21, where updated ratings differ from those of McElhany et al. (2007) assessment, the older rating is shown as an open diamond with a dashed outline (ODFW 2010).

The lack of data, as well as poor data quality, has made it difficult to assess spatial structure and diversity VSP attributes for LCR coho salmon. Low abundance, past hatchery stock transfers, other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among coho salmon populations (LCFRB 2010; ODFW 2010). The low persistence probability and risk category for the majority of LCR coho salmon populations reported above is related to the loss of spatial structure and reduced diversity. Spatial structure of some coho salmon populations is constrained by migration barriers (i.e., tributary dams) and development of lowland areas (NMFS 2013a). Inadequate spawning survey coverage, along with the presence of unmarked hatchery-origin coho salmon mixing with natural-origin spawners, also has made it difficult to ascertain the spatial structure of natural-origin populations. The mass marking of hatchery-origin fish and more extensive spawning surveys have provided better information regarding species status recently (NWFSC 2015).

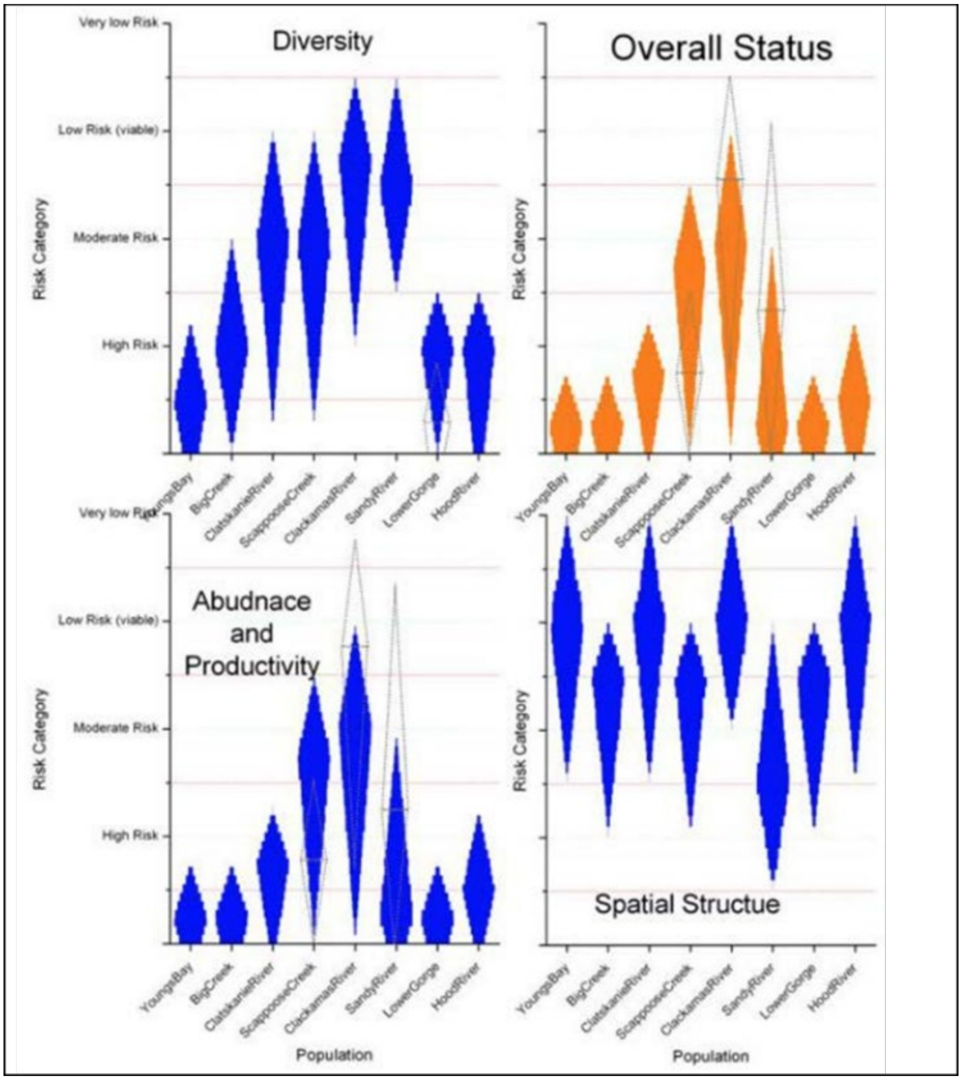


Figure 21. Extinction risk ratings for LCR coho salmon populations in Oregon for the assessment attributes abundance/productivity, diversity, and spatial structure, as well as an overall rating for populations that combines the three attributes (adapted from McElhany et al. 2007).

In summary, the 2015 status review (NWFSC 2015) concluded that the LCR Coho Salmon ESU is still at very high risk. A total of 6 of the 23 populations in the ESU are at or near their recovery viability goals (Figure 69 in NWFSC 2015), although under the recovery plan scenario these populations had recovery goals only greater than 2.0 (moderate risk). The remaining populations require a higher level of viability (NWFSC 2015) and therefore still require substantial improvements. Best available information indicates that the LCR Coho Salmon ESU is at high risk and remains at threatened status.

Limiting Factors

Understanding the limiting factors and threats that affect the LCR Coho Salmon ESU provides important information and perspective regarding the status of the species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. LCR coho salmon populations began to decline by the early 1900s because of habitat alterations and harvest rates that were unsustainable given these changing habitat conditions. There are many factors that affect the abundance, productivity, spatial structure, and diversity of the LCR Coho Salmon ESU. Factors that limit the ESU have been, and continue to be hydropower development on the Columbia River and its tributaries, habitat degradation, hatchery operations, fishery management and harvest decisions, and ecological factors including predation and environmental variability. The ESU-level recovery plan consolidates the information regarding limiting factors and threats for the LCR Coho Salmon ESU available from various sources (NMFS 2013a).

The LCR recovery plan provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Chapter 4 (NMFS 2013a) of the recovery plan describes limiting factors on a regional scale and those factors apply to the four listed species from the LCR considered in the plan, including LCR coho salmon. Chapter 6 of the recovery plan discusses the limiting factors that pertain to the MPGs that compose the LCR Coho Salmon ESU. The discussion of limiting factors in Chapter 6 (NMFS 2013a) is organized to address:

- Tributary habitat,
- Estuary habitat,
- Hydropower,
- Hatcheries,
- Harvest, and
- Predation.

Chapter 4 (NMFS 2013a) includes additional details on large scale issues including:

- Ecological interactions,
- Climate change, and
- Human population growth.

Rather than repeating this extensive discussion from the roll-up recovery plan, it is incorporated here by reference.

Harvest-related mortality is identified as a primary limiting factor for all natural populations within the ESU and occurs as a result of direct and incidental mortality of natural-origin fish in ocean fisheries, Columbia River recreational fisheries, and commercial gillnet fisheries. The LCR recovery plan envisions refinements in coho salmon harvest through (1) replacement or refinement of the existing harvest matrix to ensure that it adequately accounts for weaker components of the ESU, (2) continued use of mark-selective recreational fisheries, and (3) management of mainstem commercial fisheries to minimize impacts on natural-origin coho salmon (NMFS 2013a). The recent refinement of the harvest matrix ensured that harvest management is consistent with maintaining trajectories in populations where increasing natural production is beginning to be observed (e.g., the Clatskanie and Scappoose populations), with the assumption that additional refinements will be evaluated as natural production is documented in additional populations. Managing coho salmon harvest to minimize impacts on natural-origin fish has been complicated by uncertainties regarding annual natural-origin spawner abundance and actual harvest impacts on natural-origin fish (in both ocean and mainstem Columbia fisheries). The recovery plan notes these uncertainties and highlight the need for improved monitoring of harvest mortality and natural-origin spawner abundance.

Closely spaced releases of hatchery fish from all Columbia Basin hatcheries could lead to increased competition with natural-origin fish for food and habitat space in the estuary (NMFS 2013a). NMFS (2011b) and LCFRB (2010) identified quantifying levels of competition for food and space among hatchery and natural-origin juveniles in the estuary as a critical uncertainty. As stream-type fish, coho salmon spend less time in the Columbia River estuary and plume than do ocean-type salmon, such as fall Chinook, yet possible ecological interactions in this geographic area likely play a role. ODFW (2010a) acknowledged that uncertainty but listed competition for food and space as a secondary limiting factor for juveniles of all populations. NMFS is working to better define and describe the scientific uncertainty associated with ecological interaction between hatchery-origin and natural-origin salmon and steelhead in freshwater, estuarine, and nearshore ocean habitats (NMFS 2013a).

As mentioned above, high proportions of hatchery-origin fish in spawning populations has been purposeful in some areas, e.g., for reintroduction purposes in the Upper Cowlitz and Lewis subbasins, and will continue, but the recent opinion on the majority of hatchery production affecting this ESU (NMFS 2017j) expects Federal funding guideline requirements to reduce limiting factors relative to hatchery effects over the course of the next decade.

2.2.1.6. Life-History and Status of Snake River Fall Chinook ESU

On April 22, 1992, NMFS listed the Snake River Fall-Run Chinook Salmon (SRFC) ESU as a threatened species (57 FR 14653). The threatened status was reaffirmed on June 28, 2005 (70 FR 37159) and on May 26, 2016 (81 FR 33468). Critical habitat was designated on December 28, 1993 (58 FR 68543). It includes spawning and rearing areas limited to the Snake River below Hells Canyon Dam, and within the Clearwater, Hells Canyon, Imnaha, Lower Grand Ronde, Lower North Fork Clearwater, Lower Salmon, Lower Snake, Lower Snake-Asotin, Lower Snake-Tucannon, and Palouse hydrologic units. However, this critical habitat designation includes all river reaches presently or historically accessible to this species (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams). On October 4, 2019, NMFS announced the initiation of a new 5-year status review process including review of the SRFC ESU (84 FR 53117), which it completed and published on August 16, 2022 (NMFS 2013a, NMFS 2022).

The SRFC ESU includes naturally spawned fish in the lower mainstem of the Snake River and the lower reaches of several of the associated major tributaries, including the Tucannon, the Grande Ronde, Clearwater, Salmon, and Imnaha Rivers, along with four artificial propagation programs (NWFSC 2022). As NMFS (2005) explains, genetic resources can be housed in a hatchery program. For a detailed description of how NMFS evaluates and determines whether to include hatchery fish in an ESU or DPS, see (NMFS 2005). Table 34 lists the natural and hatchery populations included in the ESU.

Table 34. SRFC ESU description and MPGs (NWFSC 2022).

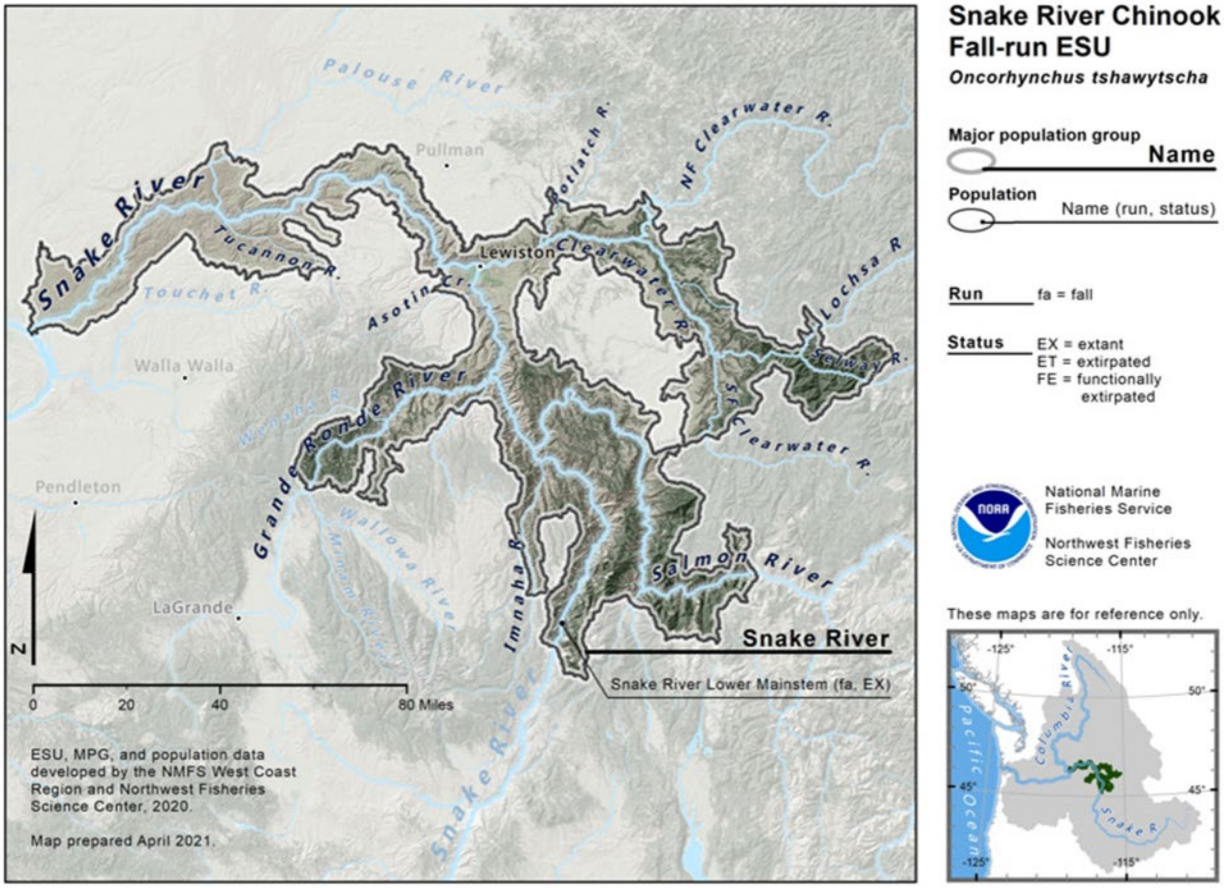
ESU Description	
Threatened	Listed under ESA in 1992; updated in 2022
1 major population groups	2 historical populations (1 extirpated)
Major Population Group	***Population***
Snake River	Lower Mainstem Fall-Run
Artificial production	
Hatchery programs included in ESU (4)	Lyons Ferry National Fish Hatchery (NFH) fall, Acclimation Ponds Program fall, Nez Perce Tribal Hatchery fall, Idaho Power fall.

Two historical populations (1 extirpated) within one MPG comprise the SRFC ESU. The extant natural population spawns and rears in the mainstem Snake River, and its tributaries, below Hells Canyon Dam. The Interior Columbia River Technical Recovery Team (ICTRT) identified five major spawning areas (MaSAs) which are: Upper Hells Canyon MaSA (Hells Canyon Dam on Snake River downstream to confluence with Salmon River); Lower Hells Canyon MaSA (Snake River from Salmon River confluence downstream to Lower Granite Dam pool); Clearwater River MaSA; Grande Ronde River MaSA; and Tucannon River MaSA (NWFSC 2022). Figure 22 shows a map of the ESU area. The recovery plan (NMFS 2017) provides three scenarios that represent a range of potential strategies that can be pursued simultaneously that addresses the entire life cycle of the species that would achieve delisting criteria (Table 35).

Table 35. Potential ESA Viability Scenarios for SRFC (NMFS 2017).

Viability Scenarios and Viability Criteria	Abundance and Productivity Metrics	Spatial Structure and Diversity Metrics
Scenario A — Two Populations: Achieve highly viable status for the extant Lower Snake River population and viable status for the currently extirpated Middle Snake River population.	a. Lower Snake River population most recent 10-year geometric mean > 3,000 natural origin spawners and 20-year geometric mean intrinsic productivity > 1.5 b. Middle Snake River population most recent 10-year geometric mean >3,000 natural origin spawners and 20-year geometric mean intrinsic productivity >1.27	a. Four of five MaSAs in the Lower Snake River population and one or more spawning areas in the Middle Snake River population are occupied. b. Hatchery influence on spawning grounds is low (e.g., pHOS < 30%) for at least one population and hatchery programs are operated to limit genetic risk (e.g., the proportion natural influence [PNI] > 67%. c. Numbers of fish showing the historically dominant subyearling life-history pattern are stable or increasing.

Viability Scenarios and Viability Criteria	**Abundance and Productivity Metrics**	**Spatial Structure and Diversity Metrics**
		d. Adult and juvenile run timing patterns are stable or adaptive. e. Indicators of genetic substructure are trending toward patterns expected for a natural origin dominated population.
Scenario B — Single Population: Achieve highly viable status for Lower Snake River population (measured in the aggregate).	a. Most recent 10-year geometric mean abundance >4,200 natural-origin spawners. b. Most recent 20-year geometric mean intrinsic productivity >1.7	a. Four of five MaSAs in the Lower Snake River population are occupied. b. Recent (2 or more brood cycles) hatchery influence on spawning ground is low (e.g., pHOS < 30%) for the population as a whole and hatchery program is operated to limit genetic risk (e.g., PNI > 67%). c. Numbers of fish showing the historically dominant subyearling life-history pattern are stable or increasing. d. Adult and juvenile run timing patterns are stable or adaptive. e. Indicators of genetic substructure are trending toward patterns expected for a natural origin dominated population
Scenario C — Single Population: Achieve highly viable status for Lower Snake River population (with Natural Production Emphasis Areas [NPEAs]	a. Population-level abundance metrics under Scenario C would need to be higher than under Scenario B to accommodate meeting the NPEA requirements. Metrics will vary depending on the proportion of natural production coming from NPEAs and the level of hatchery influence remaining in the NPEAs. b. Population-level productivity metrics for Scenario B would apply: most recent 20-year geometric mean intrinsic productivity >1.7	a. Four of five MaSAs in the Lower Snake River population are occupied. b. NPEA PNI ≥ 0.67 and NPEA production accounting for at least 40% of the natural production in the population. c. Numbers of fish showing the historically dominant subyearling life-history pattern are stable or increasing. d. Adult and juvenile run timing patterns are stable or adaptive. e. Indicators of genetic substructure are trending toward patterns expected for a natural origin dominated population.



ESU, MPG, and population data developed by the NMFS West Coast Region and Northwest Fisheries Science Center, 2020.

Map prepared April 2021.

Figure 22. Map of the SRFC ESU's spawning and rearing areas, illustrating populations and MPGs (NWFSC 2022).

The decline of this ESU was due to heavy fishing pressure beginning in the 1890s and loss of habitat with the construction of Swan Falls Dam in 1901. Additionally, construction of the Hells Canyon Complex from 1958–1967 led to the extirpation of one of the historical populations. Hatcheries mitigating for losses caused by the dams have played a major role in the production of SRFC since the 1980s (NMFS 2022). Since the species were originally listed in 1992, fishery impacts have been reduced in both ocean and river fisheries (Figure 23). Total ER has been relatively stable in the range of 40% to 50% since the mid-1990s (NWFSC 2022). Ocean fisheries are currently managed to achieve a minimum of a 30.0% reduction in the age-3 and age-4 adult equivalent total ER in ocean salmon fisheries relative to the 1988–1993 base period standard; approximately equivalent to an ocean ER limit of 29% on age-3 and age-4 SRFC. NMFS evaluated this approach under the ESA and found it not likely to jeopardize the continued existence of the SRFC ESU or destroy or adversely modify its designated critical habitat (NMFS 1996a).

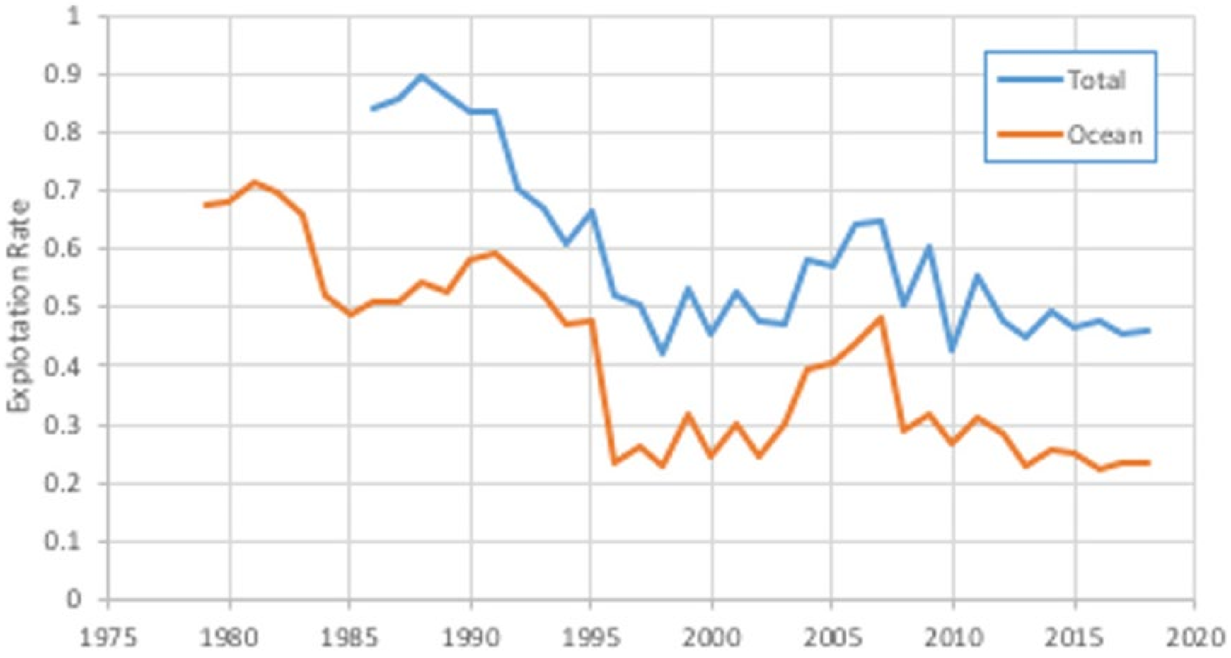


Figure 23. Total ER for SRFC. Data for marine ERs from the CTC model (Calibration 1503) and for in-river harvest rates from the Columbia River Technical Advisory Committee (TAC 2019 model calibration, old base period) (NWFSC 2022).

SRFC spawning and rearing occurs primarily in larger mainstem rivers, such as the Salmon, Snake, and Clearwater Rivers. Historically, the primary fall-run Chinook salmon spawning areas were located on the upper mainstem Snake River (Connor et al. 2005). Now a series of Snake River mainstem dams block access to the Upper Snake River and about 85% of ESU's spawning and rearing habitat (NMFS 2022). Swan Falls Dam was the first barrier to upstream migration in the Snake River, followed by the Hells Canyon Complex, composed of Brownlee Dam (completed in 1958), Oxbow Dam (completed in 1961), and Hells Canyon Dam (completed in 1967). Natural spawning is currently limited to the Snake River from the upper end of LGR to Hells Canyon Dam, the lower reaches of the Imnaha, Grande Ronde, Clearwater, Salmon, and Tucannon rivers, and small areas in the tailraces of the Lower Snake River hydroelectric dams (NMFS 2022).

Some fall-run Chinook salmon also spawn in smaller streams such as the Potlatch River, and Asotin and Alpowa Creeks, and may spawn elsewhere as well. However, annual redd surveys show that fall Chinook salmon spawning occurs in all five of the historical MaSAs that are accessible within the current range of the population (NWFSC 2022). Parental Based Tagging of the hatchery fish has allowed for spawning-ground sampling for parentage analysis. Fidelity studies have indicated there is spawner dispersal within the population from different release sites (NWFSC 2022). SRFC also spawned historically in the lower mainstem of the Clearwater, Grande Ronde, Salmon, Imnaha, and Tucannon River systems. At least some of these areas probably supported production, but at much lower levels than in the mainstem Snake River. Smaller portions of habitat in the Imnaha and Salmon Rivers have supported SRFC. Some limited spawning occurs in all of these areas, although returns to the Tucannon River are predominantly releases and strays from the Lyons Ferry Hatchery (LFH) program (NMFS 2012).

The fraction of natural-origin fish on the spawning grounds has remained relatively stable for the last ten years, with five-year means of 31% (2010–14) and 33% (2015–19, Table 3).

Table 36. Five-year mean of fraction natural-origin fish in the population (sum of all estimates divided by the number of estimates) (NWFSC 2022).

Population	1995–1999	2000–2004	2005–2009	2010–2014	2015–2019
Lower Snake River Fall-run Chinook	0.58	0.34	0.37	0.31	0.33

As a consequence of losing access to historic spawning and rearing sites (heavily influenced by the influx of groundwater in the Upper Snake River), as well as the effects of the dams on downstream water temperatures, SRFC now reside in waters that may have thermal regimes which differ from historical regimes (NWFSC 2022). In addition, alteration of the Lower Snake River by hydroelectric dams has created a series of low-velocity pools that did not exist historically. Both of these habitat alterations have created obstacles to SRFC survival. Before alteration of the Snake River Basin by dams, SRFC exhibited a largely ocean-type life- history, where they migrated downstream during their first year. Today, fall-run Chinook salmon in the Snake River Basin exhibit one of two life- histories that Connor et al. (2005) have called ocean-type and reservoir-type. Juveniles exhibiting the reservoir-type life-history overwinter in the pools created by the dams before migrating out of the Snake River. The reservoir-type life-history is likely a response to early development in cooler temperatures, which prevents juveniles from reaching a suitable size to migrate out of the Snake River and to the ocean.

Abundance, Productivity, Spatial Structure, and Diversity

Status of the species is determined based on the abundance, productivity, spatial structure, and diversity of its constituent natural populations.

Spawner abundance, productivity, and proportion of natural-origin fish abundance estimates for the Lower Mainstem Snake River population are based on counts and sampling at Lower Granite Dam. Separate estimates of the numbers of adult (age 4 and older) and jack (age 3) fall-run Chinook salmon passing over Lower Granite Dam are derived using ladder counts, in addition to the results of sampling a portion of each year's run using a trap associated with the ladder. A portion of the fish sampled at the trap are retained and used as hatchery broodstock. Historically, the data from trap sampling, including CWT recovery results, passive integrated transponder (PIT) tag detections, and the incidence of fish with adipose-fin clips, were used to construct daily estimates of hatchery proportions in the run (NWFSC 2022). At present, estimates of natural-origin returns are made from a Parental Based Genetic Tagging (PBT)[14] program (NWFSC

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[14] PBT is whereby each parent in a hatchery program, both male and female, are genotyped for polymorphic molecular markers. By genotyping each parent all of their offspring are effectively identifiable, and the method requires no juvenile handling. This allows for assignments back to individual parents when the hatchery releases return as adults wherever they are found, so long as they are genetically sampled.

2022), which is a more direct assessment of natural returns and ESU abundance risk (NWFSC 2022).

Sampling methods and statistical procedures used in generating the estimated escapements have improved substantially over the past 10-15 years. Natural-origin return levels declined substantially following the completion of the three-dam Hells Canyon Complex (1959–1967), which completely blocked access to major production areas above Hells Canyon Dam, and the construction of the lower Snake River dams (1962–1975). Based on extrapolations from sampling at Ice Harbor Dam (1977–1990), the LFH (1987–present), and at Lower Granite Dam (1990–present), hatchery strays made up an increasing proportion of returns at Lower Granite Dam (the uppermost Snake River mainstem dam) through the 1980s (Bugert and Hopley 1989, Bugert et al. 1990). Strays from out-planting Priest Rapids hatchery-origin fall-run Chinook salmon (an out-of-ESU stock from the mid-Columbia River) and SRFC from the LFH program (on-station releases initiated in the mid-1980s) were the dominant contributors. Estimated natural-origin returns reached a low of less than 100 fish in 1990. The initiation of the supplementation program in 1998 increased returns allowed to naturally spawn. In recent years, naturally spawning fall-run Chinook salmon in the lower Snake River have included returns both originating from naturally spawning parents, and from returning hatchery releases (NWFSC 2022).

In 2013, adult spawner abundance reached over 20,000 fish (Figure 24). From 2012 to 2015, natural-origin returns were over 10,000 adults. Spawner abundance has declined since 2016 to 4,998 adult natural-origin spawners in 2019 (Figure 24). In 2018, natural-origin spawner abundance was 4,916, a quarter of the return in 2013. This appears as a strong negative percent change in the five-year geometric mean (Table 37), but, when looking at the trend in longer time frames, across more than one brood cycle, it shows an increase in the ten-year geometric mean relative to the last status review, and a near-zero population change for the 15-year trend in abundance (NWFSC 2022). The geometric mean natural adult abundance for the most recent ten years (2010–2019) is 9,034 (0.15 standard error), higher than the ten-year geomean reported in the most recent status review (6,418, 0.19 standard error, 2005–2014; NWFSC 2015). While the population has not been able to maintain the higher returns it achieved in 2010 and 2013–2015, abundance has maintained at or above the ICTRT defined Minimum Abundance Threshold (3,000)[15] during climate challenges in the ocean and rivers. Escapements have been increasing since 2020 and have continued through 2022 (JSR 2022).

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[15] The ICTRT (2007) incorporated minimum abundance thresholds into population viability curves to "promote achieving the full range of abundance objectives across the recovery scenarios including utilization of multiple spawning areas, avoiding problems associated with low population densities (e.g. Allee effects) and maintaining populations at levels where compensatory processes are functional." The ICTRT recommended using 10-year geometric means of recent natural-origin spawners as a measure of current abundance. It also recommended that current intrinsic productivity should be estimated using spawner-to-spawner return pairs from low-to-moderate escapements over a recent 20-year period. The ICTRT adopted a recommendation from Beven et al. (1994) as the minimum abundance threshold for the extant Lower SRFC population.

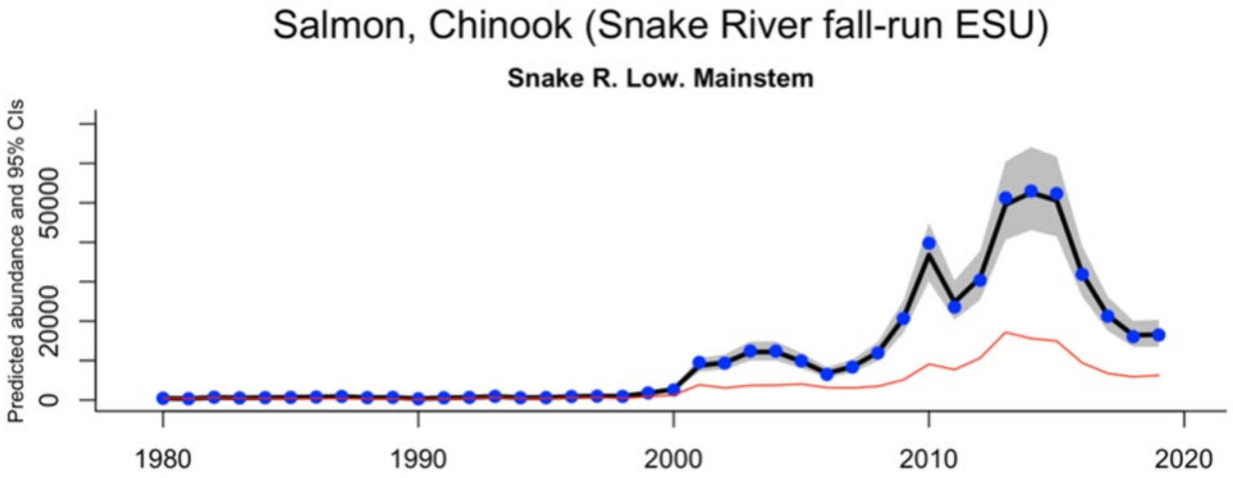

Figure 24. Smoothed trend in estimated total (thick black line, with 95% confidence interval in gray) and natural (thin red line) population spawning abundance (NWFSC 2022). Points show the annual raw spawning abundance estimates.

Table 37. Five-year geometric mean of raw natural spawner counts SRFC (NWFSC 2022).

Population	**1990–1994**	**1995–1999**	**2000–2004**	**2005–2009**	**2010–2014**	**2015–2019**	**% change**
Lower SRFC	331 (581)	548 (980)	3,014 (8,398)	3,645 (10,581)	11,254 (37,812)	7,252 (22,141)	–36 (–41)

This is the raw total spawner count times the fraction natural estimate, if available. In parentheses is the 5-year geometric mean of raw total spawner counts, computed as the product of counts raised to the power 1 over the number of counts available (2 to 5). A minimum of 2 values was used to compute the geometric mean. Percent change between the 2 most recent 5-year periods is shown on the far right.

Productivity, defined in the ICTRT viability criteria as the expected replacement rate at low to moderate abundance relative to a population's minimum abundance threshold, is a key measure of the potential resilience of a natural population to annual environmentally driven fluctuations in survival. The ICTRT Viability Report (ICTRT 2007) provided a simple method for estimating population productivity based on return-per-spawner estimates for the most recent 20 years. To assure that all sources of mortality are accounted for, the ICTRT recommended that productivities used in interior Columbia River viability assessments be expressed in terms of returns to the spawning grounds. SRFC have been above the ICTRT defined minimum abundance threshold since 2001 (NWFSC 2022). Productivity, as seen in broodyear returns-per-spawner, has been below replacement (1:1) in recent years.

The NMFS Snake River fall-run Chinook Recovery Plan (NMFS 2017) proposes that a single population viability scenario could be possible given the unique spatial complexity of the Lower Mainstem SRFC population (Table 35). The recovery plan notes that a single population viability scenario could be possible if major spawning areas, supporting the bulk of natural returns, are operating consistently with long-term diversity objectives in the proposed plan. Under this single population scenario, the requirements for a sufficient combination of natural abundance and productivity could be based on a combination of total population natural abundance distributed among the MaSas as described in Table 35 above, while meeting total specific pHOS criteria, and relatively high production from one or more major spawning areas with relatively low hatchery contributions to spawning (i.e., low hatchery influence for at least one major natural spawning production area).

In terms of spatial structure and diversity, the Lower Mainstem SRFC population was rated at low risk for Goal A (allowing natural rates and levels of spatially mediated processes) and moderate risk for Goal B (maintaining natural levels of variation) in the status review update (NWFSC 2015), resulting in an overall spatial structure and diversity rating of moderate risk (Table 38). Annual redd surveys show that fall Chinook salmon spawning occurs in all five of the historical MaSAs, and that the natural origin fraction has remained relatively stable during the last 10 years across the ESU (Figure 25).

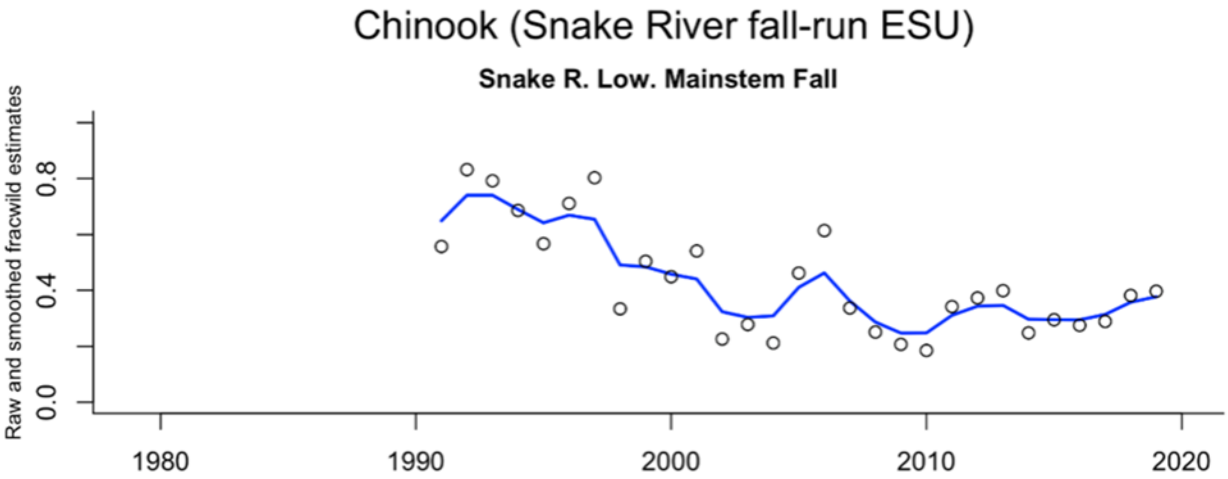

Figure 25. Smoothed trend in the estimated fraction of the natural spawning population consisting of fish of natural origin. Points show the annual raw estimates. (NWFSC 2022).

The overall current risk rating for the Lower Mainstem SRFC population is viable, as indicated by the bold outlined cell in Table 38. The single population delisting options provided in the Snake River Fall Chinook Salmon Recovery Plan would require the population to meet or exceed minimum requirements for a risk rating of “Highly Viable with a high degree of certainty”. The current rating of viable is based on evaluating current status against the criteria for the aggregate population. The overall risk rating is based on a low risk rating for abundance/productivity (A/P) and a moderate risk rating for spatial structure/diversity (SS/D). To achieve “highly viable” status with a high degree of certainty, the SS/D rating needs to be “low risk.” For abundance/productivity, the rating reflects remaining uncertainty that current increases in abundance can be sustained over the long run. While natural-origin spawning levels are above the highest delisting criteria (the minimum abundance threshold of 4,200 under recovery Scenario B) and estimated productivity is also high, neither measure is high enough to achieve the very low risk rating necessary to buffer against significant remaining uncertainty (NWFSC 2015).

Table 38. Matrix used to assess natural population viability risk rating across VSP parameters for the Lower Mainstem SRFC ESU (NWFSC 2015).[1]

Abundance/ Productivity Risk[2]	**Spatial Structure/Diversity Risk**			
	Very Low	**Low**	**Moderate**	**High**
Very Low (<1%)	HV	HV	V	M
Low (1%–5%)	V	V	V Lower Mainstem Snake R.	M
Moderate (6%–25%)	M	M	M	HR
High (>25%)	HR	HR	HR	HR

[1] Viability Key: HV-Highly Viable; V-Viable; M-Maintained; HR-High Risk. The darkest cells indicate combinations of A/P and SS/D at greatest risk (NWFSC 2015).

[2] Percentage represents the probability of extinction in a 100-year time period.

Considering the most recent information available, an increase in estimated productivity (or a decrease in the year-to-year variability associated with the estimate) would be required to achieve delisting status for the ESU, assuming that natural-origin abundance of the single extant SRFC population remains relatively high.

Limiting Factors

Understanding the limiting factors and threats that affect the SRFC ESU provides important information and perspective regarding the status of a species. One of the necessary steps in recovery and consideration for delisting is to ensure that the underlying limiting factors and threats have been addressed. This ESU has been reduced to a single remnant population with a narrow range of available habitat. However, the overall adult abundance has been increasing from the mid-1990s, with substantial growth since the year 2000 (NMFS 2017).

There are many factors that affect the abundance, productivity, spatial structure, and diversity of the SRFC ESU. Factors that limit the ESU have been, and continue to be, hydropower projects, predation, harvest, degraded estuary habitat, and degraded mainstem and tributary habitat (Ford 2011). Ocean conditions have also affected the status of this ESU. Ocean conditions affecting the survival of SRFC were generally poor during the early part of the last 20 years (NMFS 2017).

The recovery plan (NMFS 2017) provides a detailed discussion of limiting factors and threats and describes strategies for addressing each of them. Section 3.3 of the plan provides criteria for addressing the underlying causes of decline. Furthermore, Section 4.1.2 B.4. of the plan (NMFS 2017) describes the changes in current impacts on SRFC.

These changes include:

- Hydropower systems,
- Juvenile migration timing,
- Adult migration timing,
- Harvest,
- Age-at-return,
- Selection caused by non-random removals of fish for hatchery broodstock, and
- Habitat.

Rather than repeating the extensive discussion from the recovery plan, it is incorporated here by reference.

Overall, the single extant population in the ESU is currently meeting the criteria for a rating of "viable" developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Complex (NWFSC 2022). The SRFC ESU therefore is considered to be at a moderate-to-low risk of extinction, with viability largely unchanged from the prior review.

2.2.1.7 Status of the sunflower sea star

On August 18, 2021, NMFS received a petition to list the sunflower sea star (*Pycnopodia helianthoides*) as a threatened or endangered species under the ESA. On December 27, 2021, NMFS published a positive 90-day finding (86 FR 73230) announcing that the petition presented substantial scientific or commercial information indicating that the petitioned action may be warranted, and initiated a status review of the species. A Status Review Team was formed, a species status report was completed (Lowry et al. 2022), and an initial listing determination was made. On March 16, 2023, we proposed that the sunflower sea star be listed as a threatened species throughout its range, and solicited concurrent peer and public comment on this determination (88 FR 16212). The comment period closed on May 15, 2023, and the process of organizing, consolidating, and evaluating the relevance of each comment prior to producing a final species status report and listing decision is ongoing. The sunflower sea star is included in this biological opinion as a conference opinion. The conference opinion concerning the proposed listing of the sunflower sea star 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. In the case that our final determination is to list the species, either as threatened or endangered, is generally consistent with the proposed listing, this conference opinion can be adopted as the biological opinion. 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. Publication of a final listing decision is anticipated in March or April of 2024.

Description, Range, Distribution, Habitat Use, and Diet

Pycnopodia helianthoides is among the largest sea stars in the world, reaching over 1 meter (m) in total diameter from ray tip to ray tip across the central disk. The species is distinguished from other co-occurring sea stars by having 16–20 rays, a greatly reduced abactinal (dorsal) skeleton with no actinal plates, and prominently crossed pedicellariae (Fisher 1928).

The documented geographic range of the sunflower sea star spans the Northeastern Pacific Ocean from the Aleutian Islands to Baja California (Sakashita 2020; Lowry et al. 2022). This range includes 3,663 km across western coasts of the continental United States, Canada, and northern Mexico. The farthest documented reaches of sunflower sea star observations include: northernmost - Bettles Bay, AK (Gravem et al. 2021); westernmost – central and eastern Aleutian Islands (Kuluk Bay, Adak Island east to Unalaska Island, Samalga Pass, and Nikolski) (Feder 1980; O'Clair and O'Clair 1998; Jewett et al. 2015; Gravem et al. 2021); and southernmost - Bahia Asunción, Baja California Sur, MX (Gravem et al. 2021) (Figure 26). The species is generally most common from the Alaska Peninsula to Monterey, California.

The sunflower sea star has no clear associations with specific habitat types or features and is considered a habitat generalist (Gravem et al. 2021 and citations therein). The large geographic and depth range of the species indicates that it is well adapted for a wide variety of environmental conditions and habitat types. The species is found along both outer coasts and inside waters, which consist of glacial fjords, sounds, embayments, and tidewater glaciers. Preferring temperate waters, they inhabit kelp forests and rocky intertidal shoals (Hodin et al. 2021), but are regularly found in eelgrass meadows as well (Dean and Jewett 2001; Gravem et al. 2021). Sunflower sea stars occupy a wide range of benthic substrates including mud, sand, shell, gravel, and rocky bottoms while roaming in search of prey (Konar et al. 2019; Lambert et al. 2000). They occur in the low intertidal and subtidal zones to a depth of 435 m but are most commonly encountered at depths less than 25 m and rare in waters deeper than 120 m (Fisher 1928; Lambert 2000; Hemery et al. 2016; Gravem et al. 2021; Lowry et al. 2022). This characterization of their prevalence across depth ranges, however, may be biased by: (1) differential sampling methods and effort, with SCUBA-based observations dominating records; and (2) the propensity to record all sea stars as "sea star unidentified" when they occur as incidental bycatch in various survey and fishery records.

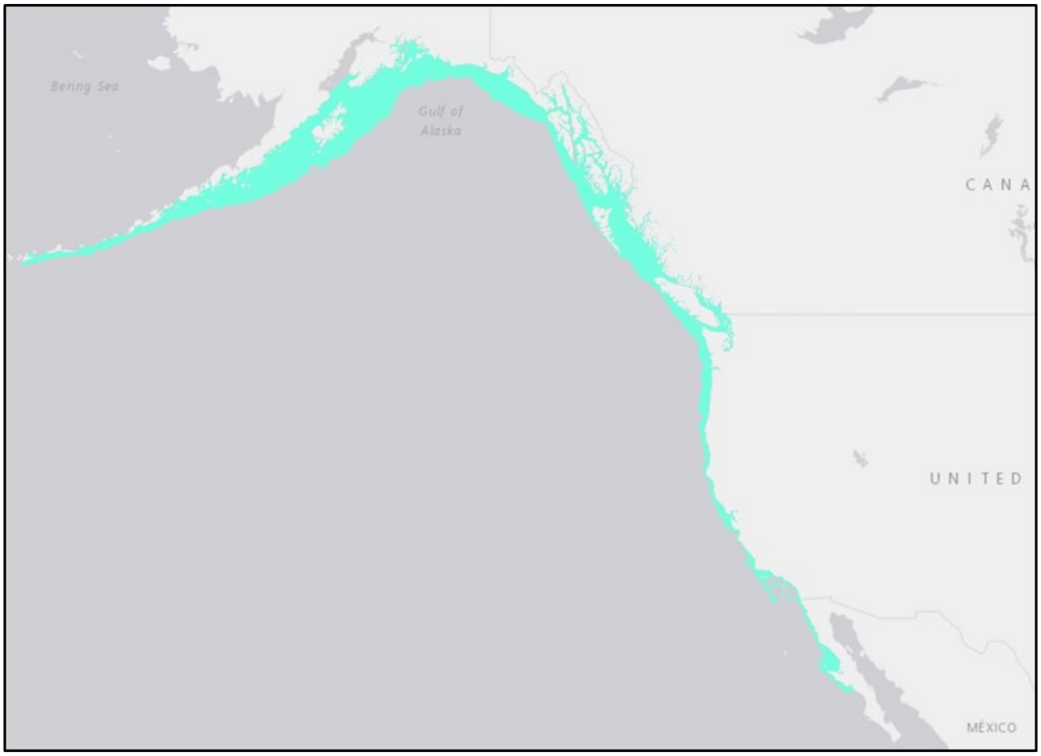

Figure 26. Map of the documented geographic range of the sunflower sea star *Pycnopodia helianthoides*. The species has been recorded to 435 m deep, but is most commonly encountered at depths less than 25 m.

Larval and pre-metamorphic sunflower sea stars are planktonic feeders and no data exist to suggest a prey preference at this stage. The diet of adult sunflower sea stars generally consists of benthic and mobile epibenthic invertebrates, including sea urchins, snails, crab, sea cucumbers, and other sea stars (Mauzey et al. 1968; Shivji et al. 1983), and appears to be driven largely by prey availability. Sunflower sea stars locate their prey by chemosensing and may show preference for dead or damaged prey (Brewer and Konar 2005), likely due to reduced energy expenditure relative to catching and subduing active prey; thus, they occasionally scavenge fish, seabirds, and octopus (Shivji et al. 1983). This behavior also predisposes them to consumption of bait used with an array of fishing gears, from longlines, to pots, to hook-and-line.

Population Demographics and Viability

Prior to the onset of the coast-wide sea star wasting syndrome (SSWS) pandemic in 2013 (see below), directed population monitoring for the sunflower sea star was haphazard and typically the result of short-term research projects rather than long-term monitoring programs. Such efforts were rarely focused on the sea star itself, but it was often included as a component of the local invertebrate assemblage. Recent descriptions of sunflower sea star distribution and population declines by Harvell et al. (2019), Gravem et al. (2021), and Hamilton et al. (2021) relied on datasets gathered either exclusively or predominantly during the 21st century and, in some cases, as a direct response to losses due to SSWS. The most intense loss occurred over just a few years from 2013-17, generally commencing later in more northern portions of the range, and impacts varied by region (Gravem et al. 2021; Lowry et al. 2022). Hence, understanding of both the historical and contemporary abundance of the sunflower sea star is patchy in time and space, with substantial gaps.

Summary data presented in Gravem et al. (2021) and Lowry et al. (2022) indicate that, prior to the 2013-17 SSWS pandemic, the sunflower sea star was fairly common throughout its range, with localized variation linked to prey availability and various physiochemical variables, such as temperature and pH (Duggins 1983; Herrlinger 1983; Eckert 2007; Rassweiler et al. 2010; Montecino-LaTorre et al. 2016; Schultz et al. 2016; Bonaviri et al. 2017; Harvell et al. 2019; Konar et al. 2019; OCNMS 2019; Rogers-Bennett and Catton 2019; Eisaguirre et al. 2020; Smith et al. 2021). Many of these surveys occurred at depth reachable with conventional SCUBA gear, i.e., <25 m deep, but OCNMS (2019) used a remotely operated vehicle and encountered individuals from 150–350 m deep. While population connections between these sea stars and those in shallow water remain unknown, this suggests deep waters may serve as a biomass reservoir for the species.

The pattern of decline by latitude as a consequence of the SSWS pandemic is striking. Hamilton et al. (2021) noted a 94.3% decline throughout the range of the sunflower sea star after the pandemic. The 12 regions defined by Hamilton et al. (2021) encompass the known range of the species, and every one exhibited a decline in density and occurrence from approximately 2013 to 2017, with the six more northern regions declining less (40 to 96% declines) than the six regions south of the Washington outer coast (99.6 to 100% declines), where the sunflower sea star is now exceptionally rare. Further, while anecdotal observations indicate recruitment continues in the U.S. portion of the Salish Sea, British Columbia, and Alaska, few of these juveniles appear to survive to adulthood (A. Gehman, University of British Columbia and the Hakai Institute, pers. comm., February 16, 2022). While variability in abundance estimates was high prior to the pandemic and boom/bust cycling was apparent in many areas, detection rates have been very low since approximately 2015 in the majority of time series datasets. There are very few reported observations of sunflower sea star recruits or adults in southern California or Mexico since 2017 despite continued, and in some cases enhanced, survey effort in these areas. In areas where adults have not been detected for several years, the potential for deleterious stochastic events, such as marine heat waves, to destroy what remains of the population is likely to be considerably increased.

There are not, to date, any range-wide or regional assessments of systematic variation in life history parameters, morphological characteristics, genetic traits, or other attributes that can be used to delineate specific populations of sunflower sea stars. As such, there is no direct biological data to establish that the species is anything but a single, panmictic population throughout its range. As habitat generalists that use a wide variety of substrates over a broad depth range, and dietary generalists that consume diverse prey based largely on their availability and encounter rate, differentiation of subpopulations is not expected to be driven by strong selection for particular environmental needs. In the 2020 IUCN status assessment report (Gravem et al. 2021), putative population segments were identified largely based on a combination of legal and geographic boundaries/barriers and data provided in response to a broad request distributed to natural resource managers and academic researchers. These regions may serve a practical purpose in terms of administrative regulation, but without further demographic information their biological relevancy is unknown.

The current range-wide (i.e., global) population estimate for the sunflower sea star is nearly 600 million individuals, based on a compilation of the best available science and information (Gravem et al. 2021; Lowry et al. 2022). While substantial, this represents less than 10% of the estimated abundance prior to 2013 and likely reflects an even greater decrease in biomass due to the loss of adults from SSWS. There is considerable uncertainty in this global abundance estimate, however, and in regional estimates that contribute to it. Low sampling effort prior to the pandemic, depth-biased disparities in data richness, inadequate species-specific documentation of occurrence, and missing information about several crucial life history parameters all contribute to this uncertainty (Lowry et al. 2022). While confidence is relatively high in estimates from more southerly, nearshore areas that are well-sampled via SCUBA, the majority of the species' range consists of deep, cold, and/or northern waters that are less well sampled.

Little is known about the natural productivity of the sunflower sea star on both an individual and population basis. Lack of information about growth rate, longevity, age at maturity, fecundity, natural mortality, the influence of larval cloning, and other fundamental biological attributes require broad assumptions be made to inform estimates (Lowry et al. 2022). Regardless, the loss of >90% of the global population of the sunflower sea star from 2013 to 2017 is likely to have had profound impacts on population-level productivity. The standing crop of individuals capable of generating new recruits has been decreased, possibly to levels where productivity will be compromised on a regional or global basis (Gravem et al. 2021; Hamilton et al. 2021; Lowry et al. 2022).

As a broadcast spawner with indeterminate growth, traits shared with many other echinoderms, the capacity for allometric increases in fecundity and high reproductive output certainly exists in the sunflower sea star. Hodin et al. (2021) noted that gonads are small in sunflower sea stars compared to other sea stars, but also documented prolonged periods over which spawning apparently occurs (i.e., gonads are ripe). If the pandemic resulted in the loss of the large, most reproductively valuable individuals across both nearshore and deep-water habitats, it could take a decade or more for sub-adults to mature, settlement to occur at detectable levels, and population rebounds to be documented (Lowry et al. 2022). The ongoing threat of a second pandemic dictates that caution is warranted when predicting population growth rate.

Provided reproduction continues to occur, even on a local basis, the prolonged planktonic period of larval sunflower sea stars affords the opportunity for substantial dispersal prior to settlement. During this period, however, larvae are at the mercy of prevailing currents, temperature variation, and a suite of biophysical variables that affect survival. Even if populations maintain relatively high levels of productivity, recent conditions in the northeast Pacific Ocean have not been favorable to larval survival for many species due to repeated marine heat waves, falling pH, and localized oxygen minimum zones (Tang et al. 2019; Boldt et al. 2020; Shelton et al. 2021; Starko et al. 2022). Studies of connectivity across the range of the sunflower sea star are largely lacking, minimizing understanding of how large-scale population patterns are affected by local and regional productivity now and in the future.

Despite substantial population declines from 2013-17, sunflower sea stars still occupy the whole of their historical range from Alaska to northern Mexico, though in nearshore areas from the outer coast of Washington to Mexico the species is now rare where it was once common

(Gravem et al. 2021; Lowry et al. 2022). Natural resource managers and researchers in the contiguous United States consider several local populations off Oregon and California to be functionally extirpated, but reports of newly settled juveniles and occasional adults in these regions demonstrate continued occupancy (Gravem et al. 2021; Lowry et al. 2022). Additionally, the lack of adequate sampling of deep waters and patchy encounter reporting in bottom-contact fisheries with a high likelihood of interaction (e.g., crustacean pot/trap fisheries) introduces sufficient uncertainty to preclude a firm statement regarding lack of occurrence.

Spatial distribution and connectivity are integrally related with the abundance and productivity criteria. As a habitat generalist with broad resilience to physiochemical environmental variables, the sunflower sea star utilizes most available benthic habitats from the nearshore down to several hundred meters deep throughout its range. Loss of over 90% of the population between 2013 and 2017 in southern portions of the range almost certainly resulted in population fragmentation, but the only areas where data exist to confirm this are shallow, SCUBA-accessible habitats. Kelp forests and rocky reefs, in particular, are well sampled, but regular occurrence on mud, sand, and other soft-bottom habitats is also well documented (Gravem et al. 2021; Lowry et al. 2022). Undersampled, deep-water habitats represent the majority of suitable habitat for the sunflower sea star by area; however, additional effort is needed to characterize both how individuals in these waters are distributed and how they are connected with populations in shallow waters.

Broad-scale, systematic comparisons of morphology, life history, behavior, physiology, genetic traits, and other aspects of diversity do not exist for the sunflower sea star (Gravem et al. 2021; Lowry et al. 2022). While some authors note animals in the northern portion of the range grow to a large diameter and mass, this general statement is not supported by data. As a result of this lack of information, adequately evaluating diversity is difficult. Data from proxy species, such as the ochre star (*Pisaster ochraceus*), demonstrate that variation in physical characteristics such as color can be both genetically and ecologically controlled in sea stars (Harley et al. 2006; Raimondi et al. 2007). While examples exist of echinoderm species with both substantial population structuring and a complete lack of population structure on the West Coast, where the sunflower sea star falls along this spectrum is unknown (Gravem et al. 2021; Lowry et al. 2022).

Following the 2020 IUCN assessment of the sunflower sea star (Gravem et al. 2021), the species was conferred Critically Endangered status on the Red List of Threatened Species[16]. Subsequent to this, The Nature Conservancy convened a working group made up of state, tribal, Federal, and provincial government; academic; and non-profit partners to create a roadmap to recovery for the species. This document uses the best available science and information to identify specific, targeted research and management efforts needed to address what workgroup participants identify as the greatest threats facing long-term persistence of the sunflower sea star (Heady et al. 2022). The roadmap also includes an inventory of knowledge gaps that can be used as a guidance tool by partner organizations to coordinate collaborative research and management directed at sunflower sea star recovery (Heady et al. 2022), in many ways paralleling the structure and intent of a formal recovery plan under the ESA. As noted above, the sunflower sea star was proposed for listing as threatened under the Endangered Species Act (88 FR 16212), and a final rule is

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[16] https://www.iucnredlist.org/species/178290276/197818455

expected in early 2024. In the proposed rule, we found that critical habitat for sunflower sea stars was not determinable.

2.2.2. Status of Critical Habitat

We review the status of designated critical habitat affected by the Proposed Action by examining the condition and trends of PBFs throughout the designated area. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and foraging). Critical habitat is described in this section; however, the proposed action has been determined to be not likely to adversely affect any critical habitat.

2.2.2.1. Puget Sound/Georgia Basin Rockfish Critical Habitat

Critical habitat was designated for both species of rockfish in 2014 (79 FR 68041, November 13, 2014). Based on new genetic information that allowed better definition of the yelloweye DPS (Andrews et al. 2018), this same action extended the boundary northward into Johnstone Strait, B.C., in 2017 (82 FR 7711). Critical habitat, however, is not designated in areas outside of U.S. jurisdiction, so while waters in Canada are part of the range of each DPS, critical habitat is not designated there. We also excluded 13 of the 14 Department of Defense Restricted Areas, Operating Areas, and Danger Zones, and waters adjacent to tribal lands, from the critical habitat designation (79 FR 68041).

Based on the best available scientific information regarding natural history and habitat needs, we developed a list of PBFs essential to the conservation of adult and juvenile yelloweye rockfish and bocaccio, and relevant to determining whether proposed specific areas are consistent with the above regulations and the ESA section (3)(5)(A) definition of "critical habitat." The PBFs essential to the conservation of yelloweye rockfish and bocaccio fall into major categories reflecting key life history phases (79 FR 68041).

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

Juvenile bocaccio only: We designated juvenile settlement sites located in the nearshore with substrates such as sand, rock, and/or cobble compositions that also support kelp. These features are essential for conservation because they enable forage opportunities and refuge from predators, and enable behavioral and physiological changes needed for juveniles to occupy deeper adult habitats. Several attributes of these sites affect the quality of the area and are useful in considering the conservation value of the feature in determining whether the feature may require special management considerations or protection, and in evaluating the effects of a Proposed Action in a section 7 consultation if the specific area containing the site is designated as critical habitat. These attributes include: (1) quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities; and (2) water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities.

Critical habitat designated for bocaccio includes approximately 1,083.11 square miles (1,743.10 sq. km) of deep water (<98.4 feet [30 m]) and nearshore (>98.4 feet [30 m]) marine habitat in Puget Sound. Critical habitat designated for yelloweye rockfish, which are associated with more specific habitat features, includes 438.45 square miles (705.62 sq km) of deepwater marine habitat in Puget Sound, all of which overlaps with bocaccio critical habitat. Approximately 46% of designated critical habitat for adult yelloweye rockfish and bocaccio overlaps with areas where the halibut fishery occurs.

Regulations for designating critical habitat at 50 C.F.R. § 424.12(b) state that the agencies shall consider PBFs essential to the conservation of a given species that "may require special management considerations or protection." Joint NMFS and USFWS regulations at 50 C.F.R. § 424.02(j) define "special management considerations or protection" to mean "any methods or procedures useful in protecting physical and biological features of the environment for the conservation of listed species." We identified a number of activities that may affect the PBFs essential to yelloweye rockfish and bocaccio such that special management considerations or protection may be required. Major categories of such activities include: (1) nearshore development and in-water construction (e.g., beach armoring, pier construction, jetty or harbor construction, pile driving construction, residential and commercial construction); (2) dredging and disposal of dredged material; (3) pollution and runoff; (4) underwater construction and operation of alternative energy hydrokinetic projects (tidal or wave energy projects) and cable laying; (5) kelp harvest; (6) fisheries; (7) non-indigenous species introduction and management; (8) artificial habitat creation; (9) research activities; (10) aquaculture, and (11) activities that lead to global climate change.

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

2.2.2.2. Green Sturgeon Critical Habitat

Designated critical habitat for Southern DPS green sturgeon includes coastal marine waters shallower than 60 fathoms (approximately 360.89 feet or 110 m) from Monterey Bay, California to the Canadian border, including Monterey Bay, the Strait of Juan de Fuca, and Rosario Strait (74 FR 52300, October 9, 2009). The PBFs essential for species conservation are: (a) a migratory pathway necessary for the safe and timely passage of Southern DPS green sturgeon within marine and between estuarine and marine habitats; (b) suitable water quality (e.g., adequate dissolved oxygen levels and acceptably low levels of contaminants that may disrupt the normal behavior, growth, and viability of subadult and adult green sturgeon); and (c) food resources, likely to include benthic invertebrates and fish species similar to those fed upon by green sturgeon in bays and estuaries, including crangonid and callianassid shrimp, Dungeness crab, mollusks, amphipods, and small fish, such as sand lances (*Ammodytes* spp.) and anchovies (Engraulidae) (Moyle 2002; Dumbauld et al. 2008). Prey resources and impact from gear are unlikely to affect green sturgeon habitat and is discussed in more detail in Section 2.11, "Not Likely to Adversely Affect Determinations."

2.2.2.3. Salmon Critical Habitat

The designated critical habitat for the Lower Columbia River Chinook and coho salmon, and Snake River fall Chinook salmon ESUs do not include offshore marine areas of the Pacific Ocean and, therefore, do not overlap with the action area. Puget Sound Chinook salmon have designated critical habitat in Puget Sound from high tide to 30 m, an area where some possible recreational and tribal halibut fishing occurs (70 FR 52629, January 2, 2006). The areas designated are all occupied and contain PBFs essential to the conservation of the species and that may require special management considerations or protection.

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). For the Pacific halibut fishery, the action area is the area in which the IPHC Area 2A halibut fishery takes place. Area 2A is defined as all marine waters off the States of California, Oregon, and Washington (50 CFR 300.61), with the fishery occurring north of Shelter Cove, California. This area includes each state's coastal and marine waters, including Puget Sound, and all waters of the Exclusive Economic Zone (EEZ) (3 to 200 nautical miles offshore). Halibut fishing in these waters is managed under the authority of the Halibut Act.

Many of the protected species evaluated in this consultation have a geographic range smaller than the spatial extent of fishing effort (distribution for each species is identified in the respective status sections). Others have geographic ranges that include areas that do not overlap with the fishery. To the extent that indirect effects may occur, these would be related to prey availability and the action area encompasses the full geographic area where effects of the Proposed Action could occur.

2.4. Environmental Baseline

The "environmental baseline" refers to the condition of the listed species and its designated critical habitat in the action area, without the consequences to the species 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 that 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).

Focusing on the impacts of activities specifically within the action area allows us to assess the prior experience and condition of the animals that will be exposed to effects from the actions under consultation. This focus is important because individuals of ESA-listed species may commonly exhibit, or be more susceptible to, adverse responses to stressors in some life history states, stages, or areas within their distributions than in others. These localized stress responses or baseline stress conditions may increase the severity of the adverse effects expected from proposed actions.

The environmental baseline for the species affected by the proposed actions includes the effects of many activities that occur across the action area considered in this opinion. In Section 2.2.5, we describe the on-going and anticipated temperature, freshwater, and marine effects of climate change. Because the impacts of climate change are ongoing, the effects are reflected in the most recent status of the species, which for salmon species, NMFS recently re-evaluated in 2022 (NWFSC 2022) and summarized in Section 2.2.5, Climate Change of this Opinion. The status of the species described in Section 2.2 of this opinion is a consequence of those effects. In the following discussion of the environmental baseline, we provide an overview of relevant federal actions in the action area that have undergone consultation and are therefore part of the baseline.

In status Section 2.2, we summarized the limiting factors for each species addressed in this opinion. The Chinook and coho salmon ESUs encompass marine and fresh waters; however, because the action area exclusively includes marine waters, the discussion here focuses in particular on harvest activities that are the primary human activities affecting Chinook and coho salmon in marine waters that occur in the action area.

2.4.1. Puget Sound/Georgia Basin Rockfish

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

Most of the benthic, deepwater (i.e., deeper than 90 feet [27.4 m]) habitats of Puget Sound proper consist of unconsolidated sediments, such as sand, mud, and cobbles. The vast majority of the rocky-bottom areas of Puget Sound occur within the San Juan Basin, with the remaining portions spread among the rest of Puget Sound proper (Palsson et al. 2009). Depths in the Puget Sound extend to over 920 feet (280 meters).

Benthic habitats within Puget Sound have been influenced by a number of factors. The degradation of some rocky habitat, loss of eelgrass and kelp, introduction of non-natural-origin species that modify habitat, and degradation of water quality are threats to marine habitat in Puget Sound (Drake et al. 2010; Palsson et al. 2009; NMFS 2017b). Some benthic habitats have been impacted by derelict fishing gear that include lost fishing nets, and shrimp and crab pots (Good et al. 2010; NRC 2018). Derelict fishing gear can continue “ghost” fishing and is known to kill rockfish, salmon, and marine mammals, as well as degrade rocky habitat by altering bottom composition and killing numerous species of marine fish and invertebrates that are eaten by rockfish (Good et al. 2010). Thousands of nets have been documented within Puget Sound and most have been found in the San Juan Basin and the Main Basin. The Northwest Straits Initiative has operated a program to remove derelict gear throughout the Puget Sound region. In addition, the WDFW and the Lummi, Stillaguamish, Tulalip, Nisqually, and Nooksack Tribes, and others, have supported or conducted derelict gear prevention and removal efforts. Net removal has mostly concentrated in waters less than 100 feet (33 m) deep where most lost nets are found (Good et al. 2010). Several hundred derelict nets have been documented in waters deeper than 100 feet deep, however, and directed efforts to develop novel methods and remove them are ongoing (NRC 2013; 2014). The removal of over 4,600 nets and over 3,000 derelict pots have restored over 650 acres of benthic habitat (Northwest Straits Initiative 2014), though many derelict nets and crab and shrimp pots remain in the marine environment. Over 200 rockfish have been documented within recovered derelict gear. Because habitats deeper than 100 feet (30.5 m) are most readily used by adult yelloweye rockfish and bocaccio, there is an unknown but potentially significant impact from deepwater derelict gear on rockfish habitats within Puget Sound.

Over the last century, human activities have introduced a variety of toxins into the Georgia Basin at levels that can affect adult and juvenile rockfish habitat and/or the prey they consume. Toxic pollutants in Puget Sound include oil and grease, polychlorinated biphenyls (PCBs), phthalates, PBDEs, and heavy metals that include zinc, copper, and lead. Several urban embayments in Puget Sound have high levels of heavy metals and organic compounds West et al. 2001). There are no studies to date that define specific adverse health effects thresholds for specific toxicants in any rockfish species; however, it is likely that PCBs pose a risk to rockfish health and fitness (Palsson et al. 2009). About 32% of the sediments in the Puget Sound region are considered to be moderately or highly contaminated (PSAT 2007), though some areas are undergoing clean-up operations that have improved benthic habitats (Sanga 2015). In a rare study of the impacts of heavy metals on rockfishes, Barst et al. (2015) demonstrated that mercury and other metals are filtered and isolated by the liver, but did not attempt to identify adverse effects thresholds associated with exposure.

Washington State has a variety of marine protected areas managed by 11 Federal, state, and local agencies (Van Cleve et al. 2009), though some of these areas are outside of the range of the rockfish DPSs. The WDFW has established 25 marine reserves within the boundary of the DPSs, and 16 host rockfish (Palsson et al. 2009), though most of these reserves are within waters shallower than those typically used by adult yelloweye rockfish or bocaccio. The WDFW reserves total 2,120.7 acres of intertidal and subtidal habitat. The total percentage of the Puget Sound region within reserve status is unknown, though Van Cleve et al. (2009) estimate that one percent of the subtidal habitats of Puget Sound are designated as a reserve. Compared to fished areas, studies have found higher fish densities, sizes, or reproductive activity in the assessed WDFW marine reserves (Eisenhardt 2001; Palsson 1998; Palsson et al. 2004; Palsson and Pacunski 1995; LeClair et al. 2018). These reserves were established over several decades with unique and somewhat unrelated ecological goals, and encompass relatively small areas (average of 23 acres).

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

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

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

As a precautionary measure, the WDFW closed the above commercial fisheries eastward of the entrance to the Strait of Juan de Fuca (Cape Flattery), which is westward of the DPSs' by approximately 60 mi (96.6 km). The WDFW extended the closure west of the DPSs to prevent commercial fishermen from concentrating gear in that area. The commercial fisheries closures listed above were enacted on a temporary basis and the WDFW permanently closed them in February of 2011.

Waters of Canada are not within the Action Area, but the DPS area for yelloweye rockfish and bocaccio includes areas of the Georgia Strait, thus the status of the environmental baseline and rockfish management influences fish within Puget Sound. Fisheries management in British Columbia, Canada, has been altered to better conserve rockfish populations. In response to declining rockfish stocks, the government of Canada initiated comprehensive changes to fishery policies beginning in the 1990s (Yamanaka and Logan 2010). Conservation efforts were focused on four management steps: (1) accounting for all catch; (2) decreasing total fishing mortality; (3) establishing areas closed to fishing; and (4) improving stock assessment and monitoring (Yamanaka and Lacko 2001). The Department of Fisheries and Oceans (DFO) adopted a policy of ensuring that inshore rockfish are subjected to fisheries mortality equal to or less than half of natural mortality.

These efforts led to the 2007 designation of a network of Rockfish Conservation Areas (RCAs) that encompasses 30% of rockfish habitat within the inside waters of Vancouver Island (Yamanaka and Logan 2010). The DFO defined and mapped "rockfish habitat" from commercial fisheries log CPUE density data as well as change in slope bathymetry analysis (Yamanaka and Logan 2010). These reserves do not allow directed commercial or recreational harvest for any species of rockfish, or the harvest of other marine species if that harvest may incidentally catch rockfish. Shortly after their establishment it was uncertain how effective RCAs were in protecting rockfish populations (Haggarty 2013), but one analysis found that sampled RCAs in Canada had 1.6 times the number of rockfish compared to unprotected areas (Cloutier 2011). Anecdotal reports that compliance with the RCAs may be poor, and that some may contain less than optimal habitat (Haggarty 2013), were later confirmed (Haggarty et al. 2016a; 2016b). Systematic monitoring of the RCAs is lacking as well, making characterization of illegal fishing incomplete (Haggarty 2013; 2016a). The DFO, WDFW, and NMFS conducted fish population surveys of some of the RCAs in 2018 but analysis was delayed by the global COVID-19 pandemic (Dayv Lowry, NOAA Fisheries, pers.comm.). Outside the RCAs, recreational fishermen generally may keep one rockfish per day from May 1 to September 30. Commercial rockfish catches in Area 4(b) are managed by a quota system (DFO 2011).

Despite curtailment of fishing pressure, establishment of RCAs, and other conservation measures in Canada, the status of the Inside Waters Designatable Unit of yelloweye rockfish (which corresponds with the Canadian portion of the population designated under the ESA) declined between 2008 and 2020. As a result, the Committee on the Status of Endangered Species in Canada revised the designation of this population from Special Concern to Threatened in 2020 (COSEWIC 2020). DFO subsequently generated a management plan for this population (Fisheries and Oceans Canada 2021) that has goals largely parallel to the ESA recovery plan (NMFS 2017).

2.4.2. Green Sturgeon

Green sturgeon occur throughout the action area. Marine waters off Washington, Oregon, and California within the action area include designated critical habitat for green sturgeon (marine waters within the 60 fm contour from Monterey Bay to the Strait of Juan de Fuca) and represent a major portion of the marine migratory habitat of the Southern DPS. Impacts on this portion of the action area are described below and include disturbance of benthic habitats and communities, reductions in water quality (contaminants, increased sedimentation, and turbidity), and increased levels of underwater noise. Southern DPS green sturgeon also occur in Puget Sound; impacts affecting Puget Sound are described in Section 2.5.2, Effects of the Proposed Action/Green Sturgeon.

Several ocean-dredged material disposal sites have been designated along the coast. In recent years, NMFS has consulted with the EPA on the proposed designation of several sites off the Oregon coast, off the mouths of the Rogue River, Umpqua River, and Yaquina River (NMFS 2009b; NMFS 2009c, consultation #2008/05438; NMFS 2012e, consultation #2011/06017). In 2012, NMFS also consulted on the use of four ocean disposal sites off the Columbia River as part of the Columbia River Channel Operations and Maintenance Program (NMFS 2012f, consultation #/2011/02095). In 2016 to 2017, NMFS consulted on the U.S. Army Corps of Engineers' operations and maintenance dredging of the Oregon coastal navigation projects, a project that included both dredging and dredge disposal (NMFS 2017e, consultation #WCR-2016/5055). Disposal of dredged materials at these disposal sites has the potential to entrain and bury small (i.e., ≤ 2 feet in length) subadult green sturgeon that, unlike adults and larger subadults, may not be able to move quickly enough to avoid precipitating sediments. This may result in injury to small subadult green sturgeon, but the number affected is expected to be low given the location of the disposal sites and the migratory patterns of green sturgeon in marine waters (e.g., green sturgeon are likely to spend limited time in one area as they move from estuary to estuary). Increased suspended sediment and turbidity levels may also result from dredging and disposal activities, but the effects on water quality are expected to be short term and have minimal impacts on sturgeon migration along the coast. Other water quality effects could result from contaminants in the dredged material. However, existing statutes and regulations require dredged material to be tested and deemed "clean" prior to disposal, such that levels of compounds in the sediments are not expected to exceed concentrations harmful to green sturgeon and other organisms occurring at the disposal sites.

In-water construction activities occur throughout the coast, including pile driving and removal activities and renewable energy installations. In 2011, NMFS consulted on the proposed Columbia River Jetty System Rehabilitation Project at the mouth of the Columbia River (NMFS 2011c, consultation #2010/06104). NMFS has also consulted on proposed renewable ocean energy projects off the Oregon coast (NMFS 2012c, consultation #2010/06138; NMFS 2012d, consultation #2012/02531). No additional section 7 consultations on construction activities that may affect sDPS of green sturgeon have been conducted in the action area as of the date of this consultation. Potential impacts from these projects include underwater noise and electromagnetic fields that could attract or deter green sturgeon in the area, as well as the installation of structures that may pose physical barriers to migration. In general, the sound levels generated by these projects are expected to be below estimated threshold levels that would result in injury to fish. In addition, the projects typically cover a small area and would not create a continuous physical barrier to passage. Additional studies are needed, however, to better understand the impacts of underwater noise and electromagnetic fields on green sturgeon. In 2014, NMFS consulted on a project in Yaquina Bay (NMFS 2014b, consultation WCR-2013-9) that included dredging and riprap replacement that could impact green sturgeon through an increase in stormwater contaminants, reduction of forage in the dredging area, and physical injury from ocean disposal of dredged material. The number of green sturgeon injured or killed by reduced forage, increased stormwater contaminants, and ocean disposal each year was estimated to be small because of the areal extent of the effects, the migratory nature of green sturgeon, and the action occurring outside the species' spawning habitat.

Dredging activities, disposal of dredged material at ocean disposal sites, bottom trawling activities, and the management and operation of renewable ocean energy installations may affect benthic habitats and prey availability for green sturgeon in marine waters by disturbing benthic habitats and injuring or burying prey resources. In general, effects are expected to be localized and small relative to the abundance of prey available to green sturgeon. Some of these benthic communities are in high energy environments characterized by frequent disturbance and rapid recolonization. In addition, it is unclear whether disturbance of benthic habitats may reduce or enhance feeding opportunities for green sturgeon. Climate change may also alter conditions in coastal marine waters and result in shifts in the distribution of prey resources for green sturgeon in coastal marine areas. We are limited in our ability to assess the effects of climate change on green sturgeon critical habitat, however, because of the limited information available regarding green sturgeon habitat use in coastal marine waters. In addition, variation in the effects of climate change on the marine environment adds to the uncertainty. For example, the effects of climate change may cause some species to increase in abundance and expand in distribution, whereas other species may decline in abundance and become more restricted in distribution.

2.4.3. Puget Sound Chinook Salmon, Lower Columbia River Chinook and Coho Salmon, and Snake River Fall Chinook Salmon

In the status section, we provided an overview of the long-term trends in the harvest of ESA-listed Chinook salmon. In this section, we first describe the magnitude of fishing-related mortality that occurred between 1999 and 2018[17] and how that harvest was distributed across marine area fisheries both inside and outside the action areas. Since much of the harvest mortality on these ESUs occurs in salmon fisheries outside the action area, this provides a comprehensive picture of harvest related impacts. We then describe fishing impacts in more detail for the individual fisheries within the action area.

Coastwide overview of harvest impacts in salmon fisheries

Puget Sound Chinook Salmon ESU

As discussed in Section 2.2.1.3, the Puget Sound Chinook Salmon ESU comprises 22 Puget Sound Chinook salmon populations that are aggregated for management purposes into 14 management units. The populations have distinct migration patterns that affect where harvest impacts occur and the relative magnitude of harvest impacts. Forty percent or more of the harvest of most Puget Sound Chinook salmon stocks occurs in salmon fisheries outside the action area and primarily in Canadian waters. These fisheries are managed under the terms of the Pacific Salmon Treaty Agreement. Southern U.S. salmon fisheries are managed under the terms of resource management plans (RMP) jointly developed by the Puget Sound Treaty Tribes and State of Washington (‘co-managers’) and approved by NMFS under the ESA. Since the expiration of the 2010 RMP in 2014, population-specific impact limits have been defined and evaluated through a series of annual harvest management plans. The Puget Sound co-managers have submitted a new long-term RMP with conservation objectives under which they expect to manage for the next decade, with the expectation that it will be reviewed and authorized under the ESA in time for implementation during the 2024/25 season and beyond.

The trends in total ER for the Puget Sound populations vary considerably. Most are relatively stable, but some show increasing trends over time (e.g., Skagit River summer/fall, Skokomish) while others show decreasing trends (e.g., Nooksack, Nisqually, and Green) (Figures 27-29). The distribution of ERs among Alaskan, Canadian and southern west coast U.S. fisheries also varies considerably (Table 38). The Nooksack populations are particularly vulnerable to harvest in Canada and have an ER that averages 42.9% (Figure 28, Table 39). The ER on Strait of Juan de Fuca populations (Elwha and Dungeness) is relatively low averaging 14.% (Figure 27). ERs on South Puget Sound populations range from 25.6-64.6% (Figure 29). For mid-Puget Sound populations, ERs range from 19.8-56.0%. The proportion of the total exploitation that occurs in the PFMC fishery also varies by management unit, but ranges from 2.8-16.2% (Table 39).

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[17] Estimates of harvest-related mortality are only available for these years. FRAM related estimates of mortality are updated every few years and these are the most recent estimates.

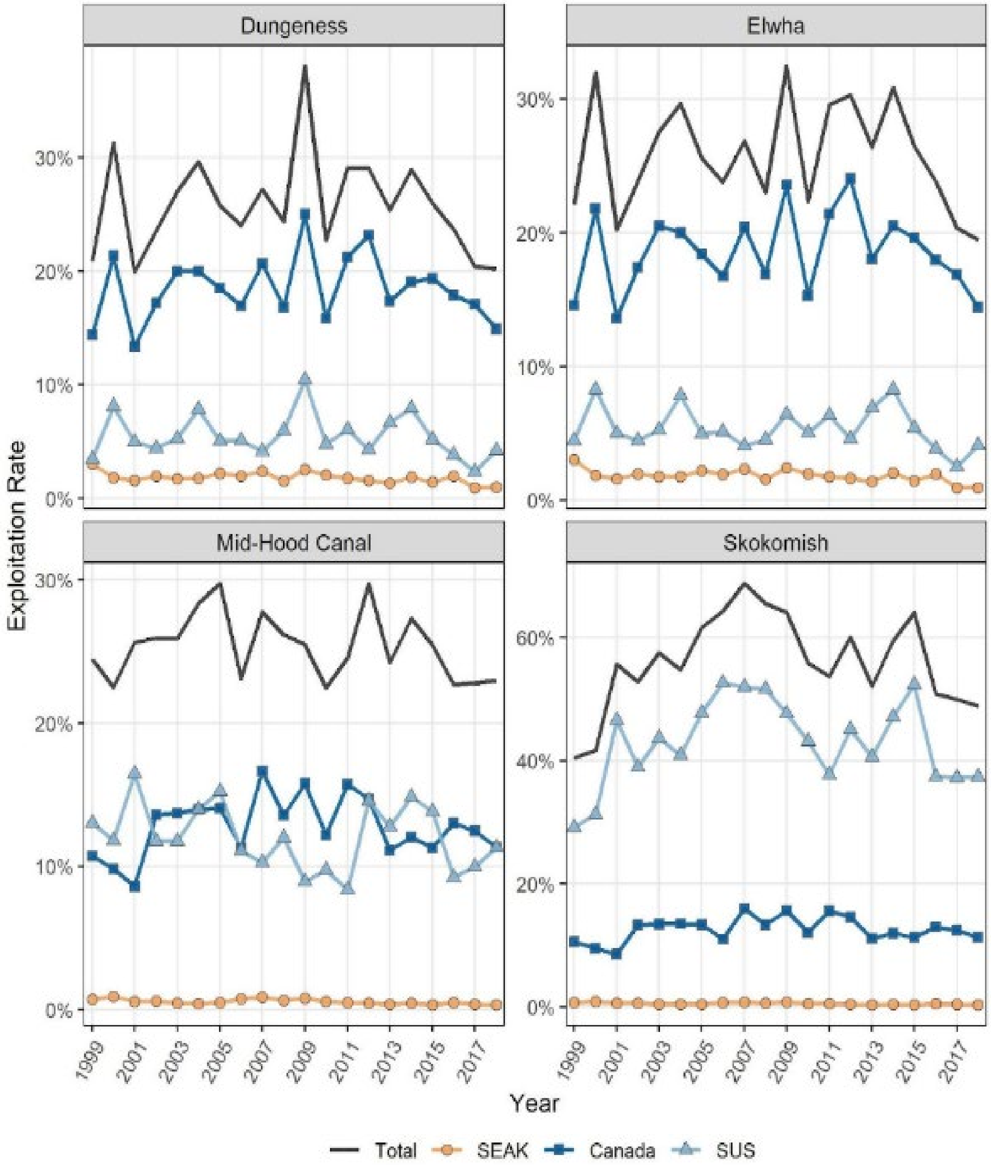


Figure 27. Total adult equivalent calendar year ERs on Strait of Juan de Fuca and Hood Canal Puget Sound Chinook salmon populations between 1999 and 2018 from FRAM model runs using actual post-season fishery catches and best available estimates of annual stock abundances. Between the 4 panels, note the different ER scales used on the x-axis.

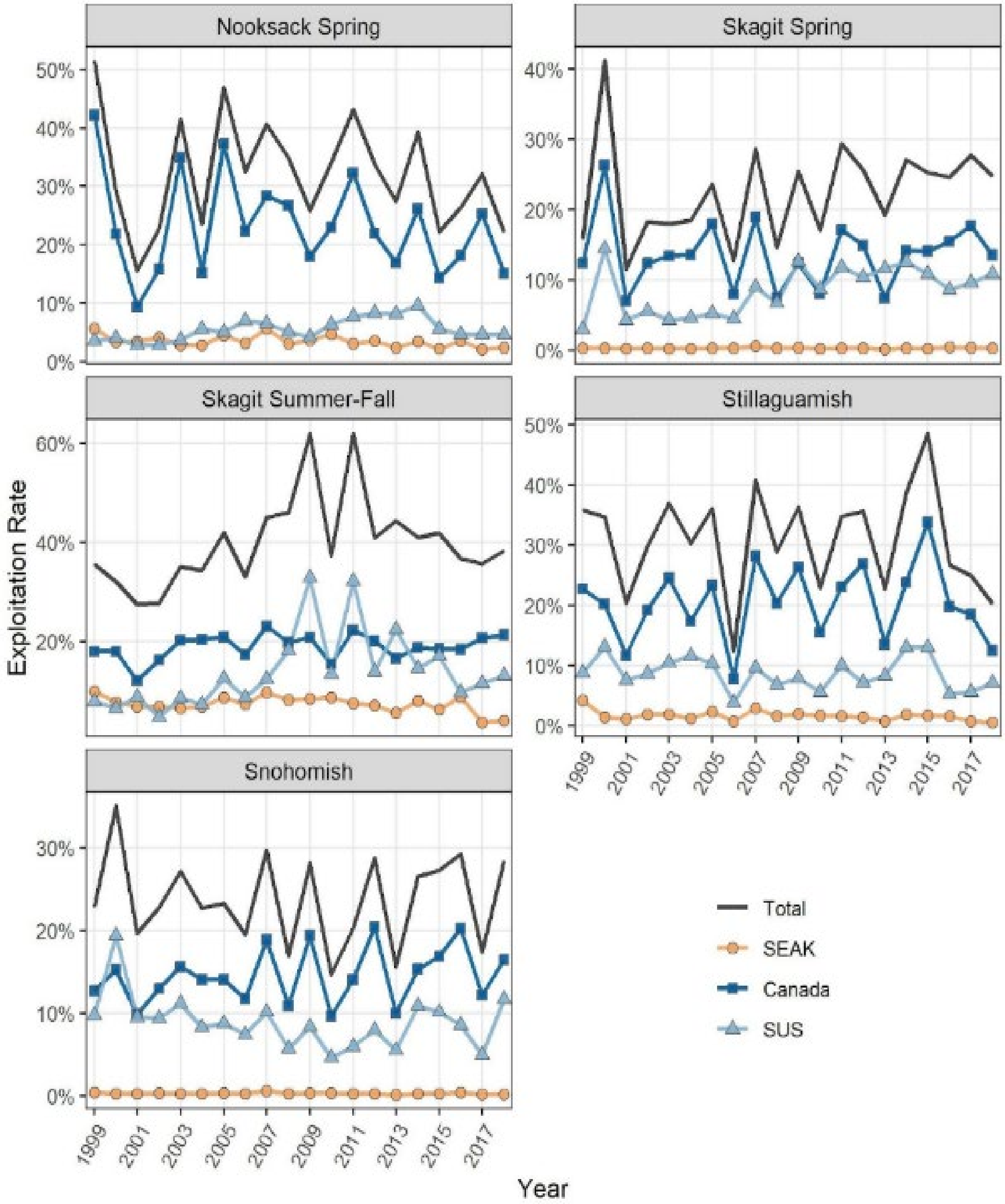


Figure 28. Total adult equivalent calendar year ERs on northern Puget Sound Chinook salmon populations between 1999 and 2018 from FRAM model runs using actual post-season fishery catches and best available estimates of annual stock abundances. Between the 5 figures, note the different ER scales used on the x-axis.

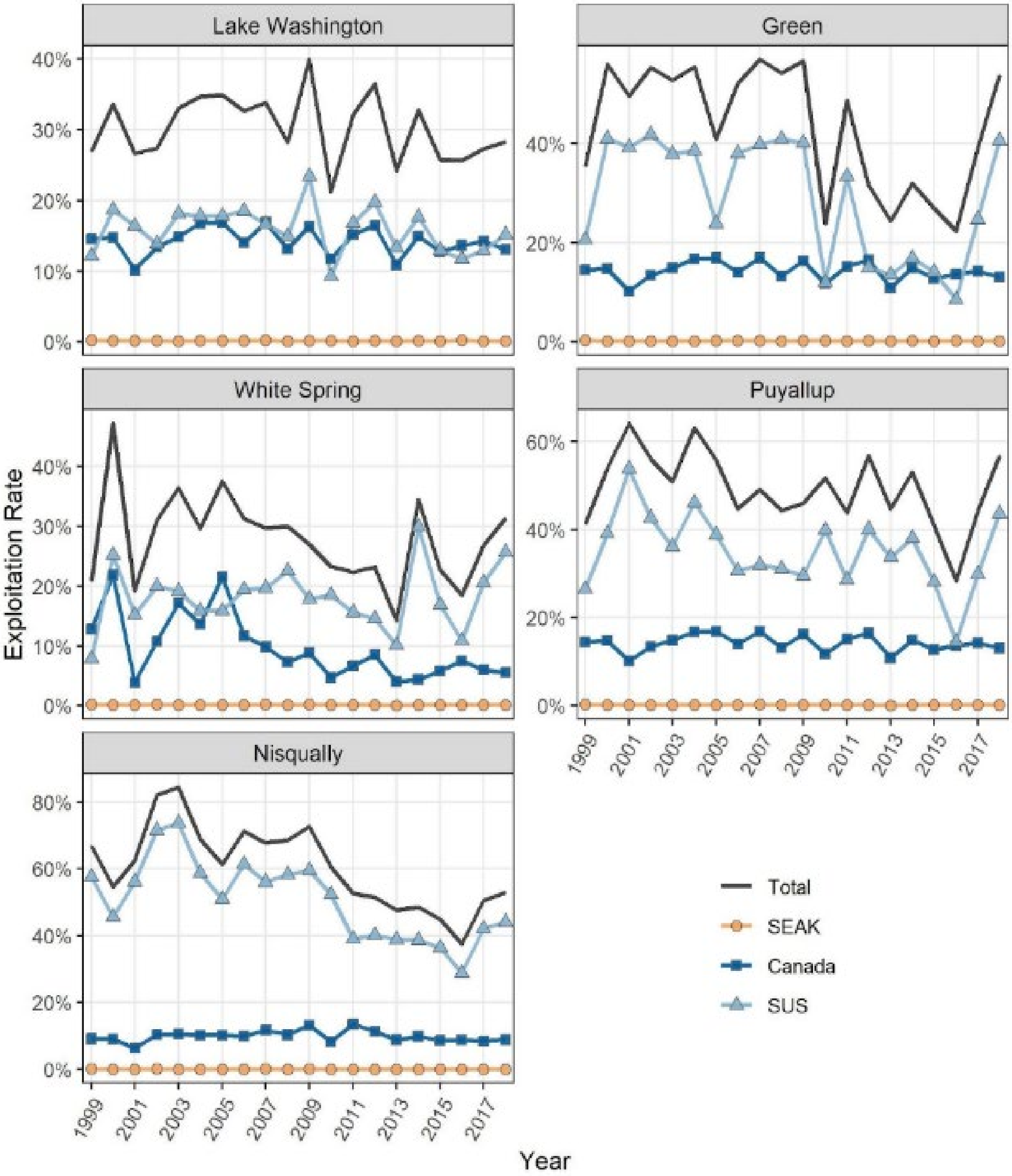


Figure 29. Total adult equivalent calendar year ERs on southern Puget Sound Chinook salmon populations between 1999 and 2018 from FRAM model runs using actual post-season fishery catches and best available estimates of annual stock abundances. Between the 5 figures, note the different ER scales used on the x-axis.

Table 39. The proportional distribution of exploitation impacts of Puget Sound Chinook salmon distribution in marine areas and Puget Sound fisheries between 1999 and 2018.

	SEAK % of Exploitation	Canadian % of Exploitation	PFMC % of Exploitation	Puget Sound % of Exploitation
Stock	**Average 1999 – 2018**			
Nooksack River (early)	10.8%	72.2%	7.2%	9.9%
Skagit River (early)	1.5%	60.7%	4.0%	33.8%
Skagit River (summer/fall)	18.2%	47.3%	2.8%	31.6%
Stillaguamish River	5.5%	66.3%	6.3%	21.9%
Snohomish River	1.4%	61.1%	7.3%	30.2%
Lake Washington	0.5%	47.0%	16.2%	36.2%
Duwamish-Green River	0.4%	32.8%	11.3%	55.5%
Puyallup River	0.3%	28.7%	9.9%	61.0%
Nisqually River	0.1%	16.3%	10.1%	73.4%
White River (early)	0.5%	34.6%	4.8%	60.1%
Skokomish River	1.0%	22.4%	10.9%	65.8%
Mid-Hood Canal Rivers	2.1%	50.4%	24.4%	23.1%
Dungeness River (early)	7.1%	71.6%	5.9%	15.4%
Elwha River	7.1%	72.0%	5.9%	14.9%

Lower Columbia River (LCR) Chinook Salmon ESU

The LCR Chinook Salmon ESU has three components including spring stocks, tule stocks, and far-north migrating bright stocks (See Status Section 2.2.1.4 for more detail). These components have different distributions and are subject to different rates of exploitation.

Exploitation rates for LCR spring Chinook salmon in all marine area fisheries ranged between 10.9 and 23% from 1999 to 2018, but were notably higher in 2002 and 2012 with increases occurring mostly in southern west coast U.S. fisheries (Figure 30). Between 1999 and 2018 the ER on LCR spring Chinook salmon in the action area (marine area fisheries) averaged 16.9%. The majority of fishing related mortality occurred in PFMC salmon fisheries (Figure 31A).

LCR tule Chinook salmon are caught primarily in Canadian and SUS west coast salmon fisheries (Figure 31B). The tule component of the LCR Chinook Salmon ESU in SUS fisheries has been managed in recent years subject to a total ER (marine and freshwater fisheries) that applies to all marine and mainstem Columbia River freshwater fisheries below Bonneville Dam (NMFS 2012b). The ER limit applied by fishery managers for tule Chinook salmon has declined over the years as reflected in a series of consultations on SUS fisheries from 65% in 2001 to the current abundance-based management framework that allows the ER to vary from 30% to 41% depending on abundance (see Section 2.2.1.4 for a more detailed review). ERs in marine area fisheries have declined since 2005 (Figure 30). Between 1999 and 2018 the ER on LCR tule populations in marine area fisheries averaged 31.8%.

North Fork Lewis River fall Chinook salmon are the primary representative of the bright component of the LCR Chinook Salmon ESU, commonly referred to as the “Lower Columbia Wild” stock. As noted in the Status Section 2.2.1.4 this is one of the few healthy wild stocks in the LCR. This is a far-north migrating stock so the marine area exploitation occurs primarily in northern fisheries in Alaska and Canada (Figure 31C). ERs in marine area fisheries have been relatively stable since 1999 with modest reductions in Canadian and SEAK fisheries in recent years (Figure 31C). The ER on LCR bright populations averaged 49.6% in marine area fisheries between 1999 and 2018.

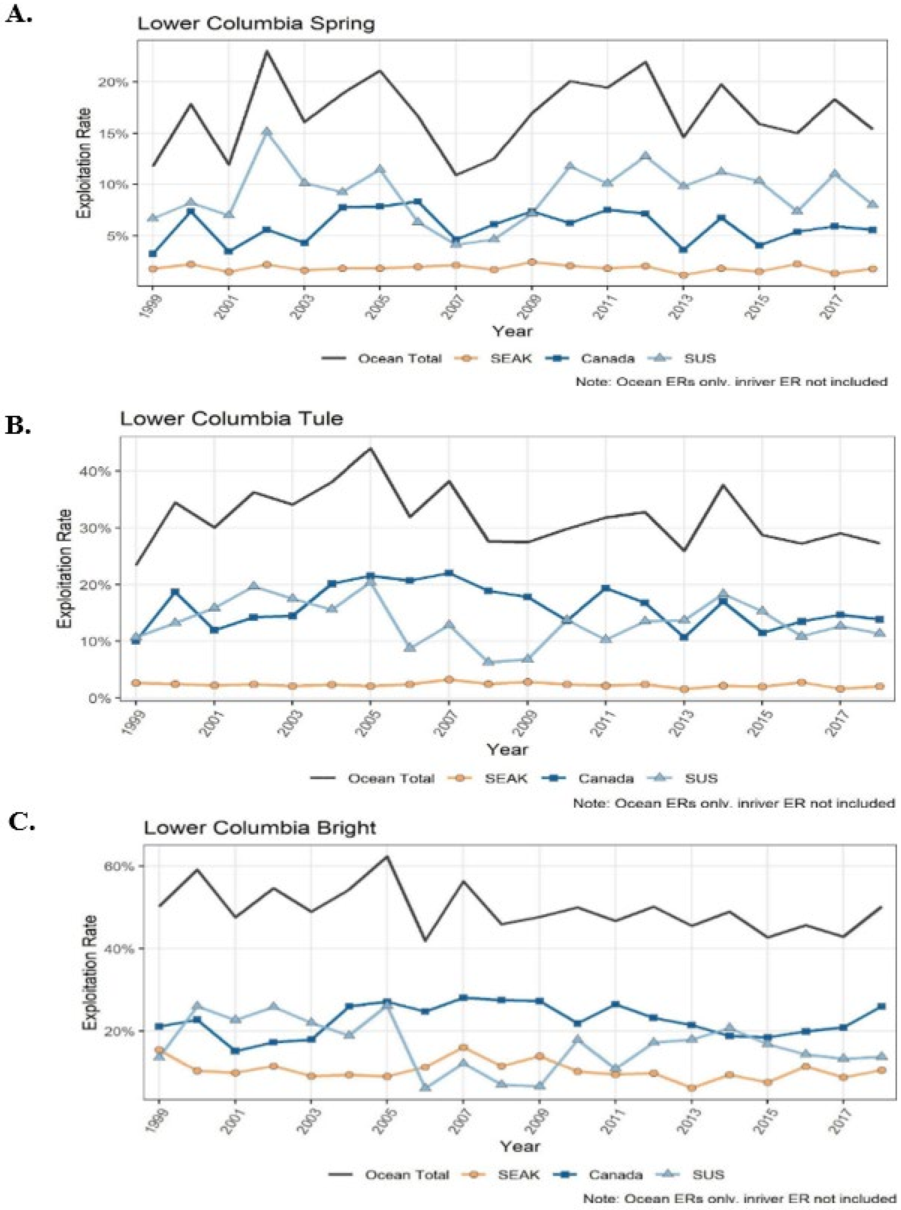


Figure 30. Lower Columbia River spring (A), tule (B), and bright (C) Chinook salmon adult equivalent calendar year marine area ERs between 1999 and 2018 from FRAM model runs using actual post-season fishery catches and best available estimates of annual stock abundances.

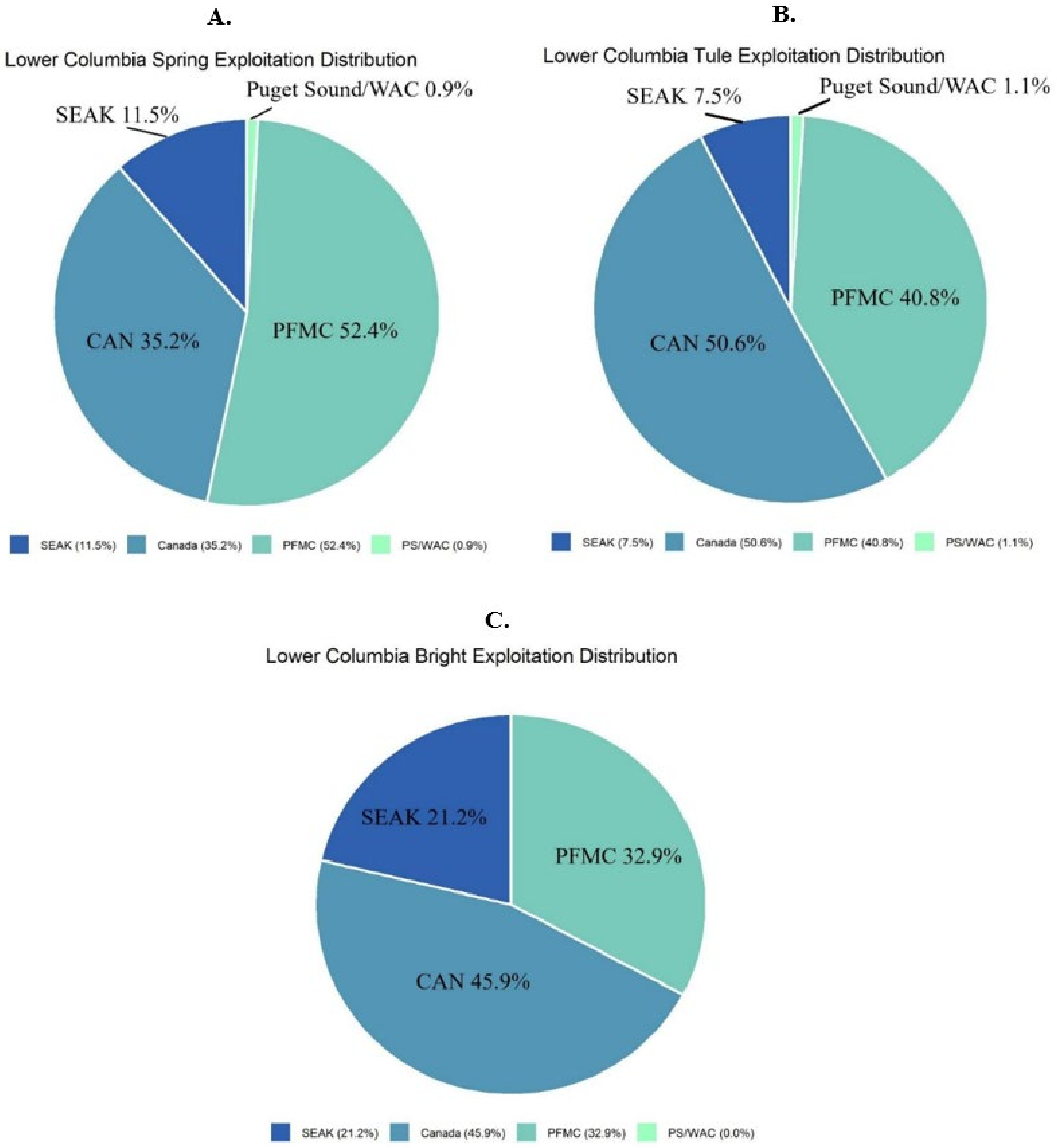
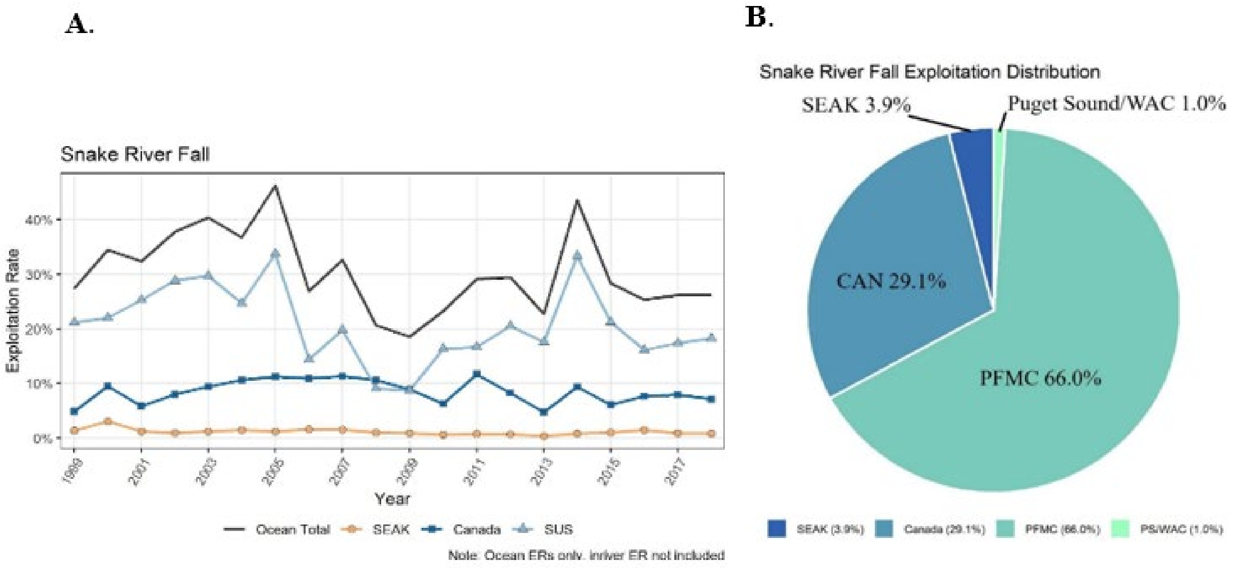


Figure 31. Lower Columbia River spring (A), tule (B), and bright (C) Chinook salmon average ER distribution in marine area fisheries between 1999 and 2018.

Snake River Fall-run Chinook Salmon ESU

SRFC salmon have a broad marine area distribution that ranges from Oregon to SEAK. FRAM based estimates of exploitation rates on SRFC in marine area fisheries have varied between roughly 30% and 50% since 1999 with the greatest variability occurring in the SUS west coast salmon fisheries, averaging 30.4% in marine area fisheries (Figure 32A). PFMC fisheries accounted for the majority of salmon fishing-related mortality in marine water fisheries (Figure 32B)



Note: Ocean ERs only, inriver ER not included

Figure 32. SRFC salmon adult-equivalent calendar year exploitation (A) and distribution (B) between 1999 and 2018 from FRAM model runs using actual post-season fishery catches and best available estimates of annual stock abundances.

Lower Columbia River Coho Salmon ESU

The marine distribution of Lower Columbia River coho salmon ranges from as far south as northern California and as far north as southeast Alaska. LCR coho salmon typically display two major life-history types, either early or late returning freshwater entry (Myers et al. 2006). Early returning (Type-S) coho salmon generally migrate south of the Columbia River once they reach the ocean as far south as the waters off northern California. Late returning (Type-N) coho salmon have a northern distribution in the ocean extending as far as northern British Columbia and southeast Alaska. Fisheries affecting LCR coho salmon have been managed since 2015 using an abundance-based exploitation rate matrix that applies to all ocean and inriver fisheries below Bonneville Dam. Significant reductions in overall harvest rates for all marine area fisheries and freshwater fisheries up to Bonneville Dam have occurred over time, particularly in ocean fisheries. Since 2018, total exploitation rates ranged from 6% to 14.6% (PFMC 2023), averaging 13.2% (Figure 33). Total exploitation rate conservation objectives have been limited to 23% or less in seven of the last ten years.

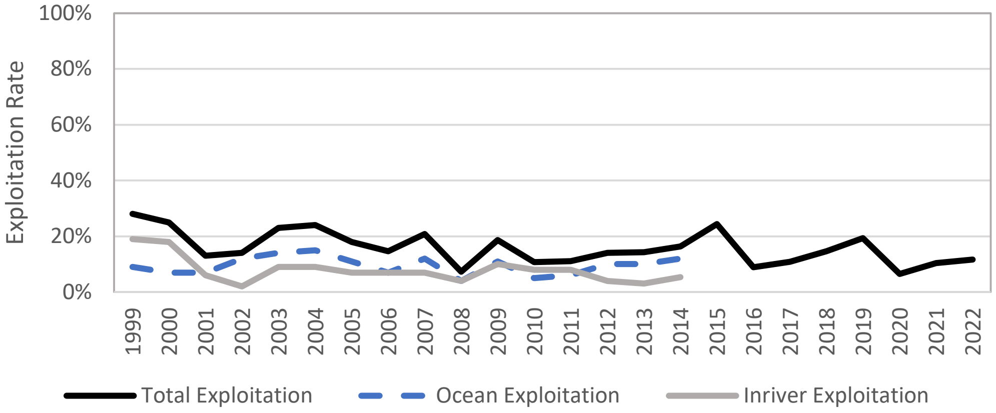


Figure 33. LCR Coho salmon exploitation rate in ocean and inriver fisheries, and total.

Southern U.S. PFMC and Puget Sound Salmon Fisheries

NMFS promulgates regulations for fisheries in the Exclusive Economic Zone (EEZ) off the Pacific Coast of Washington, Oregon, and California pursuant to the Magnuson-Stevens Act. NMFS and the PFMC manage fisheries for Chinook and coho in federal waters under the Pacific Coast Salmon Management Plan (FMP) (PFMC 2022). It covers wild and hatchery fish under conservation objectives and status determination criteria to manage the fishery for optimum yield, and allocates salmon among user groups. Beginning in late February, the PFMC develops annual regulations consistent with the FMP through a public process that leads to recommendations to NMFS. The FMP provides a framework for setting annual regulations that define catch levels and allocations based on year specific circumstances (PFMC 2022). The current FMP requires that the PFMC manage fisheries consistent with NMFS' ESA-related consultation standards or recovery plans to meet the immediate needs for conservation and long-term recovery for all ESA listed species (PFMC 2022). These standards are either reasonable and prudent alternatives described in jeopardy biological opinions on the fishery, or are management standards or frameworks developed by the PFMC or co-managers and approved by NMFS having been determined through an ESA section 7 consultation to be not likely to jeopardize the listed species in question.

NMFS has previously considered the effects of PFMC salmon fisheries on ESA-listed species under its jurisdiction for ESA compliance through completion of biological opinions (Table 1) (NMFS 1996a, 1999, 2000, 2001a, 2001b, 2004, 2007, 2011, 2012b; 2015, 2018a, 2021a, 2022b, 2023a, 2023b). These opinions are still in effect and address harvest effects including species that are affected by the proposed action considered in this opinion.

The FRAM projected that there was negligible chance that the proposed halibut fishery would encounter Oregon Coast or Southern Oregon/Northern California coho salmon, at a rate of <0.5 and <0.1 fish per year, respectively. At this low encounter rate, it is highly unlikely that the proposed halibut fishery would encounter fish from these ESUs.

Puget Sound Chinook Salmon ESU

As discussed in Section 2.2.1.3, the ESU comprises 22 Puget Sound Chinook salmon populations that are aggregated for management purposes into 14 management units. The populations have distinct migration patterns that affect where harvest impacts occur and the relative magnitude of harvest impacts. Fisheries are managed for objectives for each management unit, and these vary considerably depending on the status of each unit.

The magnitude and distribution of harvest impacts on Puget Sound Chinook salmon varies by stock. In 2004, NMFS issued a biological opinion on the anticipated effects of PFMC fisheries on the listed Puget Sound Chinook salmon ESU for 2004 and future fishing years. The 2004 opinion found that exploitation rates in PFMC area fisheries (NMFS 2004a) on Puget Sound spring and fall Chinook salmon populations of 3% and 6%, respectively, would not jeopardize the species. Between 1999 and 2018 ERs on Puget Sound populations in PFMC fisheries ranged from 0.9% to 6.2% and, except for Mid-Hood Canal River populations, accounted for between 2.8 and 16.2% of each stock's total ER (Figures 27–29 and Table 39).

LCR Chinook Salmon ESU

As discussed in Section 2.4.1.1, the LCR Chinook Salmon ESU has three components including spring, tule, and far-north migrating bright stocks. These stocks have different distributions and are subject to different harvest impacts. As discussed above PFMC salmon fisheries have been managed since 2012 using an abundance-based management plan framework on the tule component. The plan specifies a total ER that may vary from year to year between 30 and 41% depending on a particular run size indicator. PFMC fisheries are managed such that all marine area salmon fisheries and inriver fisheries below Bonneville Dam stay within this total ER. NMFS reviewed the proposed management framework in 2012 and concluded that it would not jeopardize LCR Chinook salmon (NMFS 2012b).

The ER on LCR spring Chinook salmon populations in PFMC fisheries averaged 9.0% exploitation from 1999 to 2018, accounting for 52.4% of the marine area exploitation (Figures 30A and 31A).

The ER on LCR tule populations in PFMC fisheries has averaged 13.0% (Figures 30B and 31B) and accounted for 40.8% of the total marine exploitation on LCR tule Chinook salmon.

The ER on LCR bright populations averaged 16.5% in PFMC fisheries between 1999 and 2018 and accounted for 32.9% of the marine area exploitation (Figures 30C and 31C).

Snake River Fall-run Chinook Salmon ESU

As discussed above, SRFC salmon are managed subject to an ER limit that applies to all marine area fisheries to a 30% reduction standard relative to the 1988 to 1993 base period. Because of their distribution and timing, more of the marine area impacts on SRFC salmon occur in PFMC fisheries. From 1999 to 2018 ERs on SRFC salmon in PFMC fisheries averaged 20.5% and accounted for 66.0% of the overall marine area harvest (Figure 32A and B).

Lower Columbia River Coho Salmon

As discussed previously, LCR coho are managed under an abundance-based framework that limits the total exploitation rate on all marine and freshwater fisheries combined. Since 1994 ocean fisheries have accounted for 67% of the LCR coho harvest mortality (Figure 34). Exploitation rates for ocean fisheries averaged 80% from 1970 to 1983, 49% from 1984 to 1993, 10% from 1994 to 2007, 9% from 2008 to 2017, and 10% from 2018 to 2021.

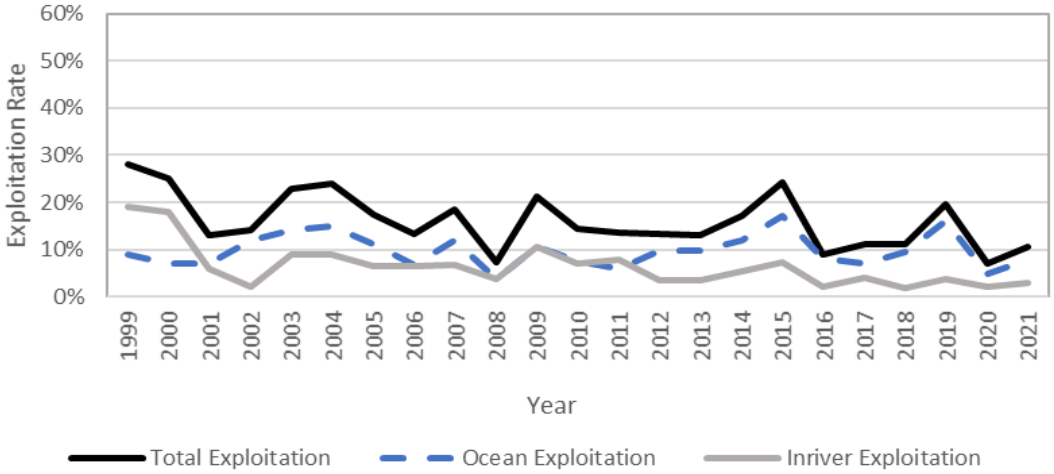


Figure 34. Lower Columbia River coho exploitation rate (%) from 1999 to 2021.

PFMC Halibut Fishery

PFMC halibut fisheries in 2023 and beyond are the subject of this opinion, so they are not included in the environmental baseline. However, historical PFMC halibut fisheries have contributed to the current status of the salmon ESUs that are the subject of this opinion and are therefore considered here.

Salmon are caught during commercial and recreational halibut fisheries occurring in the action area. However, the majority of the catch is accounted for as part of the Pacific Coast Salmon FMP management framework when salmon fisheries are legally open for retention; therefore, they are accounted for in the environmental baseline under the information reported above in the PFMC Salmon Fisheries Environmental Baseline section and not part of the proposed action. When salmon fishing is prohibited, halibut fisheries occasionally encounter salmon, which are considered in this biological opinion. From 2007 through 2016, injuries and death from encounters with fishing gear and handling during times and areas where salmon fishing is otherwise closed is estimated to have resulted in the take of ESA-listed Puget Sound Chinook salmon (<2 fish/year), Lower Columbia River Chinook salmon (2.4 fish/year), Snake River fall Chinook salmon (<1 fish/year), and Lower Columbia River coho salmon (<3 fish/year) (NMFS 2018).

2.4.3.1 Puget Sound Fisheries

Puget Sound Salmon Fisheries

The effects of Puget Sound fisheries on Puget Sound salmon stocks are of course higher than the effects on other stocks. Puget Sound salmon fisheries are managed by the State of Washington and the Puget Sound Treaty Tribes. Each year they develop conservation objectives to conserve and rebuild Puget Sound Chinook salmon, and allowable levels of mortality in order to permit access to and equitable harvest sharing of Puget Sound Chinook salmon, including harvest of surplus hatchery-raised salmon. The North of Falcon process is used to establish seasons for recreational and commercial fisheries in Washington's state waters, including Puget Sound. The preseason planning process is an open process involving federal, tribal, state, and industry representatives, as well as public citizens and occurs at the same time and is coordinated with the PFMC process.

In 2004, the State and Treaty Tribal fishery co-managers began managing Chinook salmon mortality in Puget Sound salmon and Treaty Tribal steelhead net fisheries to meet the conservation and allocation objectives described in a series of RMPs. NMFS determined that fisheries managed consistent with the terms of the RMPs would not jeopardize the survival and recovery of the ESU (NMFS 2005, NMFS 2010a, NMFS 2014; 2015; 2016; 2018b; 2019c; 2020b; 2021a; 2022c). The 2010–2014 Puget Sound Chinook Harvest RMP was adopted as the harvest component of the Puget Sound Salmon Recovery Plan which includes the Puget Sound Chinook Salmon ESU (SSDC 2007). NMFS recently completed a biological opinion on the RMP for the 2023 Puget Sound salmon fishing season and concluded that it would not jeopardize listed species or adversely modify their critical habitat. A new long-term RMP has been submitted to NMFS, and is currently under review. Since 1999, average ERs in Puget Sound fisheries on Puget Sound Chinook salmon ranged from 3.2% to 44.4% depending on the stock (Figures 27–29). Not surprisingly, a higher proportion of the overall harvest impact on the Puget Sound Chinook Salmon ESU occurs in Puget Sound fisheries for stocks from the south and mid-Sound areas (Table 39). Puget Sound salmon fisheries catch LCR Chinook salmon, SRFC salmon and LCR coho on occasion, but the ERs in Puget Sound fisheries on these ESUs are just fractions of 1%.

Puget Sound bottomfish and shrimp trawl fisheries

Recreational fishers targeting bottomfish and the shrimp trawl fishery in Puget Sound can incidentally catch listed Puget Sound Chinook salmon. In 2012, NMFS issued an incidental take permit to the WDFW for listed species caught in these two fisheries, including Puget Sound Chinook salmon (NMFS 2012a). The permit was in effect for 5 years and authorized the total incidental take of up to 92 Puget Sound Chinook salmon annually. Some of these fish would be released. Some released fish were expected to survive; thus, of the total takes, we authorized a subset of lethal take of up to 50 Chinook salmon annually. As of 2023, this permit has not been renewed; however, we are working with the WDFW and tribal co-managers on their preparation of a new permit covering the same two fisheries, and adding commercial and recreational shrimp pot/trap fisheries, that would allow incidental take of 137 Chinook salmon annually in coming years.

2.4.3.2. Hatchery production

Hatchery production of salmonids has occurred for over 100 years. Currently, there are hundreds of hatchery programs in Alaska, Oregon, Washington, California, and Idaho that produce juvenile salmon that migrate through the action area. Many of these fish contribute to both fisheries and supplementing abundance in the action area as well as providing prey for other ESA-listed species like Southern Resident killer whales (SRKW).

NMFS has completed section 7 consultation on more than a hundred hatchery programs in numerous Biological Opinions (Report to Congress, 2023). These effects are detailed in the individual hatchery consultations and further described in Appendix C of NMFS (2018), which is incorporated here by reference. For efficiency, discussion of these effects is not repeated here.

Hatcheries can provide benefits by reducing demographic risks and preserving genetic traits for populations at low abundance in degraded habitats; providing harvest opportunity is an important contributor to upholding the meaningful exercise of treaty rights for the Northwest tribes. Hatchery-origin fish may also pose risk through genetic, ecological, or harvest effects. Six factors may pose positive, negligible, or negative effects on population viability of naturally-produced salmon and steelhead:

1. The hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock,
2. hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities,
3. hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas, the migration corridor, estuary, and ocean,
4. research, monitoring, and evaluation that exists because of the hatchery program,
5. the operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program, and
6. fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

Beginning in the 1990s, state and tribal co-managers took steps to reduce risks identified for Puget Sound hatchery programs as better information became available (PSTT and WDFW 2004), in response to reviews of hatchery programs (e.g., Currens and Busack 1995; HSRG 2002), and as part of the region-wide Puget Sound salmon recovery planning effort (SSPS 2005). The intent of hatchery reform is to reduce negative effects of artificial propagation on natural populations while retaining proven production and potential conservation benefits. The goals of conservation programs are to restore and maintain natural populations. Hatchery programs in the Pacific Northwest are phasing out use of dissimilar broodstocks, such as out-of-basin or out-of-ESU stocks, replacing them with fish derived from, or more compatible with, locally adapted populations. Producing fish that are better suited for survival in the wild is now an explicit objective of many salmon hatchery programs. Hatchery programs are also incorporating improved production techniques with changes proposed to ensure that existing natural salmonid populations are preserved, and that hatchery-induced genetic and ecological effects on natural populations are minimized.

Here in the environmental baseline, we take account of the effects on ESA-listed species and their critical habitat that may be affected by the returning increased Chinook salmon produced from these programs that escape contributing to the prey base (i.e., those not eaten by SRKW) or caught by the fisheries by incorporating by reference the effects evaluated in site specific consultations. We explain above the six factors we evaluate that may pose positive, negligible, or negative effects on population viability of naturally-produced salmon and steelhead from hatchery program operation.

2.4.3.3. Habitat

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. Many of these activities have a federal nexus and have undergone ESA Section 7 consultation. Those actions have nearly all met the standard of not jeopardizing the continued existence of the listed salmonids or adversely modifying their critical habitat, and when they did not meet that standard, NMFS identified RPAs. In addition, the environmental baseline is influenced by many actions that pre-date the salmonid listings and that have substantially degraded salmon habitat and lowered natural production of the salmon ESUs that are the subject of this opinion.

Activities that NMFS has consulted on that affect salmon habitat, are discussed in detail in NMFS 2018 and NMFS 2023 and incorporated here by reference. Briefly, these include hydropower projects (Mud Mountain Dam (NMFS 2014d); Howard Hanson Dam, Operation, and Maintenance (NMFS 2019g)), the National Flood Insurance program (NMFS 2008c), and marine construction (NMFS 2020g; 2021h; 2022b), among others.

In 2020 and 2021, NMFS issued opinions for 39 (NMFS 2020f) and 11 (NMFS 2021b) habitat-modifying projects in the nearshore marine areas of Puget Sound. The opinions concluded that the proposed action would jeopardize the continued existence of, and adversely modify critical habitat for, Puget Sound Chinook salmon and SRKWs. In a novel approach, the RPAs for these opinions 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. A variety of mitigation options were provided for each of the projects and required that all debits be offset by an equal amount of credits, resulting in no net loss of habitat (NMFS 2020f; 2021h). This “conservation calculator” has been adapted for Puget Sound nearshore habitat (critical for juvenile salmon survival) to help developers and other entities conducting work on structures in the nearshore environment calculate the habitat impacts, or debits, and habitat improvements, or credits, of their projects. When debits are offset with an equivalent number of credits, the result is no net loss of nearshore habitat. More information on the conservation calculator can be found at https://www.fisheries.noaa.gov/west-coast/habitat-conservation/puget-sound-nearshore-habitat-conservation-calculator.

In addition to increased hatchery production, the funding initiative for U.S. domestic actions associated with the new PST Agreement included funding for habitat restoration projects to improve habitat conditions for specified populations of Puget Sound Chinook salmon (NMFS 2019h; 2022b). In FY20, FY21, and FY22, $8.9 million, $8.8 million, and $8.8 million, respectively, was directed at habitat restoration projects within the northern boundary watersheds of Nooksack, Skagit, Stillaguamish, Snohomish, Dungeness, and Mid-Hood Canal. Additionally, for FY2023, the U.S. commissioners have committed to support for three Puget Sound critical stocks of Chinook salmon.

NMFS developed phased selection criteria to select projects, which are described in NMFS (2023).

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 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 2020d), including the ESUs that are the subject of this opinion. 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.

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

2.4.4. Research Effects in the Environmental Baseline

The listed salmon, green sturgeon, and rockfish species in this opinion are the subject of scientific research and monitoring activities. Most biological opinions issued by NMFS have conditions requiring specific monitoring, evaluation, and research projects to gather information to aid the preservation and recovery of listed species. The impacts of these research activities pose both benefits and risks. Research on the listed species in the action area is currently provided coverage under section 7 of the ESA or under the ESA 4(d) research programs (NMFS 2023b), or included in the estimates of fishery mortality discussed in Section 2.5, Effects of the Proposed Action, in this opinion.

For the year 2023, NMFS has issued several ESA section 10(a)(1)(A) scientific research permits allowing lethal and non-lethal take of listed species within the action area. Table 40 displays the total take for the ongoing research authorized under ESA sections 4(d) and 10(a)(1)(A) within the action area for the listed Puget Sound/Georgia Basin rockfish species DPSs, Southern DPS green sturgeon, Puget Sound Chinook Salmon ESU, Lower Columbia River Chinook Salmon ESU, Lower Columbia River Coho Salmon ESU, and Snake River Fall-run Chinook Salmon ESU.

Table 40. Total requested take of ESA-listed species for scientific research and monitoring approved for 2023, plus the permits evaluated in the biological opinion covering new scientific research (NMFS 2023).

Species	Life Stage	Origin[a]	Total Requested Take	Percent of Abundance	Lethal Take	Percent of ESU/DPS killed
PS/GB bocaccio[d]	Adult	Natural	26	2.323[b]	15	0.977[b]
	Subadult	Natural	2		1	
	Juvenile	Natural	79		29	
PS/GB yelloweye rockfish[d]	Adult	Natural	32	0.081[b]	20	0.047b
	Subadult	Natural	2		1	
	Juvenile	Natural	59		33	
Southern green sturgeon DPS	Adult	Natural	522	24.542	12	0.564
	Subadult	Natural	346	3.099	11	0.099
	Juvenile	Natural	6,663	150.372	193	4.356
	Larvae	Natural	11,256	-	1,051	-
	Egg	Natural	4,370		4,370	
PS Chinook salmon[b]	Adult	LHAC	960	7.107[a]	62	0.336[a]
		LHIA	691		16	
		Natural	853	3.650	37	0.158
	Juvenile	LHAC	223,285	9,569	0.871	0.037
		LHIA	275,089	3.169	5,596	0.064
		Natural	770,310	20.661	13,768	0.369
LCR Chinook salmon	Adult	LHAC	151	0.866[a]	13	0.069[a]
		LHIA	12		0	
		Natural	420	1.434	19	0.065
	Juvenile	LHAC	2,	0.010	664	0.002
		LHIA	428	0.045	45	0.005
		Natural	514,518	4.621	6,483	0.058
LCR coho salmon	Adult	LHAC	676	4.433[a]	42	0.263[a]
		LHIA	31		0	
		Natural	1,121	5.990	19	0.102
	Juvenile	LHAC	19,776	0.249	1,101	0.014
		LHIA	875	0.270	116	0.036
		Natural	241,705	29.226	2,926	0.354
Snake River fall Chinook salmon	Adult	LHAC	83	0.786[a]	14	0.101[a]
		LHIA	34		1	
		Natural	87	1.198	9	0.124
	Juvenile	LHAC	2,630	0.101	283	0.011
		LHIA	2,013	0.068	144	0.005
		Natural	4,529	0.566	264	0.033

[a] Abundances for adult hatchery salmonids are LHAC and LHIA combined.

[b] Abundance for these species are only known for the adult life stage which is used to represent the entire DPS

[c] Abundances for all adult components are combined.

Actual take levels associated with these activities are almost certain to be substantially lower than the permitted levels. There are three reasons for this: (1) most researchers do not handle the full number of individuals they are allowed — our research tracking system reveals that researchers, on average, end up taking about 37% of the number of fish they estimate needing; (2) the estimates of mortality for each proposed study are purposefully inflated (the amount depends upon the species) to account for potential accidental deaths, and it is therefore likely that fewer fish (in some cases many fewer), especially juveniles, than the researchers are allotted are killed; and (3) researchers within the same watershed are encouraged to collaborate on studies (i.e., share fish samples and biological data among permit holders) so that overall impacts on listed species are reduced (NMFS 2023b).

2.4.5. Harvest and Bycatch Effects in the Environmental Baseline

2.4.5.1 Puget Sound/Georgia Basin Rockfishes

In this section, we summarize past and present impacts on rockfish from federal and state-managed fisheries within the portion of the action area in the Puget Sound/Georgia Basin. Recreational fishermen targeting bottom fish, and the commercial shrimp trawl fishery in Puget Sound, can incidentally catch listed rockfish. In 2012, we issued an incidental take permit (ITP) to the WDFW for listed rockfish in these fisheries (Table 41). This ITP expired in 2017 and we are currently working with the WDFW and tribal co-managers in their preparation of a new ITP application that will provide renewed coverage for these fisheries, as well as providing novel coverage for recreational and commercial pot/trap-based shrimp fisheries throughout greater Puget Sound.

Table 41. Anticipated Maximum Annual Takes for Bocaccio and Yelloweye Rockfish by the fisheries within the WDFW ITP (2012–2017) (WDFW 2012).

	Recreational bottomfish		**Shrimp trawl**		**Total annual take**	
	Lethal	**Non-lethal**	**Lethal**	**Non-lethal**	**Lethal**	**Non-lethal**
Bocaccio	12	26	5	0	17	26
Yelloweye Rockfish	87	55	10	0	87	65

In 2023, we estimated that up to 117 yelloweye rockfish and 145 bocaccio will be incidentally caught annually by recreational anglers targeting salmon (NMFS 2023b), and that 56% (66 yelloweye) and 53% (77 bocaccio) of these incidentally caught fish will be mortalities. We anticipate similar numbers of mortalities in the salmon fishery and the fisheries in Table 41 for the foreseeable future. As shown in Table 40, for 2023 we permitted various researchers a total lethal take of 54 yelloweye rockfish and 45 bocaccio.

2.4.5.2 Green Sturgeon

In this section, we summarize past and present impacts on green sturgeon from Federal and state-managed fisheries within the action area. Other fisheries that affect Southern DPS green sturgeon, but occur outside of the action area, are discussed in Section 2.2, Rangewide Status of the Species and Critical Habitat, of this opinion. Green sturgeon interactions in the fisheries may involve capture in fishing gear, removal from the water, and handling of the fish prior to release back into the water. Retention of green sturgeon is prohibited throughout the west coast, but some portion of the green sturgeon incidentally caught dies immediately or after being released back into the water. Because Southern DPS green sturgeon are not morphologically distinguishable from Northern DPS green sturgeon, the effects of these fisheries described below are not specific to Southern DPS green sturgeon. To estimate the effects of these fisheries on Southern DPS green sturgeon, we used stock composition information from genetic and tagging studies to estimate the proportion of the green sturgeon incidentally caught that may belong to the Southern DPS.

Pacific Halibut Fishery

We provide a brief summary of the past effects of the Pacific halibut fishery on Southern DPS green sturgeon. Section 2.5, Effects of the Proposed Action, provides an analysis of these effects and the expected effects of the fishery on green sturgeon under the Proposed Action.

There are no records of green sturgeon catch in the Washington treaty fisheries and no recent catches in the recreational fishery; however, one green sturgeon was caught in the non-treaty directed commercial fishery. The Observer Program reported that the green sturgeon was caught in the directed commercial fishery off the coast of northern California on July 10, 2019, and sampled by an observer.

Ocean Sampling Program (OSP) data from the late 1980s to present indicate no records of green sturgeon catch in the recreational Pacific halibut fisheries off the outer coast of Washington; any green sturgeon catch would have been recorded (Heather Reed, WDFW, email to Susan Wang and Phaedra Doukakis, NMFS, January 21, 2014, regarding Pacific halibut fisheries and green sturgeon catch data). Occasional catches of green sturgeon have occurred in the Puget Sound recreational fishery. One green sturgeon was caught and released in the Puget Sound creel survey in 2008, and one catch record card reported two green sturgeon harvested in 2003, though this record is suspected to be a misidentification (Heather Reed, WDFW, email to Susan Wang and Phaedra Doukakis, NMFS, January 21, 2014, regarding Pacific halibut fisheries and green sturgeon catch data). WDFW RecFin data for 2003 to 2013 also show one green sturgeon caught and released in the Puget Sound bottom fish fishery in 2008 (unpublished WDFW RecFin data, from Eric Kraig, WDFW, January 7, 2014). No green sturgeon were reported in the Washington recreational halibut fisheries from 2014 to December 2022 (Heather Reed, WDFW, email to Susan Wang and Phaedra Doukakis, NMFS, January 5, 2017, regarding Pacific halibut fisheries and green sturgeon catch data; M. Culver, WDFW, email to Susan Bishop, NMFS WCR, August 24, 2017, regarding halibut fisheries in Washington waters; Lorna Wargo, WDFW, email to Katie Davis, NMFS, December 19, 2022, regarding ESA bycatch associated with recreational halibut trips). For the recreational fisheries off the coast of California, there are no records of green sturgeon catch in the CRFS database (data collection began in 2004) (C. McKnight, pers. comm., CDFW, January 28, 2014; D. Wilson-Vandenberg, CDFW, email to Susan Wang, Phaedra Doukakis, and other NMFS and CDFW personnel, January 5, 2017, regarding Pacific halibut fisheries off California and CDFW green sturgeon catch data; Melanie Parker, CDFW, email to Katie Davis, Heather Fitch, and Joshua Lindsay, NMFS, December 16, 2022, regarding records of ESA-listed species encounters in the recreational halibut fishery in California).

Overall, the estimated number of green sturgeon encountered in the Pacific halibut fisheries has ranged from zero to one per year, with no encounters in most years. The fish may have belonged to either the Southern DPS or Northern DPS. Genetic analyses have not yet been conducted to determine the DPS composition of green sturgeon caught in the Pacific halibut fisheries.

Pacific Coast Groundfish Fishery

Halibut are retained in the sablefish fishery north of Point Chehalis, WA. Any ESA interactions with that fishery are not part of this biological opinion and are evaluated as part of the Pacific coast groundfish fishery as discussed here.

In 2012, NMFS evaluated the impacts of the Federal Pacific Coast groundfish fishery on Southern DPS green sturgeon (NMFS 2012b). Green sturgeon have been encountered in the limited entry (LE) groundfish bottom trawl (as of 2011, called the Individual Fishing Quota, or IFQ, bottom trawl fishery) and the at-sea Pacific hake/whiting (at-sea hake) sectors occurring along the California, Oregon, and Washington coasts, with varying levels of bycatch over the years (Richerson et al. 2022). The majority of the green sturgeon encounters occurred in the LE/IFQ bottom trawl fishery in marine waters of northern Oregon and southern Washington, near the mouth of the Columbia River (Richerson et al. 2022). During the most recent years observed, from 2015 to 2019, the federally-managed groundfish sectors encountered between 0 and 12 Southern DPS green sturgeon per year (Richerson et al. 2022). In prior years, the IFQ groundfish sector encountered greater numbers of Southern DPS green sturgeon (e.g., 23 in 2009). In the at-sea hake sector, the green sturgeon encountered are dead (up to one Southern DPS green sturgeon per year in 2005 and 2006); however, no bycatch of green sturgeon has been observed in this fishery since 2006 (Richerson et al. 2022). In the LE/IFQ groundfish sector, the majority of the green sturgeon are released alive, though some level of immediate and post-release mortality occurs. Post-release mortality is estimated to be between 2% and 26% in the state-managed California halibut trawl fishery (Doukakis et al. 2020, as cited in Richerson et al. 2022). Applying this bycatch mortality rate, we estimate that up to three Southern DPS green sturgeon may be killed in the Pacific Coast groundfish fishery per year. The opinion also allows for incidental take of Southern DPS green sturgeon by the NMFS Observer Program, when observing and handling fish encountered in this fishery and the California halibut bottom trawl fishery (described below). No lethal take would be expected from this handling by the NMFS observers.

California Halibut Bottom Trawl Fishery

Green sturgeon are encountered in the state-regulated California halibut bottom trawl fishery conducted in coastal marine waters. The annual fleet-wide bycatch estimates for green sturgeon range from 45 to 786 fish during years 2002–2014 and 288 to 664 fish during 2015–2019 (Richerson et al. 2022). It is possible that individual green sturgeon are encountered by the fishery more than once per year, but recapture rates are not known. Green sturgeon bycatch sampled from 2015 to 2019, showed that 96% of green sturgeon encountered off California likely belong to the Southern DPS (C. Garza pers comm as described in Richerson et al. 2022). Based on the 2015 through 2019 bycatch data, Richerson et al. (2022) estimate that the California halibut bottom trawl fishery encounters 278 to 640 Southern DPS green sturgeon per year. Applying the post-release mortality of between 2% and 26% in the state-managed California halibut trawl fishery (Doukakis et al. 2020, as cited in Richerson et al. 2022), we estimate that encounters with the California halibut bottom trawl fishery kill 5 to 166 Southern DPS green sturgeon per year.

2.4.5.3 Listed salmonid stocks

Salmon Fisheries

The PFMC and NMFS manage fisheries for Chinook and coho in federal waters under the Salmon Fishery Management Plan (PFMC 2016). It covers wild and hatchery fish under conservation objectives and status determination criteria to manage the fishery for optimum yield, and allocates salmon among user groups. The PFMC management of coastal fisheries is an open process that begins in late February, after abundance estimates are released, and continues at March and April Council meetings and public hearings. Each year, the PFMC recommends season length, quota, and bag limits to NMFS based on the amount of salmon available for harvest under conservation reference points (PFMC 2016).

Puget Sound salmon fisheries are managed by the State of Washington and the treaty tribes. The state and tribal co-managers completed a multi-year fishery management framework for Puget Sound Chinook that NMFS is evaluating for consistency with the requirements of the ESA. Each year the state and tribal comanagers plan fisheries consistent with the conservation objectives described in the framework consistent with that year's forecast salmon abundance. Fisheries are managed to protect the weakest stocks which may result in foregone harvest on stronger stocks. The North of Falcon process is used to establish seasons for recreational and commercial fisheries in Washington's state waters, including Puget Sound. This is an open process involving federal, state, tribal, and industry representatives, as well as citizens.

In the past, fisheries exploitation rates were, in most cases, too high in light of the declining productivity of natural Chinook and coho salmon stocks. Over the last two decades, the co-managers implemented several strategies to manage fisheries to reduce harvest impacts and to implement harvest objectives that are consistent with the underlying production of the natural population. Time and area closures are implemented to reduce catches of weak stocks and to reduce Chinook and coho salmon bycatch in other fisheries. Other regulations, such as size limits, bag limits, and requirements for the use of barbless hooks in all recreational fisheries, are also used. The state and tribal fishery co-managers manage Chinook and coho salmon mortality in PFMC, Puget Sound salmon, and tribal steelhead net fisheries to meet the conservation and allocation objectives described in a series of jointly developed Puget Sound Chinook salmon harvest plans. These plans have been adopted sequentially as the harvest component of the Puget Sound Salmon Recovery Plan, which includes the Puget Sound Chinook salmon ESU.

Forty percent or more of the harvest of most Puget Sound Chinook salmon stocks occurs in salmon fisheries outside the action area and primarily in Canadian waters. These fisheries are managed under the terms of the Pacific Salmon Treaty Agreement. The effects of these fisheries were assessed in previous biological opinions (NMFS 2004a; 73 FR 7816, February 11, 2008).

Exploitation rates on Puget Sound spring Chinook salmon and fall Chinook salmon stock aggregates have each been less than 20% on average in recent years. In 2004, NMFS issued a biological opinion on the anticipated effects of PFMC fisheries on the listed Puget Sound Chinook salmon ESU for 2004 and future fishing years. The 2004 opinion found that exploitation rates in PFMC Area fisheries on Puget Sound spring and fall Chinook salmon populations of 3% and 6%, respectively, would not jeopardize the species (NMFS 2004a).

The exploitation rate on Lower Columbia River tule Chinook salmon in PFMC salmon fisheries averaged 13% from 2001 to 2010 (NMFS 2012a), accounting for 31% of the total exploitation that occurred in all fisheries over this time period. NMFS completed a biological opinion on PFMC fisheries for the Lower Columbia River Chinook salmon ESU in 2012. That biological opinion allowed for take based on an abundance-based framework for tules resulting in exploitation rates between 30% and 41% (including impacts in Columbia in-river fisheries) and ocean exploitation rates consistent with achieving escapement goal objectives for spring (0% to 28%) and bright stocks (1% to 11%).

The exploitation rate on Lower Columbia River coho salmon in PFMC salmon fisheries averaged 15%, with a range of 7%–24% between 2005 and 2016 (PFMC 2016). Management objectives for Lower Columbia River natural coho must not exceed a coastwide marine and mainstem Columbia River exploitation rate of 18%. Management objectives for Snake River fall Chinook include a reduction of at least 30% in the total ocean age-3 and age-4 adult equivalent exploitation rate from the 1988–1993 average. The 2016 preseason Snake River Fall Index projection was 40.9%; the postseason estimate was not available (PFMC 2016).

Groundfish Fisheries

In 2017, NMFS evaluated the impacts of the Pacific Coast Groundfish Fishery Management Plan on listed salmon (NMFS 2017b, consultation number 2017-7552). The bycatch of salmon in these fisheries is limited primarily to Chinook salmon with relatively few individuals from other species caught each year. The bycatch of Chinook salmon dropped steadily from a high of over 18,000 in 2002 to less than 2000 in 2004 (NMFS 2017d). Over the last 10 years, the fishery has taken an average of 7,032 Chinook salmon per year as bycatch across all sectors, with a low of 3,156 in 2020 (due to COVID-19 impacts on fishing) and a high of 15,262 in 2014 (Figure 35) (also see Table 1 from Matson et al. [2022]). Bycatch consists of primarily subadult Chinook salmon taken annually in the groundfish fisheries. The effects on ESA-listed Chinook salmon ESUs most likely to be subject to measurable impacts (SRFC salmon, LCR Chinook salmon, and UWR Chinook salmon) were very low (NMFS 2017d).

Although listed and unlisted ESUs contribute to bycatch, the major contributors to Chinook salmon bycatch in the at-sea sector were from unlisted ESUs. They contributed, on average, Klamath/Trinity Chinook salmon (28%) followed by southern Oregon/northern California (25%), Oregon Coast (10%), and northern British Columbia (11%) Chinook salmon (NMFS 2017b). Samples from Chinook salmon bycatch in the shore side whiting sector showed a contribution from Central Valley Chinook salmon (13%), similar to the Oregon Coast and very low contribution from British Columbia Chinook salmon (NMFS 2017d). The remainder of stocks which included contributions from listed ESUs contributed 5% or less of the Chinook salmon bycatch in either fleet on average. In general, the shore side fishery is focused closer to shore. It does not extend as far south as the at-sea fishery (NMFS 2017d).

The results demonstrate a strong regional pattern in contribution of Chinook salmon ESUs, with a greater proportion of southern Chinook salmon ESUs as bycatch when the fleets move south along the coast and similar patterns in the distribution of those salmon between the at-sea and shore side fleets. Samples from years when fisheries had more southerly distribution include more southern ESUs and vice versa. Moreover, some ESUs fit this pattern more closely than others (e.g., Puget Sound, Central Valley) due to different migration patterns (tending to migrate differentially north or south). Catches further north included Columbia River and increasing percentages of Puget Sound and Fraser River Chinook salmon.

These low contribution rates to bycatch from the listed Chinook salmon ESUs (i.e., 5% or less) are consistent with the previous qualitative characterizations of likely bycatch levels described by NMFS in its most recent opinion on west coast groundfish fisheries (NMFS 2017d). These genetic sampling results provide more specific information regarding the stock composition of the Chinook salmon bycatch in the whiting fishery, but the results support the more qualitative expectations in the 2006 supplemental opinion that impacts on listed ESUs are very low; i.e., less than 1% mortality per year for the most affected ESUs (NMFS 2017d).

Estimated annual bycatch of LCR coho in the PFMC groundfish fisheries across all sectors is low at just under 50 fish per year with an estimated exploitation rate of under one percent (NMFS 2017b).

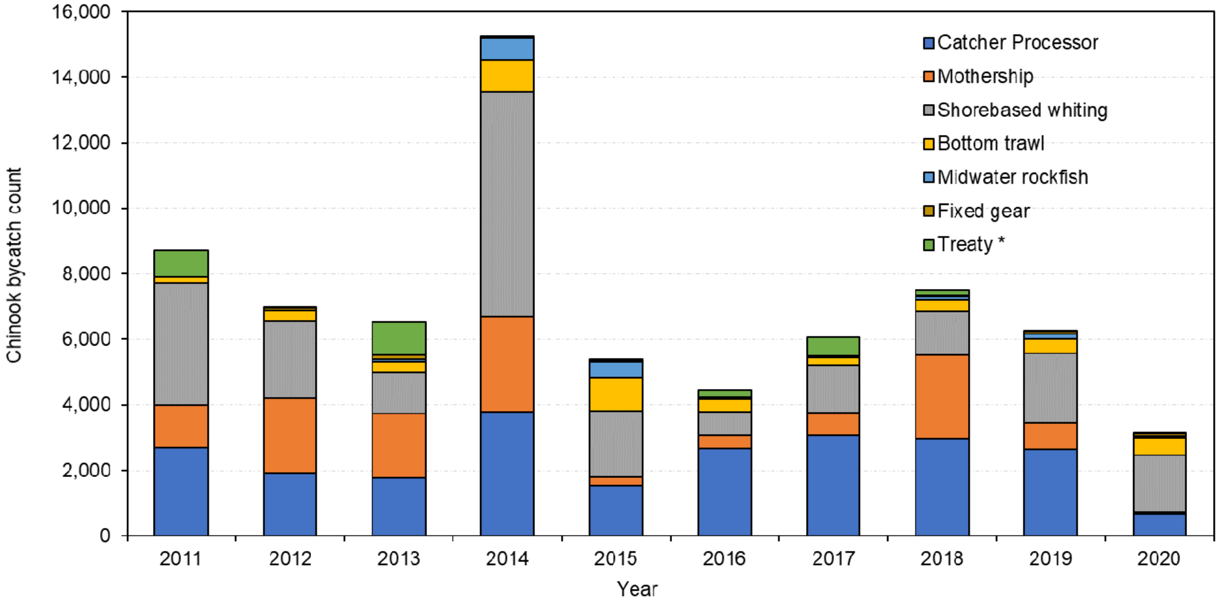


Figure 35. Chinook salmon bycatch in groundfish fisheries from 2011 to 2020, with annual distribution among sectors. Figure from Matson et al. (2022), recreated from Matson and Hooper 2021. *Treaty bycatch from 2011 to 2015 includes whiting only (bottom trawl values were unavailable during that period), and from 2016 forward includes whiting plus bottom trawl.

2.5. Effects of the Proposed 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 (see 50 CFR 402.02). 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 the factors set forth in 50 CFR 402.17(a) and (b).

2.5.1. Puget Sound/Georgia Basin Rockfish

We first assess the general effects of proposed recreational and commercial halibut fisheries, and the IPHC survey used to manage halibut populations, on individual yelloweye rockfish and bocaccio that are encountered, killed, or injured. Next, we assess the population-level effects of each fishery. We then assess the potential habitat and prey effects of the recreational and commercial fisheries targeting halibut in the U.S. portion of the Puget Sound/Georgia Basin. We analyze direct effects on listed rockfish in two steps: first, we estimate the number of listed rockfish likely caught in the fisheries and assess both the sublethal and lethal effects on individuals; then we consider the consequences of those sublethal and lethal effects at the population level. We analyze indirect effects by considering the potential effects of fishing activities on benthic habitats and the availability of prey resources for listed rockfish. Throughout, we identify data gaps and uncertainties, and explain how we base assumptions in our analysis on the best available science.

The halibut fisheries does not occur in the South Sound, in Hood Canal, and some of the Main Basin. As such, we assess the effects of the fishery in portions of the Main Basin, the eastern Strait of Juan de Fuca, and the San Juan Islands.

2.5.1.1. Effects from Recreational Halibut Fishing in Puget Sound

Anglers targeting halibut use lures and bait that may also catch yelloweye rockfish and bocaccio. Historically, many anglers would simultaneously target halibut and rockfish (Olander 1991). In recent years, a number of recreational anglers have begun to anchor their boats while halibut fishing. While anchored, they typically put down a chum-bag to attract halibut to their bait/jigs. Anglers typically anchor in areas with less bottom structure and rocky habitat to avoid losing the anchor. Because the retention of rockfish is no longer allowed per WDFW regulations, anglers cannot target rockfish, but nonetheless unintentionally hook them. In order to reduce impacts from barotrauma (see below), recreational anglers targeting halibut and bottom fish are now required by state regulation to have a descending device onboard, rigged, and ready to return rockfish to depth. Use of descending devices, however, is not tightly regulated or monitored. While WDFW regulations for anglers targeting bottomfish (such as lingcod) do not allow fishing in waters deeper than 120 feet (36.6 m) (where subadult and adult listed rockfish are most likely to reside), this regulation does not apply to anglers targeting halibut. The halibut regulations do include a prohibition on barbed hooks and limit terminal tackle to two individual hooks (no treble hooks). Each measure reduces injury to ESA-listed rockfish by reducing soft-tissue damage and the time needed to release fish from the hook. Capturing (and handling) fish on hook-and-line causes them injury and physiological stress, and can kill them. In some cases, individual fish can recover fairly rapidly and be released alive without the use of a descending device.

For rockfish caught in waters deeper than 60 feet (18.3 m), the primary cause of injury and death is barotrauma. Barotrauma occurs when rockfish are brought up from depth and the rapid decompression causes over-inflation and/or rupture of the swim bladder. This, in turn, can result in a wide array of injuries, including organ torsion, stomach eversion, exophthalmia (bulging eyes), capillary rupture, and other damages (Parker et al. 2006; Jarvis and Lowe 2008; Pribyl et al. 2011; Rankin et al. 2017; Wegner et al. 2021). These injuries cause various levels of disorientation, which can result in fish remaining at the surface after they are released and making them subject to predation, damage from solar radiation, and gas embolisms (Hannah and Matteson 2007; Palsson et al. 2009). Injuries can include harm from differences in water pressure experienced by fish brought to the surface from depths (barotraumas), differences in water temperatures (between the sea and surface), and hypoxia upon exposure to air. The severity of these injuries is dictated by the amount of time fish are held out of the water and their general treatment while aboard. Physical trauma may lead to predation after fish are released (Palsson et al. 2009; Pribyl et al. 2011). For yelloweye rockfish, the physiological and behavioral impacts from barotrauma last at least several days to weeks, impairing predator avoidance and potentially affecting reproductive activities (Rankin et al. 2017).

A number of devices have been invented and used to return rockfish to the depth of their capture as a means to mitigate barotrauma. Collectively these are referred to as recompression devices or descending devices. When rockfish are released at depth, there are many variables that may influence long-term survival, such as angler experience and handling time in addition to thermal shock and depth of capture (Schroeder and Love 2002; Jarvis and Lowe 2008; Pribyl et al. 2009; Pribyl et al. 2011; Rankin et al. 2017; Wenger et al. 2021). A study of yelloweye rockfish found that when they are caught in the hook-and-line fishery and released at the surface, the mortality rate is high; however, when they are released with a decompression device, survival may be high (Hochalter and Reed 2011). Another study demonstrated that rosy rockfish (*Sebastes rosaceus*) with barotrauma-induced exophthalmia (bulging eyes) and recompressed in a controlled chamber showed improved visual function after 4 days and further improvement at 1 month (Rogers et al. 2011). A recent study found that short-term (48 hours) survival for recompressed yelloweye rockfish was 95.1%, while 77.8% of canary rockfish survived when caught in less than 100 m (Figure 1 *in* Hannah et al. 2014). The PFMC Groundfish Management Team also estimated mortality rates reflecting release with descending devices for cowcod, canary, and yelloweye rockfish management (PFMC 2014) that follows initial estimates of surface mortality created by developing a generalized linear model of the proportion of fish released dead by depth and by species based on information from observer program data (PFMC 2008). The 2014 rates accounted for reduced mortality as a result of being rapidly returned to depth, mitigating barotrauma, sun exposure, and surface predation-related mortality. The estimation method incorporated short-term mortality rates from cage studies and longer-term mortality rates from acoustic tagging studies. The mortality estimates and associated confidence intervals in each depth bin were estimated using a Bayesian Hierarchical Method, which accounted for variation between species and the sample size of each species using data from the latitude of the focal species (PFMC 2014). The report did not include discard mortality rates for bocaccio. Thus, only the discard mortality rates for yelloweye rockfish are reported below (Table 42).

Table 42. Bayesian Hierarchical Method: Total discard mortality (%) estimates by depth bin for yelloweye rockfish at the surface, and reflecting the use of descending devices incorporating short-term mortality, long-term mortality, unaccounted for mortality, and upper 60, 75, 90, and 95 percent confidence intervals as precautionary buffers for uncertainty (Source PFMC 2014).

Depth (fm)	Current Surface Mortality	Mortality w/ Descending Device	Estimate w/ 60% CI	Estimate w/ 75% CI	Estimate w/ 90% CI	Estimate w/ 95% CI
0–10	22%	22%[1]	22%[1]	22%[1]	22%[1]	22%[1]
10–20	39%	22%	23%	24%	26%	27%
20–30	56%	22%	23%	24%	24%	27%
30–50	100%	23%	24%	25%	27%	28%
50–100	100%	35%	39%	45%	57%	65%
>100	100%	100%	100%	100%	100%	100%

[1] The value reflects surface mortality because mortality estimates for descending devices are not expected to exceed surface release.

Despite the myriad potential impacts of barotrauma, female yelloweye rockfish can remain reproductively viable after recompression (Blain 2014; Wegner et al. 2021). A study conducted in Alaska found that fifteen recompressed female yelloweye rockfish remained reproductively viable 1 to 2 years after the event (Blain 2014). Blain (2014) also found no evidence that embryo quality was adversely affected 1 to 2 years after the recompression event in the study. A female yelloweye rockfish caught by the WDFW in Hood Canal and tagged with an external dart tag was later sighted with an ROV. Capture and sighting were 5 months apart, and the individual was not gravid at capture but was carrying a full brood when resighted (Dayv Lowry, NOAA Fisheries, pers. comm.).

The WDFW has estimated that anglers targeting halibut catch some yelloweye rockfish, but no bocaccio have been reported in recent years (Table 43). There are a number of uncertainties regarding WDFW recreational fishing bycatch estimates because: (1) they are based on dockside interviews of a subset of anglers; (2) anglers whose trips originated from a marina or private dock are typically not surveyed at public docks; and (3) identification of rockfish to species is poor, with only 5% and 31% of anglers able to correctly identify bocaccio and yelloweye, respectively (Sawchuck 2012).

Table 43. WDFW estimates of yelloweye rockfish and bocaccio caught in the recreational halibut fishery in 2017. No yelloweye or bocaccio rockfish were caught from 2018 through 2021, and only one yelloweye rockfish was caught in 2022.

Species	Projected Annual Catch for Recreational Halibut Fishery	Percent of DPS
Yelloweye rockfish	82 (range 0 to 82)	<0.0001
Bocaccio	0	0

We do not know the average depth of listed rockfish caught in the halibut fishery, though it is likely that many anglers target halibut in waters from 100 to 400 feet (30.5 to 121.9 m) of water (Olander 1991). For the purposes of estimating mortality rates, we assume that the average depth of caught and released listed rockfish is 300 feet (91.4 m). Estimated mortality based on the 95% confidence interval of released yelloweye rockfish from this depth is 28% (PFMC 2014). WDFW estimates for listed rockfish bycatch from anglers targeting halibut are typically low relative to fishermen targeting salmon or bottomfish. This is likely because the halibut season is short compared to these other fisheries and because, as discussed below, many adult listed rockfish have already been removed from the population. The popularity of anchoring while targeting halibut may reduce rockfish encounters because anglers typically avoid rocky habitats when fishing on the anchor, thus they may also avoid prime habitats occupied by adult yelloweye rockfish and bocaccio. If the 2017 estimate of maximum fishery catch of 82 yelloweye rockfish occurred in the recreational halibut fishery, it would have a moderate impact on their abundance and a proportionally similar impact on yelloweye rockfish productivity, spatial structure, or diversity, particularly because only 28% (23 individuals) of these fish are projected to be mortalities.

2.5.1.2. Effects from Tribal Halibut Fishery in Puget Sound and the IPHC Fishery Independent Setline Survey

The IPHC Fishery Independent Setline Survey (FISS) included waters of Puget Sound and the Strait of Juan de Fuca in 2011, 2014, 2017, and 2018. The IPHC does not have plans in the near future to extend the FISS into Puget Sound at this time; however, these stations could be included in the future. The FISS would have similar bycatch risk and habitat effects as the commercial fishery discussed below, with the caveat that it is of much lower intensity (around 13 sets with 6 skates) compared to the commercial fishery. As such, we include the effects of the FISS in the following analysis of the commercial fishery in Puget Sound.

As described in the Proposed Action, gear used in the commercial fisheries includes:

- Hook-and-line (rod and reel, no more than two hooks)
- Hand line (no more than two hooks)
- Longline (snap gear only)
- Bottom troll (no more than six lines)

Effects on individual listed rockfish from being caught on commercial halibut gear would be virtually the same as described above in the recreational fishery. However, fish caught on longline gear would be hooked and suspended near the seafloor for minutes to hours; thus, effects would be more severe and some fish are likely harmed or killed by predators, such as dogfish, sixgill sharks, harbor seals, and sea lions (James 2016).

We do not know several gear and catch characteristics of the commercial halibut fishery in Puget Sound, including:

- The average number of hooks per skate
- The average number of skates per set
- The number of sets per landing
- The proportion of gear types used (i.e., rod/reel, hand line, longline, bottom troll)

The NWIFC has provided reports of listed rockfish caught in the commercial halibut fishery for 2014, 2015, 2016, and 2017. The Lummi Nation also provided eight yelloweye rockfish and several biological samples from additional yelloweye rockfish to NMFS from the 2016 and 2017 fishery. There is some uncertainty regarding the record keeping of the non-halibut catch in the tribal halibut fishery in Puget Sound. The NWIFC reported a total of 31 yelloweye rockfish and no bocaccio caught in the commercial fishery over 3 years (James 2016), but have also noted tribal concern about the potential uses of rockfish catch information. The tribes have not provided the precise location or gear used in the fishery, and therefore it is challenging to estimate the total catch of listed rockfish in future seasons.

In order to conduct this analysis, we assumed that the dominant gear used in the tribal commercial fisheries is longlines because they are much more efficient and generally result in greater catch per effort compared to all other gear types. As described in the Proposed Action, we presumed that 100 hooks are used per skate (which is the typical industry standard); that 4, 6, or 8 skates are used per set; and that 2–3 sets contribute to each landing. These are the same assumptions used for the 2014 and 2017 fishery analysis (NMFS 2014; NMFS 2017a) and represent a conservative, and consistent, assessment method.

In the absence of sufficient data on listed rockfish bycatch in the tribal fishery at issue, we considered data from nearby commercial halibut fisheries and past state fisheries with similar fishery characteristics. In order to understand the potential bycatch of listed rockfish, we assess available data on the average catch per skate from longline research reports published by Fisheries and Oceans Canada, some of which are developed in coordination with the IPHC. These information sources come from research and fisheries using longlines from inside (mostly waters in Canada) and outside of the range of the DPSs. Table 44 summarizes available data on the average number of yelloweye rockfish and bocaccio per skate from research outside the DPSs' range.

Table 44. Data on yelloweye rockfish and bocaccio from outside the area of the DPSs.

Type of Survey and Source	**Yelloweye** fish per skate (year)	**Bocaccio** fish per skate	**Location**
Halibut standardized stock assessment data. COSEWIC 2008.	2.25 (1995) 1.06 (2003) 1.32 (2004)	Not reported	B.C. coastal waters (outside of the DPSs).
Halibut standardized stock assessment. Obradovich et al. 2008.	0.683	0.011	From PSMC area grouping 3C/D, 5A
Halibut standardized stock assessment. Yamanaka et al. 2008.	0.716	0.012	From PSMC area grouping 3C/D, 5A
Halibut standardized stock assessment. Yamanaka et al. 2007.	0.774	0.005	From West Coast Vancouver Island region.
Halibut standardized stock assessment. Lochead et al. 2006.	0.782	0.005	From West Coast Vancouver Island region.
Standardized stock assessment. Fleming et al. 2010.	1.715	0.245	From PSMC area grouping 3C/D, 5A
Halibut stock assessment survey. Yamanaka et al. 2004.	0.42	0.0	West Coast Vancouver Island

Available data from outside the DPSs' range show that yelloweye rockfish were caught from an average of 0.716 to 2.25 fish per skate and bocaccio from an average of 0.0 to 0.245 fish per skate. The data from the west coast of Vancouver Island may not be directly analogous to the risk of catch inside the Puget Sound/Georgia Basin DPSs because the abundance and population characteristics of each species differ (Drake et al. 2010). As such, we then assessed available data from within the range of the DPSs to understand the risk of bycatch from longline fisheries. Most of this recent information is from waters in the Canadian portion of the DPSs (i.e., from the Strait of Georgia and Johnstone Strait).

Non-tribal commercial longline (or set line) fisheries in Puget Sound were closed by the WDFW in 2010 to protect rockfish. Data from the past non-tribal set line fisheries within the range of the DPSs show that yelloweye rockfish and bocaccio have been caught in the North Puget Sound area that overlaps the contemporary halibut fishery (waters of the San Juan Islands and Strait of Juan de Fuca area) (Table 45) (Palsson et al. 2009).

Table 45. Proportion of yelloweye rockfish and bocaccio in the total rockfish catch for past set line fisheries in the North Puget Sound. Table created from data in Palsson et al. (2009).

	1970–1987	**1988**	**1989**	**1990**	**1991–1992**	**1993–2003**
Yelloweye	28%	49.8%	72.5%	83.4%	91.9%	48.8%
Bocaccio	2.8%	0.0%	0.0%	0.0%	0.0%	0.0%

Data from set line fisheries in the North Sound show that bocaccio were undocumented as catch after 1988 and yelloweye rockfish were a large component of the rockfish catch in each time period. However, the data presented in Palsson et al. (2009) are not directly analogous to the contemporary commercial halibut fishery because the set line fisheries targeted other species, such as dogfish and rockfish, and may have used different baits and fished in different habitat types, all of which may have influenced the catch rate of yelloweye rockfish and bocaccio. In addition, the composition of rockfish catch from the set line fishery may not be directly analogous to the present-day commercial halibut fishery because listed rockfish have been depleted, making them proportionally rarer compared to non-listed species, and their size structure has been truncated, resulting in lower hook selectivity for the remaining small fish (Drake et al. 2010). We cannot calculate the catch rates of fish per skate from the data summarized in Palsson et al. (2009), and no more contemporary data are available to update this analysis.

Most of the remaining data from within the range of the DPSs comes from longline research and fisheries on the inside of Vancouver Island. Some of these surveys were inshore rockfish population assessments, while others were halibut stock assessment surveys. Most of these research reports provide catch-per-skate for yelloweye rockfish and bocaccio (summarized in Table 46).

Table 46. Longline research and fisheries data from the inside of Vancouver Island (Canada).

Type of Survey and Source	Yelloweye	Bocaccio	Location
DFO inshore rockfish longline surveys. (Lochead and Yamanaka 2007)	2.3792 (kg/skate) Converted to 1.191 fish per 100-hook skate.	0.0 (kg/skate)	Inside waters of Vancouver Island[a]
DFO inshore rockfish longline surveys. (Lochead and Yamanaka 2006)	2.8411(kg/skate) Converted to 0.52 fish per 100 hook skate.	0.0 (kg/skate)	Central and North inside Vancouver Island[a] (DFO areas 12 and 13)
DFO inshore rockfish longline surveys. (Lochead and Yamanaka 2004)	2.7761 (kg/skate) Converted to 1.08 fish per 100 hook skate.	0.0 (kg/skate)	Central and North inside Vancouver Island[a] (DFO areas 12 and 13)
Halibut standardized stock assessment (FISS). (IPHC 2011)	0.0 fish per skate	0.0 fish per skate	Puget Sound
Halibut standardized stock assessment (FISS). (IPHC 2014)	0.0 fish per skate	0.0 fish per skate	Puget Sound
Dogfish longline survey. (King and McFarlane 2009)	Converted to 0.23 fish per 100 hook skate	0.0 fish per skate	Inside of Vancouver Island
Dogfish longline survey. (King et al. 2012)	Converted to 0.12 fish per 100 hook skate	0.0 fish per skate	Inside of Vancouver Island

[a] Some data from outside the DPSs' geographic range

Available data from research in the Canadian portions of the DPSs show that yelloweye rockfish were caught from 0.23 to 1.191 fish per skate and bocaccio were not caught. In 2011, 2014, and 2017 the IPHC expanded their FISS into the Puget Sound/Georgia Basin DPSs. They fished 13-14 stations within the U.S. portion of the DPSs and 2 stations just to the west of the DPSs' border (near Port Angeles). Each station was fished with standardized gear (1,800 feet of groundline, 100 hooks) with a minimum 5-hour soak time. No rockfish of any species were caught within this survey in 2011 and 2014 (Dykstra 2011, 2014), and one yelloweye rockfish was caught at a station near San Juan Island in 2017 (Geernaert 2017).

Of the reports summarized in Table 46, the inshore rockfish surveys conducted by the DFO in 2005 (Lochead and Yamanaka 2007) and the 2011 IPHC survey provide the most spatial coverage for waters inside the DPSs and provide data closest to the waters fished by the tribal commercial longline fishery in U.S. waters. The goal of the 2005 survey conducted by DFO was to provide a relative index of abundance for inshore rockfish stocks (Lochead and Yamanaka 2007). The study used a depth-stratified random design to determine sampling locations. To ensure that rockfish habitat was sampled, the DFO used benthic habitat charts to determine if sampling blocks were located on flat, muddy, or sandy bottoms (where rockfish are unlikely to occur) and eliminated these sites for sampling. As such, the study preferentially selected rockfish habitat in close proximity to U.S. waters and thus provides a geographically close and conservative comparison for catch rates from longlines targeting halibut. For these reasons, we assess this data to elucidate a range of potential bycatch rates for waters within the U.S. portion of the DPSs.

Lochead and Yamanaka (2007) found that yelloweye rockfish were caught at greater rates further away from the international border. Yelloweye rockfish were caught at one station in DFO management regions along the international border (Areas 19, 18, and 29) (Lochead and Yamanaka 2007) (Figure 36). No bocaccio were caught in this survey.

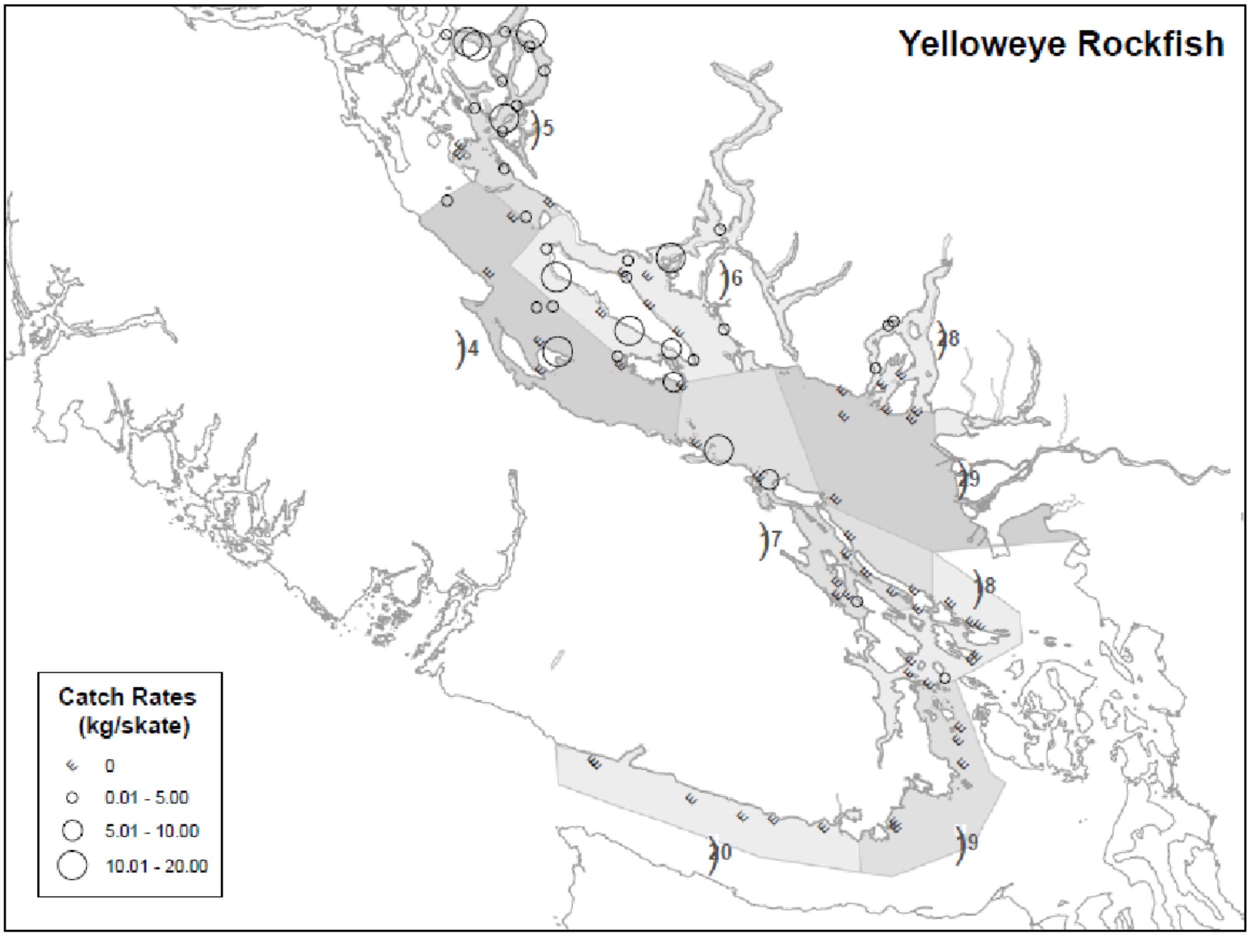


Figure 36. Catch of yelloweye rockfish in the DPS (from Lochead and Yamanaka 2007).

In order to determine a range of potential bycatch rates for proposed longline fisheries, we considered the data and catch rates summarized in Tables 45 and 46. We prioritized catch data that is closer in space and time to the U.S. halibut fishery in the rockfish DPSs because it serves as the best proxy to estimate bycatch rates in the proposed commercial longline fishery. As such, we further assessed the specific catch rates for Areas 18, 19, and 29 in the study by Lochead and Yamanaka (2007) because they are the closest to the halibut fisheries in the Proposed Action and consist of more sets (89) than used by the IPHC (11–12 where the halibut fishery occurs in Puget Sound area) in their 2011, 2014, and 2017 survey (Table 47).

Table 47. Catch rates for areas along the international border reported in Lochead and Yamanaka (2007).

Species/Area	**Total for Areas 18, 19, and 29 (along international border)**
Yelloweye	Converted to 0.0313 fish per skate
Bocaccio	0.0

Yelloweye Rockfish Bycatch Estimates

To estimate potential bycatch rates for yelloweye rockfish in the tribal/commercial longline fishery in the Puget Sound region, we used the following data and assumptions:

- We used catch-per-skate in Areas 18, 19, and 29 (all along the international border), data summarized in Table 48, to estimate potential bycatch for yelloweye rockfish.
- To determine this range of catch, we assessed the low (443), average (527), and high (569) annual landings that have occurred for each DPS over the past several years (see Section 1.3, Proposed Federal Action).
- Two to three sets were used per each landing (see Section 1.2, Consultation History).
- Four, six, or eight skates were used for each set (see Section 1.2, Consultation History).
- All catch was assumed to result in mortality, as a cautionary approach.

Table 48. Yelloweye rockfish bycatch estimates for the proposed tribal/commercial halibut fishery.

Species	**Low Estimate**[a]	**Medium Estimate**[b]	**High Estimate**[c]	**Abundance Scenario**[d]	**Percent of DPS killed (low estimate)**	**Percent of DPS killed (medium estimate)**	**Percent of DPS killed (high estimate)**
Yelloweye Rockfish	111	247	427	143,086	0.08	0.17	0.3

[a] The low range estimate uses catch data from areas along the international border reported in Lochead and Yamanaka (2007), the low number of landings (501), the low number of sets (2), and the low number of skates (4) used in Puget Sound.

[b] The medium range estimate uses the same catch data from areas along the international border reported in Lochead and Yamanaka (2007), the average number of landings (534), the average number of sets (2.5), and the average number of skates (6) used in Puget Sound.

[c] The high range estimate uses the same catch data from areas along the international border reported in Lochead and Yamanaka (2007), the high number of landings (550), the high number of sets (3), and the high number of skates (8) used in Puget Sound.

[d] This Abundance scenario is derived from the combined WDFW ROV survey in the San Juan Islands in 2010, and the 2015 ROV survey in Puget Sound proper (described in Section 2.2, Analytical Approach). We use the lower confidence intervals reported in WDFW (2017). We chose the 2010 survey in the San Juan Islands because it occurred over a wider range of habitat-types than the 2008 survey.

Available data show yelloweye rockfish are a consistently caught species on longline research surveys on the inside waters (Table 46), and available information indicates they are caught at greater rates toward the northern portions of the inside waters of Vancouver Island (Table 46, Figures 36 and 37).

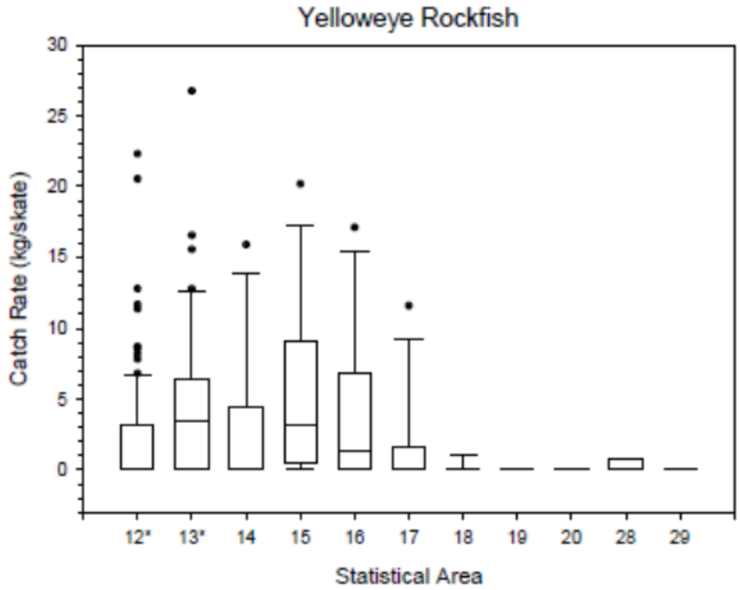


Figure 37. Yelloweye rockfish catch rate by statistical area on inside waters of Vancouver Island. Areas 18, 19, and 29 are along the international border (From Lochead and Yamanaka 2007).

Research surveys from near the international border (Lochead and Yamanaka 2007) and in Puget Sound (Claude Dykstra, IPHC, email to Dan Tonnes, NMFS, December 14, 2011 and June 2, 2014) show that yelloweye rockfish are rarely caught in recent times. Rare encounter rates may be the result of depressed population numbers in inside waters and because of the relative lack of older, bigger fish (Pacunski et al. 2013) that are typically more susceptible to hook-and-line catch. Periodic rockfish population surveys in various portions of the U.S. waters of the DPSs using a remotely operated vehicle (ROV) have also produced low encounter rates and low density estimates for all size classes of yelloweye rockfish since 2008 (Pacunski et al. 2013; 2020; Lowry et al. 2022). Yelloweye rockfish are primarily associated with the bottom, which makes them much more susceptible to longline baits compared to some other semi-pelagic rockfish species, such as bocaccio.

It is very likely that the actual catch of yelloweye rockfish in the commercial longline fishery in Puget Sound would be closer to, or even below, the low estimate and medium estimate (111 to 247 fish) than the high estimate (427 fish). As a rough point of comparison, the IPHC stock assessment surveys in Puget Sound (that overlap with the commercial halibut fishery) caught one yelloweye rockfish over three survey years, for an aggregate of 0.0049 fish per skate. If we use this fish-per-skate applied to the commercial halibut fishery, with the same assumptions as Table 48, it would lead to a low of 40, a medium of 62, to a high of 67 yelloweye rockfish caught per year. As such, we anticipate that catch of yelloweye rockfish by the proposed commercial fishing will not exceed the medium estimate of 247 fish annually. We presume that any fish caught in the commercial halibut fishery would be killed.

Bocaccio Bycatch Estimates

Available data show that bocaccio have not been caught on longline gear in research surveys in the inside waters of the DPS in recent times (Tables 46 and 47), and are caught at low levels in areas outside of the DPS, compared to many other rockfish species. This may be because population numbers are naturally lower within the DPS compared to coastal waters, population abundance is depressed in inside waters, and/or because of their life history. Bocaccio are semi-pelagic rockfish, meaning they can spend time suspended in the water column and also move long distances. These factors likely make them less susceptible to longline baits that are deployed at or very near the bottom. Bocaccio have only been encountered a handful of times in periodic ROV surveys of the DPS, most in the San Juan Islands (Pacunski et al. 2013; 2020; Lowry et al. 2022).

Of the six longline research studies we found for waters within the range of the DPS, no bocaccio were reported (Table 46), and available longline data for fisheries inside the DPS do not show bocaccio catch since the 1970s (Tables 45 and 47). For a conservative analysis, we can compare a bycatch scenario where bocaccio would be caught at the lowest reported rate (0.005 fish per skate) in coastal waters outside of the DPS' range (Table 44). Even if bocaccio were caught at this rate in the commercial longline fishery in Puget Sound, it would equate to a low estimate of 18, a medium estimate of 40, and a high estimate of 68 fish caught annually (using the same assumptions used to generate estimates in Table 48).

Given the lack of catches reported in Puget Sound by the IPHC (Claude Dykstra, IPHC, email to Dan Tonnes, NMFS, December 14, 2011 and June 2, 2014; https://www.iphc.int/data/fiss-data-query), recent set line data reported by Palsson et al. (2009), the lack of reported catches in the longline fishery over the past 3 years (James 2016), the lack of bocaccio catch in waters from the inside of Vancouver Island and Puget Sound (Tables 46 and 47), and ROV data demonstrating very low abundance and density, it is likely that the actual catch of bocaccio in the commercial longline fishery in Puget Sound would be closer to, or even below, the low estimate (18 fish) annually. We presume that any fish caught in the commercial fishery would be killed.

2.5.1.3. Fishery Effects on Listed Rockfish Population Demographics and Productivity

Longline fisheries predominantly catch larger and sexually mature rockfish (Obradovich et al. 2008; Flemming et al. 2010), and this dynamic is likely for recreationally caught rockfish. Yelloweye rockfish do not typically enter the longline fishery until they approach and exceed 12 inches (300 mm) (Figure 38) (Obradovich et al. 2008). Most bocaccio appear to enter the fishery from 16 to 24 inches long (400 to 600 mm) (Obradovich et al. 2008; Yamanaka et al. 2008; Flemming et al. 2010).

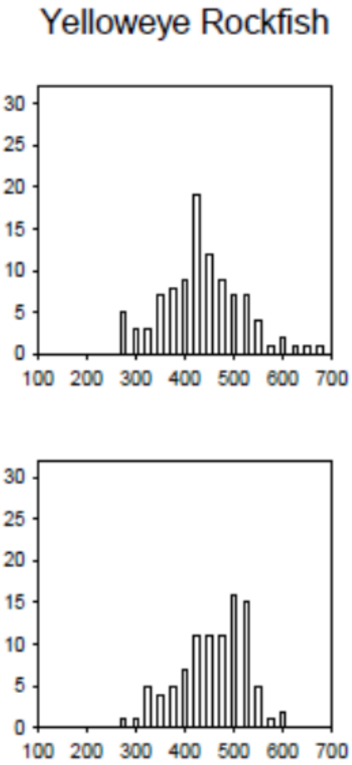


Figure 38. Yelloweye rockfish catch size distribution from longline catch in Lochead and Yamanaka (2007). The y axis is fish age and the x axis is length in millimeters. Top chart is for male, and bottom chart is for female, yelloweye rockfish.

It is probable that baits and hooks of longlines are too big for ingestion for rockfish smaller than 12 inches (300 mm). As a consequence, these fisheries remove older rockfish from the population. Longline-caught yelloweye rockfish range from about 10 years old to over 100 years old (Yamanaka et al. 2007; Obradovitch et al 2008) (Figure 39).

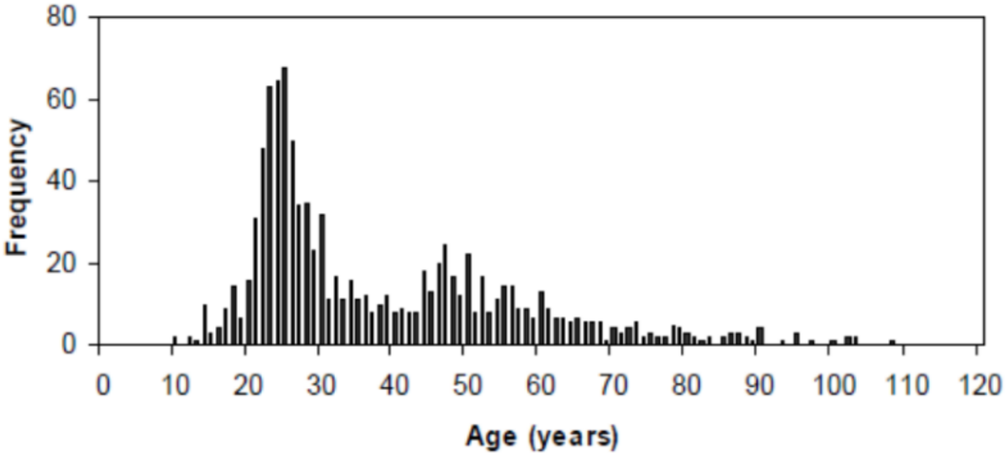


Figure 39. Age distribution of yelloweye rockfish longline catch (reported in Yamanaka et al. 2007). Data are for a total of 1,019 fish of mixed sex.

Any bocaccio that would be caught in the longline fishery would also likely be adults, given the lack of smaller fish documented in research surveys (Obradovich et al. 2008; Yamanaka et al. 2008; Flemming et al. 2010). Research fisheries have found zero to few sexually immature yelloweye rockfish and bocaccio within the catch (Obradovich et al. 2008; Yamanaka et al. 2008; Fleming et al. 2010). For example, Obradovich et al. (2008) found no sexually immature bocaccio, and only 0.9% of the yelloweye rockfish catch consisted of immature fish. The rest of each species were sexually "maturing" to "resting." Yamanaka et al. (2008) reported 0.8% of the yelloweye catch as sexually immature, while Lochead and Yamanaka (2007) reported 4.6% of the yelloweye catch as sexually immature. As such, the vast majority of fisheries bycatch from halibut fisheries are likely to be older and more productive yelloweye rockfish and bocaccio.

The removal of larger and older fish from the population would have a disproportionate impact on population productivity by reducing the total number of larvae released, and potentially affecting the timing of parturition and viability of individual larvae from smaller females. Yelloweye rockfish are a common proportion of longline catch (Tables 47 and 48), particularly in areas with maturing and mature fish (Obradovich et al. 2008; Yamanaka et al. 2008; Flemming et al. 2010) approaching sizes greater than 12 inches (300 mm). Thus, the impacts on yelloweye rockfish demographics and productivity would be more acute than on bocaccio.

Habitat Effects from Fisheries

The habitat effects of the Proposed Action are discussed generally here and additional analysis regarding habitat effects are located in Section 2.2, Rangewide Status of the Species and Critical Habitat, and Section 2.7, Integration and Synthesis.

Habitat Effects: Puget Sound Area

Hook-and-line gear used by the recreational halibut fishery, including jigs. weights, hooks, and anchors, has the potential to alter benthic habitats by snagging structure and being lost. However, there have been no observations of adverse effects in deepwater areas of the seafloor from lost recreational fishing gear in WDFW habitat surveys (Pacunski et al. 2013), and lost gear in the recreational halibut fishery would be on very small spatial scales. Cumulative impacts of gear loss over decades of fishing have not been evaluated, but observations of lost recreational fishing gear from rockfish habitat during ROV surveys are rare (Pacunski et al. 2013; 2020; Lowry et al. 2022).

Gear used in commercial halibut fisheries could result in adverse effects on some deepwater (greater than 98 feet [30 m]) areas. Alteration to bottom habitats from longline fisheries is likely small because the gear is limited in weight and area fished (Morgan and Chuenpagdee 2003). When hauling longlines, there is potential for the hooks to snag structural organisms such as sponges and thus move rocks and/or cause small areas of turbidity (Morgan and Chuenpagdee 2003). Longline gear that is lost can result in longer-term habitat alterations, though these would be expected to decrease over time as sediments and biota cover the lines. Some longlines can be snagged and lost on the sea floor and thus have the potential to alter habitat in localized areas. However, only five longlines have been documented in the extensive derelict gear surveys or removal efforts in Puget Sound (Kyle Antonelis, email to Dan Tonnes, NMFS, January 29, 2014, regarding derelict gear surveys and removal efforts), compared to over five thousand nets, and impacts from these lost nets have far greater ecological impact (Drinkwin et al. 2023).

2.5.2. Green Sturgeon

The proposed fishing may affect Southern DPS green sturgeon directly by capture in the fishing gear and removal and handling of those fish prior to release back into the water. The proposed fishing may also affect Southern DPS green sturgeon indirectly by reducing prey availability in marine waters. We analyzed the effects in three steps. First, we examined the overlap between the fishery and Southern DPS green sturgeon distribution. Next, we evaluated direct effects by estimating the number of Southern DPS green sturgeon that may be encountered and the mortalities expected annually from the proposed fishing, considering the effects at both the individual and population levels. Finally, we evaluated indirect effects by considering the potential effects of fishing activities on the availability of prey resources for green sturgeon. We identify data gaps and uncertainties, and describe how we based assumptions in our analysis on the best available science.

2.5.2.1. Degree of Spatial Overlap

The spatial extent of the proposed fishery overlaps with the Southern DPS green sturgeon's main migratory corridor (from Monterey Bay to Vancouver Island), potentiating incidental catch of the species in the fishery. Within this range, Southern DPS green sturgeon make multiple migrations throughout their lives to and from their natal spawning habitat in the California Central Valley to coastal bays and estuaries further up the coast, including Humboldt Bay in California, Coos Bay and Winchester Bay in Oregon, the Columbia River estuary, and Willapa Bay and Grays Harbor in Washington, as well as forays (less common) into Puget Sound (Moser and Lindley 2007; Lindley et al. 2008; Lindley et al. 2011). Further, Southern DPS green sturgeon have been found to move seasonally between the coastal bays and estuaries and the nearshore marine environment (Heironimus 2021b, as cited in NMFS 2021d). Thus, green sturgeon densities may be highest in marine waters adjacent to these coastal bays and estuaries. Green sturgeon typically occupy marine waters within the 110 meter (60 fm) depth contour, but can occur in deeper waters (Erickson and Hightower 2007).

The recreational fisheries have the highest degree of overlap with Southern DPS green sturgeon because the fisheries occur throughout the coastal waters from Puget Sound to northern California. The Washington treaty fisheries have the lowest degree of overlap, because they are restricted to Puget Sound and the area off the north coast of Washington to the waters off Grays Harbor. The non-treaty directed commercial fishery also has a low degree of overlap with Southern DPS green sturgeon. The IPHC FISS typically has a low degree of overlap with Southern DPS green sturgeon, but in some years the FISS would overlap; however, given the gear used it is unlikely that the FISS would catch green sturgeon. The non-treaty commercial fishery off Washington is not likely to encounter green sturgeon because the area within the 100-fm contour (where green sturgeon would most likely occur) is closed to commercial fishing because of the RCA. The PFMC took final action in March 2023 to recommend that NMFS extend the boundary of the non-trawl RCA to 75 fm from the Oregon–Washington border to 34°27' N lat. (southern California), with the goal that this be implemented by January 1, 2024. The non-trawl RCA closures limit the non-treaty commercial fishery in waters shoreward of the specified contours, or state waters, whichever is more seaward, thus limiting the overlap with

Southern DPS green sturgeon[18]. Although both commercial and recreational Pacific halibut fishing is allowed throughout the coast of California, fishing typically does not occur in waters south of Mendocino County, further limiting the spatial overlap with Southern DPS green sturgeon distribution.

2.5.2.2. Effects from Encounters with Fishing Gear

The proposed fishing may cause stress, injuries, and mortalities to Southern DPS green sturgeon from capture in fishing gear and associated handling. This analysis considers whether effects of capture and handling in the proposed fisheries may reduce the reproduction, numbers, or distribution of Southern DPS green sturgeon. We evaluated these effects based on the best scientific information available about past fishery interactions with green sturgeon.

Uncertainty exists regarding the historical number of green sturgeon captured in the Pacific halibut fisheries because consistent methods of monitoring green sturgeon catch varied by fishery sector and area. Monitoring has been the most consistent in the recreational fisheries. As described in the Environmental Baseline section of this opinion, observer data from the directed commercial fishery are available for the years 2018–2022 and show occasional encounters of one to three green sturgeon a year, with no green sturgeon encounters in most years. Prior to 2018, all of the documented encounters were in the recreational fishery; however, no green sturgeon were reported as bycatch in the recreational fishery between 2018 and 2022 and the directed commercial fishery reported one green sturgeon.

Data from the directed commercial fishery confirmed previous assumptions that, based on the gear types used (e.g., longline, troll, hook-and-line), the limited spatial overlap with green sturgeon, and the limited fishing seasons, the number of green sturgeon encounters are similar to or less than what has been recorded for the recreational fisheries (Richerson et al. 2022). This is consistent with available data from other fisheries using similar gear.

Given uncertainties in the available data, we made precautionary assumptions in our analysis to ensure the proposed fishing is not likely to jeopardize the continued existence of Southern DPS green sturgeon. We included in our analysis the maximum estimated number of green sturgeon encounters in the proposed fisheries between 2001 and 2022 (up to three green sturgeon per year) (Lynn Mattes, ODFW, email to Susan Wang and Sarah Williams, NMFS, and Daniel Erickson, ODFW, January 14, 2014, regarding Pacific halibut fisheries off Oregon and ODFW green sturgeon catch data; Lynn Mattes, ODFW, email to Katie Davis, NMFS, December November 22, 2022). Because biological information and tissue samples were not collected from the green sturgeon encountered in the fishery, we are not able to determine whether the fish were subadults or adults and whether they belonged to the Southern or Northern DPS. To be conservative, we assumed that all of the green sturgeon encountered per year would be subadult or adult Southern DPS green sturgeon. Therefore, the directed commercial, tribal, and recreational fisheries, and the IPHC FISS combined are expected to incidentally catch up to three Southern DPS green sturgeon subadults or adults per year.

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[18] https://www.webapps.nwfsc.noaa.gov/portal7/apps/MapSeries/index.html?appid=68756b4bec924a1ea6e7d293ebbeb5a1

The potential effects of this incidental catch include sublethal and/or lethal effects on individual fish. All of the green sturgeon bycatch records indicate that the fish were released alive. Based on this, we would expect most of the fish to be released alive and survive. These fish may experience sublethal effects, including stress and injury that may result in altered migratory behavior or altered growth and development. Capture and release in the fishery may disrupt the migration of adults on their spawning migration, resulting in a loss of spawning potential. We would also expect some portion of the fish to die because of delayed mortality after release. We do not have direct estimates of post-release mortality for these fisheries. The best available information is an estimated post-release mortality rate of 2.6% for hook-and-line gear, based on a white sturgeon study in the Fraser River (Robichaud et al. 2006). Doukakis et al. (2020) estimated an 18% post-release mortality rate during a 21-day post-release survival study in the California halibut trawl fishery. Although conditions may differ in marine waters and when using longline or troll gear, 2.6% is the best estimate for non-trawl gear available at this time. Based on an estimated 2.6% post-release mortality rate, we estimate that incidental catch in the proposed fisheries kills up to one Southern DPS green sturgeon per year (2.6% of up to three fish per year = 0.078 fish killed per year, rounded up to one fish per year).

To analyze the effects at the population level, we use Mora's (2016) and Mora et al. (2018) estimated population abundance of Southern DPS green sturgeon adults (2,106; 95 percent confidence interval [CI] = 1,246–2,966) and subadults (11,055; 95 percent CI = 6,540–15,571). Given these estimated abundances, the expected incidental take of Southern DPS green sturgeon in the proposed fishery would affect 0% to 0.24% of the adult population, with lethal take of 0 to 0.08 percent of the adult population, or affect 0% to 0.05% of the subadult population, with lethal take of 0% to 0.015% of the subadult population per year. Given past interactions with the fishery, we would expect no encounters with green sturgeon in most years. The high estimates represent conservative estimates given the highest estimated take per year (three fish encountered and one fish killed) and the lowest estimated adult and subadult abundances. As stated before, there is a level of uncertainty in the population abundance estimates, as well as in the estimated incidental catch per year. We do not expect the Proposed Action to further restrict the spatial structure or diversity of the species; however, the Proposed Action could reduce the abundance or productivity of individuals caught in the fishery. Given the low number of fish likely to be encountered per year, we would expect a minimal reduction in abundance and/or productivity for the Southern DPS green sturgeon population.

2.5.2.3. Effects on Prey Availability

We expect the proposed fishery to have low impacts on prey availability for Southern DPS green sturgeon. Green sturgeon are known to feed on small fish and benthic invertebrates in coastal estuaries and likely have similar prey species in marine waters. Although the proposed fishery overlaps with green sturgeon distribution and critical habitat, the fish species caught in the proposed fishery are not typical prey items for green sturgeon.

2.5.3. Chinook and Coho Salmon

The data used for this analysis encompasses the 2018 through 2022 time period for the ocean recreational, ocean commercial, and the Puget Sound recreational and commercial halibut fisheries to the extent data are available. This time period was chosen because the structure of the all-depth and shoreside fisheries, fishery agreements, establishment of Rockfish Conservation Areas, reduction in fishing days, and number of vessels in both the commercial and recreational halibut fisheries (Section 1.3, Proposed Federal Action), as well as the pattern of salmon bycatch, observer coverage, and regulation in these years, is expected to be reflective of the period under consideration in the biological opinion, because these aspects of the fishery are likely to remain similar for the foreseeable future. A new 10-year RMP for Puget Sound salmon fisheries should be completed for implementation beginning with the 2024 salmon fishing season and is expected to result in salmon seasons representative of this time frame as well.

As described above (Section 1.3, Proposed Federal Action), halibut are harvested in commercial, tribal, and recreational fisheries, and in the IPHC FISS. As detailed below, only the recreational halibut fishery impacts ESA-listed salmon (the salmon troll fishery that incidentally harvests halibut also impacts salmon; however, those impacts are not part of this proposed action); those impacts are limited to four ESUs and the magnitude of the impact is thought to be minimal. Pacific halibut fisheries pose low risk to ESA-listed salmon stocks. Any impact on water quality from vessels transiting critical habitat areas on their way to the fishing grounds would be very short-term and transitory in nature and minimal compared to the number of other vessels in the area (NMFS 2004b).

Between 2018 and 2022, 28 Chinook and 74 coho were encountered incidental to the recreational halibut fishery when salmon were not targeted (L. Mattes (ODFW), email to Heather Fitch, May 1, 2023 and L. Wargo (WDFW), email to Heather Fitch, May 6, 2023 and May 31, 2023, emails regarding salmon caught in the recreational halibut fishery). This is in part due to differences in the gear and fishing depth that is used to target salmon and halibut. Barbless hooks must be used when fishermen are targeting salmon. Larger circle or “J” hooks are most commonly used when fishing for halibut, as mentioned in more detail in Section 1.3.3, Gear Fished in the Halibut Fishery. As described in Section 1.3.3, there are no depth restrictions for the recreational fishery, but the gear is fished on or near the bottom to maximize harvest of halibut whereas salmon are a pelagic species generally found above 80 fathoms in the water column (OSU 2003).

Commercial halibut fisheries occur in Washington, Oregon, and California waters, generally as far south as Point Arena; most of the commercial fishery occurs in Oregon waters. Commercial halibut fishing rarely, if ever, affects salmon because of the depth of the halibut fishery and the size of the terminal tackle used. The commercial halibut fishery occurs in open waters up to 150 fathoms in depth; commercial halibut fishing gear is deployed on or near the seafloor as described in Section 1.3, Proposed Federal Action, because halibut are a benthic species spending most of their time on or near the substrate. As described previously, salmon are generally fished at 80 fathoms or less (OSU 2003). Chinook salmon, for example, are generally found above 40 fathoms (Healey 1991) and are a pelagic species living in the water column; thus, they are unlikely to interact with commercial halibut fishing gear. The commercial halibut fishery uses size 16/0 hooks, much larger than what is used to fish for salmon, which are typically 4/0 or 3/0 size hooks. The IPHC conducts stock assessment surveys using commercial gear in the same general and adjacent areas and depths as the commercial halibut fishery, and records all bycatch of non-halibut species. There are no records of salmon bycatch during the IPHC FISS in the action area (IPHC 2023). Collectively, the available information indicates that salmon are rarely, if ever, caught incidentally by commercial halibut gear. Since 2018, only one salmon has been reported in the non-tribal commercial halibut fishery (NMFS West Coast Region Observer Program, unpublished data from 2018 to 2022). Additionally, the directed commercial halibut fishery has only been open between 1 and 7 days each year since 2009, providing very little opportunity to interact with salmon. Therefore, we expect that salmon caught incidentally in the proposed commercial halibut fisheries will be a rare event.

The IPHC FISS occurs off the Washington and Oregon coasts in most years and occasionally the California coast and Washington inland marine waters. No salmon have been recorded during the IPHC FISS during the entire FISS time series (IPHC 2023).

The tribal commercial halibut fishery occurs off the Washington coast and in the U.S. waters of the Salish Sea (including the Strait of Juan de Fuca and Puget Sound in the area of the San Juan Islands); the season has historically been short in duration (typically less than 2 weeks) (Table 1-3). The tribal ceremonial and subsistence (C&S) fishery occurs in the same area and uses the same gear as the tribal commercial fishery. Although Table 3 indicates the fishery is open 365 days per year, C&S halibut fishing does not occur 365 days a year. Limited ceremonial fisheries are scheduled for specific occasions (e.g., funerals, community events) by tribal regulation, and subsistence fishing allows for the infrequent catch of halibut in fisheries targeted at other species during the year (J. Petersen, NWIFC, email to Katie Davis, December 7, 2022). Each tribe has slightly different regulations on what information is required on fish tickets; however, all landed catch (halibut and other species) is required to be reported on fish tickets. Catch that is not landed, considered to be minimal, is not required to be reported on tribal fish tickets (J. Petersen, NWIFC, email to Katie Davis, December 7, 2022). One unidentified salmon was recorded as bycatch in the 2012 tribal commercial fishery in Puget Sound (Sandy Zeiner, NWIFC Fisheries Biologist, email to Sarah Williams, NMFS, May 31, 2012, regarding season structure, effort, and salmon bycatch; Sandy Zeiner, NWIFC Fisheries Biologist, email to Susan Bishop, NMFS, March 5, 2014, regarding fishing depths of Puget Sound tribal halibut fisheries), but otherwise there is no reported incidental catch of salmon in the tribal fishery as of 2022 (Joe Petersen, NWIFC, email to Katie Davis, NMFS, December 7, 2022). Therefore, we do not expect that salmon will be caught incidentally in the proposed tribal halibut fisheries.

Recreational halibut fisheries occur in waters off Washington, Oregon, and northern California. Since 2009, the recreational halibut fisheries off Oregon and California have generally occurred coincident with open seasons for salmon managed under the Pacific Fishery Management Council's Pacific Coast Salmon Fishery Management Plan (M. Culver, WDFW Regional Director, letter to Frank Lockhart, NMFS, May 15, 2012; M. Culver, WDFW Regional Director, email to Susan Bishop, NMFS, February 13, 2014, regarding halibut fisheries in Washington waters; G. Kirchner, ODFW Section Manager, email to Susan Bishop, NMFS WCR, July 6, 2014, regarding salmon bycatch during halibut fisheries; S. Williams, ODFW Deputy Administrator, letter to Frank Lockhart, NMFS, June 21, 2012, regarding halibut fishery data request, Mercier 2020, Mercier 2021, Mercier 2022, Norton 2019, PFMC 2018, PFMC 2019, PFMC 2020, PFMC 2021, PFMC 2022, Shaw 2018. Salmon caught during coincident halibut/salmon openings are considered to be taken in the PFMC and Puget Sound salmon fisheries, are counted against any applicable salmon fishery quotas or other applicable management limits, and thus are evaluated as part of the proposed actions considered in biological opinions on those salmon fisheries. Salmon retention is prohibited when the salmon recreational season is closed. The biological opinions regarding the effects of the Pacific Coast

Salmon Fishery Management Plan on salmon ESUs are listed in Table 1. The limited recreational halibut fisheries that are open when the salmon fisheries are closed occur mostly on the Washington coast and in the Salish Sea (i.e., Puget Sound and the Strait of Juan de Fuca) in May and June and sometimes April in the Salish Sea. Salmon are encountered more often, but are unlikely to be discarded during August and September off the Washington and Oregon coasts because salmon fisheries are more likely to be open at that time concurrent with the recreational halibut fishery (these salmon are not part of this analysis because they are considered in other biological opinions). There is no record of salmon being encountered during the October halibut fishery (L. Mattes, ODFW Section Manager, email to H. Fitch, NMFS WCR, May 1, 2023), regarding salmon bycatch during halibut fisheries; L. Wargo, WDFW, email to H. Fitch, May 6, 2023, regarding salmon bycatch during halibut fisheries). As described below, of the ESA-listed species, only Chinook and coho salmon are encountered in recreational halibut fisheries (Table 49), and the only ESA-listed salmon ESUs that are expected to be adversely affected by these recreational halibut fisheries are Snake River fall Chinook salmon, Puget Sound Chinook salmon, Lower Columbia River Chinook salmon, and Lower Columbia River coho salmon.

Relatively few salmon are encountered during the recreational halibut fishery when salmon is otherwise closed. Ninety-one Chinook and 74 coho were encountered in the fishery between 2018 and 2022 (an average of 18 Chinook and 15 coho per year) which would include hatchery and wild fish returning to rivers in both southern British Columbia and along the southern U.S. west coast (Table 49). Retention is prohibited, so the fish are required to be released but a proportion die as a result of hooking or handling mortality. Fishing-related mortality of Chinook salmon in Puget Sound recreational halibut fisheries during the analysis period (2018–2022) was very low, ranging from 0.5 to 3 Chinook salmon per year, with an average of 1.4 fish per year (Table 51). The non-retention mortality of Chinook salmon in recreational halibut fisheries in coastal waters during the analysis period (2018–2022) ranged from 0 to 3 Chinook salmon per year, with an average of 1.0 fish per year. NMFS used the Fishery Regulation and Assessment model (FRAM) to estimate the likely stock composition and magnitude of ESA-listed Chinook salmon caught in the coastal and Puget Sound areas of the recreational halibut fishery. FRAM is the same model used to estimate stock-specific impacts in the salmon fishery. The estimated catch of ESA-listed Chinook salmon (hatchery and wild) was 0.1 Snake River fall Chinook salmon, 1.2 Puget Sound Chinook salmon, and 0.1 Lower Columbia River Chinook salmon per year (Table 51). The FRAM projected that there was an insignificant chance that the proposed halibut fishery would encounter Upper Willamette River Chinook salmon, at a rate of 0.04 fish per year. At this low encounter rate, it is highly unlikely that the proposed halibut fishery would encounter a fish from this ESU. Additionally, although all the fish in the affected ESUs are listed as threatened, the ESA protective 4(d) regulations for these species prohibit take only for natural-origin and hatchery-origin fish with an intact adipose fin (70 FR 37160, June 28, 2005). The intent of the regulation is to enable hatchery fish produced for harvest (adipose fin clipped) to be caught in the salmon fishery while providing protection for natural-origin salmon and hatchery-origin salmon produced for conservation (adipose fin intact). In the case of the Chinook salmon ESUs that are expected to be affected by the halibut fishery, ESA take prohibitions only apply to a low percentage of the salmon in the ESUs. For example, mark rates for Chinook salmon ranged from 57% to 82% in the Puget Sound salmon fishery and 50% to 56% in the ocean salmon fisheries from 2018 to 2022 (J. Carey, NMFS, email to S. Bishop regarding summaries of mark rates on Chinook salmon by Puget Sound and ocean salmon management area from 2018 to 2022, June 9, 2023). Thus, the catch in the proposed fishery of an ESA-listed Chinook salmon for which take has been prohibited is even lower than predicted by FRAM (0.1 to 0.2 Puget Sound, 0.02 to 0.21 Snake River fall Chinook, and 0.0 to 0.06 Lower Columbia River Chinook salmon per year). Given the very low level of impacts and annual variability in abundance among the co-mingled stocks, different populations within the ESUs would likely be affected each year and the effect on any single population would be small. Encounters are apportioned into stocks and ages using base-period FRAM exploitation rates and stock-specific abundance inputs, then the mortalities for those stock and age-specific encounters are calculated based on fishery-specific release mortality rates.

Coho are also encountered in the recreational halibut fisheries off of the Oregon and Washington coasts and in Puget Sound (Table 49). Non-retention mortality of coho salmon in Puget Sound recreational halibut fisheries during the analysis period (2018–2022) averaged 0.3 fish per year (ranging from 0 fish to 0.7 fish) (Table 50). The non-retention mortality of coho salmon in recreational halibut fisheries on the coast during the analysis period (2018–2022) ranged from 1 to 5 coho per year, with an average of 3 fish per year (Table 50). Based on the known distributions of ESA-listed coho, Lower Columbia River coho salmon is the ESU most likely to be found in the area, but they would be comingled with other non-listed coho salmon stocks from Puget Sound, the Washington coast, Canada, and the upper Columbia River. As described above for Chinook salmon, NMFS used FRAM to estimate the likely stock composition of the coho salmon caught in the recreational halibut fishery. The estimated catch of ESA-listed coho salmon (hatchery and wild) was 1 Lower Columbia River coho per year (Table 51). As stated above in the discussion of Chinook salmon, although all the fish in the Lower Columbia River coho salmon ESU are listed as threatened, the ESA protective 4(d) regulations for these species prohibit take only for natural-origin and hatchery-origin fish with an intact adipose fin (70 FR 37160, June 28, 2005). Mark rates for coho salmon in the ocean salmon recreational fishery off the Washington coast (2018–2022) ranged from a low of 12% to a high of 81% during the analysis period, depending on the time and location with mark rates during the times and locations most likely to encounter coho in the halibut fishery of well over 50% (Pacific Fishery Management Council Preseason Reports III for 2018, 2019, 2020, 2021, and 2022). Thus, the catch in the proposed fishery of an ESA-listed salmon for which take has been prohibited is even lower (0.01 to 1.10 unmarked Lower Columbia River coho salmon per year) (Table 51). Given the very low level of impacts and annual variability in abundance among the commingled stocks, different populations within the ESU may be affected each year and the effect on any single population would be negligible. Encounter and release estimates are converted into fishery-related mortalities using fishery-specific release mortality rates and an assumed dropoff mortality rate of 5%.

Table 49. Encounters of salmon (number of fish) by year and area in targeted coastal and Puget Sound recreational halibut fisheries. Does not include catch at times or areas when the marine salmon sport fisheries were open coincident with the halibut fishery. Data provided by WDFW and ODFW.

	Chinook			**Coho**		
Year	**Puget Sound**	**Ocean**	**Total**	**Puget Sound**	**Ocean**	**Total**
2018	4	7	11	0	8	8
2019	11	6	17	3	10	13
2020	22	0	22	6	24	30
2021	10	3	13	2	11	13
2022	5	23	28	0	10	10
Total	52	23	91	11	63	74
Annual Average	10	8	18	2	13	15

Table 50. Total mortality (caught and released) of salmon (number of fish) by year and area in targeted ocean and Puget Sound recreational halibut fisheries. Does not include catch at times or areas when the marine salmon sport fisheries were open coincident with the halibut fishery. Data provided by WDFW and ODFW.

	Chinook			**Coho**		
Year	**Puget Sound**	**Ocean**	**Total**	**Puget Sound**	Ocean	**Total**
2018	0.5	1	1	0	1	1
2019	1	1	2	0.4	3	3
2020	3	0	3	1	5	5
2021	1	0.4	2	0.2	2	2
2022	1	3	4	0	2	2
Total	7	5	12	1	13	14
Annual Average	1.4	1.0	2.4	0.26	2.6	3

Table 51. Proportion of estimated impacts on ESA-listed salmon.

ESU	FRAM estimated impacts (marked and unmarked fish)	Estimated impacts on unmarked fish
Puget Sound Chinook	1.2 fish per year	0.1–0.2 fish per year
Lower Columbia River Chinook	0.1 fish per year	0–0.06 fish per year
Snake River fall Chinook	0.1 fish per year	0.02–0.21 fish per year
Total Chinook	**1.4 fish per year**	**0.1–0.5 fish per year**
Lower Columbia River coho	1 fish per year	0.01–1.1 fish per year
Total Coho	**1 fish per year**	**0.01–1.1 fish per year**

2.5.4 Sunflower Sea Stars

The proposed action recreational fishery is not anticipated to noticeably affect sunflower sea stars. The directed fishery, IPHC FISS, and tribal commercial fishery may affect sunflower sea stars directly by capture with longline fishing gear, followed by removal and handling prior to release back into the water (Lowry et al. 2022). We analyzed the effects by examining overlap between the proposed action area and sunflower sea star distribution, and evaluated direct effects by estimating the number of sunflower sea stars that may be encountered annually during the proposed action. We identify data gaps and uncertainties, and describe how we based assumptions in our analysis on the best available science.

Sunflower sea stars occur throughout, and well beyond, the action area. Although sunflower sea stars are most abundant in waters between eastern Alaska and British Columbia, they are generally common from the Alaska Peninsula to Monterey, California. Since 2017, sunflower sea stars have been rare south of Cape Flattery, WA, but also experienced a sharp decline further north in Washington and in Washington inland marine waters (Gravem et al. 2021; Hamilton et al. 2021; Lowry et al. 2022). The portion of the stock from Cape Flattery, WA, south does not constitute a significant portion of the population. The portion of the stock in the Washington inland marine waters is likely a biologically significant source population. Sunflower sea stars dwell in the low intertidal and subtidal zones to a depth of 238 fathoms (435 m), are most commonly encountered at depths less than 13 fathoms (25 m), and are rare in waters deeper than 66 fathoms (120 m). This understanding of depth distribution is biased, however, by: (1) the preponderance of available data coming from SCUBA surveys in the nearshore and; (2) the tendency for fisheries-focused research efforts to report this non-target species in aggregate with other sea stars as "sea stars, unidentified."

2.5.4.1. Effects from Fisheries

Sunflower sea star bycatch has been documented in the IPHC FISS (IPHC 2023) but sunflower sea star bycatch has been known to go unreported or may be aggregated with other sea stars in commercial fisheries. Research is lacking on post-release condition; however, sunflower sea stars are capable of tolerating on-deck handling, as individuals can regenerate rays after autotomy and/or injury in nature (Lowry et al 2022). Handling-stress could exacerbate symptoms of sea star wasting syndrome (SSWS) or increase susceptibility to other sources of mortality, which would make handling a greater threat from the southern Washington coast down through California where abundance is extremely low due to SSWS. Bycatch in fisheries is considered a low-level concern compared to SSWS and impacts from global climate change. For the proposed action evaluated here, all catches are assumed to result in mortality in order to apply a cautious approach.

Effects from the Fishery Independent Setline Survey

The IPHC FISS is generally conducted in coastal waters of Area 2A from Washington into northern California and, in some years, has included Washington inland marine waters (2011, 2014, 2017, and 2018). The FISS standard depth ranges from 10 to 400 fathoms (18 to 731 m).

Sunflower sea stars have been recorded in the FISS since 2008, though they were likely encountered well prior to that, and were captured in 9 of the 14 years (no survey occurred in 2020; IPHC 2022) (Table 52). The annual average number of sunflower sea star interactions over the reporting period was 37, but this includes an unusually high encounter rate of 329 stars in 2014 that was nearly five times the next highest prevalence. What drove this anomaly is unknown, though it may have been connected to a marine heatwave that dominated the majority of the northeast Pacific Ocean from 2014-16, and progressively propagated into Puget Sound (Khangaonkar et al. 2021). Many of the sunflower sea stars encountered in 2014 came from shallow and/or inland waters of Puget Sound, with 132 caught in one survey set north of Protection Island in the Strait of Juan de Fuca (one survey set contains a set of six skates with 100 hooks per skate). Climate change projections indicate that marine heat waves will become more frequent and intense in coming years, potentially driving higher sunflower sea star encounter rates in nearshore waters, but this effect has not yet manifested. There were no sea stars encountered in the 2010, 2015, 2016, 2019, and 2021 surveys, and in 8 of the 14 years the number was 1 or 0 sea stars. Almost all sunflower sea star interactions (97%) occurred between 2011 and 2014, with five or fewer sunflower sea stars recorded in subsequent years. Since 2018, almost half (49%) of the sunflower sea star catch has occurred in Washington inland marine waters, which are not part of the standard FISS area but are surveyed occasionally (4 of the last 14 years). Since the sunflower sea star population sharply declined in 2017, the FISS survey has encountered an average of 0.5 sunflower sea stars annually. Unidentified starfish and sunflower sea stars have also been recorded in the FISS; however, if identification issues are occurring, it is not apparent in available data.

Due to the high variability of sunflower sea star catches, it is difficult to predict how many will be caught in future surveys. The incidental catch of sunflower sea stars during FISS surveys is expected to be low in most years, with the potential for high catches in years in which environmental or demographic drivers of sea star abundance increase encounter likelihood.

Given the prevalence of encounters in Washington's inland marine waters, years in which the survey extends into this region are also expected to correlate with higher catch. The expected catch of sunflower sea stars in the FISS survey is a long-term average of 14.5–37.0 per year, with the expectation that some years may greatly exceed that number but that most years' catch will be between 0 and 10 sunflower sea stars. Mortality rates as a consequence of interaction with longline gear, and associated handling, have not been established for sunflower sea stars. Mortalities of sunflower sea stars from causes other than sea star wasting syndrome are thought to be minimal compared to impacts of the syndrome itself (Lowry et al. 2022). Enhanced monitoring over the next several years will evaluate this assumption.

Table 52. Sunflower sea star catches in IPHC FISS surveys in number of individuals from 2008–2022 and estimated annual catch. Asterisks indicate years in which sampling occurred inside Puget Sound.

Year	Sunflower sea stars
2008	9
2009	1
2010	0
2011*	51
2012	50
2013	69
2014*	329
2015	0
2016	0
2017*	6
2018*	1
2019	0
2020	--
2021	0
2022	1
Average including rare high 2014 value	37
Average excluding rare high 2014 value	14.5

Effects from the Non-Tribal Commercial Fisheries

The non-tribal, directed commercial fishery occurs south of Point Chehalis, WA. Commercial fishing for halibut occurs at depths from 19 to 242 fathoms (35–443 m), with an average of 131 fathoms (239 m); whereas sunflower sea stars are most commonly encountered at depths less than 13 fathoms (25 m) and are apparently rare in waters deeper than 66 fathoms (120 m). Commercial gear is primarily bottom contact longline gear, with other gear types such as hand line, hook and line, and bottom troll also utilized.

Expanded bycatch data from the non-tribal, directed commercial fishery is available from 2018 through 2020 from observer sampling (K. Kent, personal communication, May 9, 2022). No sunflower sea stars were identified; however, unidentified sea stars were observed, with annual discards ranging from 2 to 746 lb (0.2 to 64 individuals based on Lowry et al. [2022] individual adult weight of 5 kg). Due to general uncertainty in identification and reporting of sunflower sea stars (Lowry et al. 2022), a portion of the unidentified sea star bycatch may have been sunflower sea stars. The IPHC FISS identified 42% of sea star catches as sunflower sea stars (IPHC 2023); based on that percent, approximately 0 to 27 unidentified sea stars annually sampled by observers may have been sunflower sea stars. Observer coverage began after the sunflower sea star population sharply declined, so bycatch of sunflower sea stars may have been higher prior to 2018.

Additional uncertainty in the non-tribal, directed commercial fishery bycatch estimates exist because it is unclear how many observed vessels assigned to directed halibut also targeted groundfish. In 2018 and 2019, between 85% and 93% of vessels fishing for halibut also landed groundfish, leaving potentially only 0 to 4 sunflower sea stars attributable to the non-tribal, directed commercial halibut fishery. However, since it’s possible that all of these observed vessels targeted only halibut, the maximum potential number of sunflower sea star bycatch is used in the estimate.

The estimated take of sunflower sea stars in the non-tribal, directed commercial halibut fishery may range from 0 to 27 annually if encounter rates are similar to those of the IPHC FISS (Table 53). Because the IPHC FISS experienced a high degree of variability in bycatch rates, there is potential that the non-tribal, directed commercial fishery would as well given the similarity in fishing practices. Therefore, there may also be the potential for up to 240 sunflower sea stars to be encountered in hotspot catches, proportional to hotspot catches in the FISS. Mortalities of sunflower sea stars from causes other than sea star wasting syndrome are thought to be minimal compared to impacts of the syndrome itself (Lowry et al. 2022). Enhanced monitoring over the next several years will evaluate this assumption.

Table 53. Estimated sunflower sea star bycatch in the directed commercial halibut fishery from 2018 to 2020, and estimated annual catch.

Year	Unidentified sea stars	Estimated sunflower sea stars
2018	0	0
2019	3	1
2020	64	27

Year	Unidentified sea stars	Estimated sunflower sea stars
Estimated annual take	--	0 to 27, with up to 240 due to hotspot catches

Note: Bycatch estimates for the sunflower sea star are based on observer reports of unidentified sea stars assuming the same encounter rate for sunflower sea stars proportional to all sea stars in the IPHC FISS. Hotspot estimates based on FISS hotspot catch in 2014, much of which came from a single station in the inland waters of Washington State.

Effects from the Tribal Commercial Fisheries

The Washington tribal fishery occurs in inland marine waters and on the northwest coast of Washington. Commercial fishing for halibut typically occurs at depths up to 150 fathoms (274 m). Commercial gear is primarily bottom contact gear such as longline gear, with other gear types such as hand line, hook and line, and bottom troll also utilized.

Sunflower sea star bycatch estimates are not available at this time for the tribal fishery. Given the similarity in gear type and fishing practices as the non-tribal directed commercial fishery, the non-tribal directed commercial fishery is an appropriate proxy to estimate catch. The tribal fishery is allocated 35% of the Area 2A allocation with most going to the tribal commercial fishery. The non-tribal commercial fishery receives approximately 17% of the overall Area 2A allocation.

The estimated catch of sunflower sea stars in the non-tribal directed commercial halibut fishery is based on the assumption that encounter rates would be similar to those of the non-tribal commercial fishery and the IPHC FISS. Similar to the non-tribal directed commercial fishery, the tribal commercial fishery would also likely experience a high degree of variability in bycatch rates given the similarity in fishing gear and locations as the IPHC FISS. Using the rate of 0–27 estimated annual catch in the non-tribal, directed commercial fishery and the percentage difference in allocation, the tribal commercial fishery is expected to catch 0–54 sunflower sea stars annually, with up to 480 possible due to hotspot catches, proportional to those experienced in the IPHC FISS survey.

Mortalities of sunflower sea stars from causes other than sea star wasting syndrome are thought to be minimal compared to the impacts of the syndrome itself (Lowry et al. 2022). Enhanced monitoring over the next several years will evaluate this assumption.

Effects from the Recreational Fishery

Recreational halibut fisheries occur all along the coast from Puget Sound to northern California, with no depth restrictions but considerable timing restrictions. Recreational halibut anglers use handline gear with no more than two hooks attached, or spear fishing gear. Gear is typically fished on or near the bottom, and actively tended. Unlike commercial fishing operations, soak time is on the order of tens of minutes, rather than hours. Due to presumed low likelihood of hand line or spearfishing gear catching sunflower sea stars, the recreational fishery is not expected to catch any sunflower sea stars. Sunflower sea stars have not been reported as bycatch from any marine-based recreational hook-and-line fisheries in Washington State since at least 2003 (E. Kraig e-mail to Dayv Lowry, NOAA Fisheries, March 23, 2023).

Mortalities of sunflower sea stars from causes other than sea star wasting syndrome are thought to be minimal compared to impacts of the syndrome itself (Lowry et al. 2022). Enhanced monitoring over the next several years will evaluate this assumption.

Summary of Fishery Effects

Based on available estimates for annual take, bycatch in IPHC FISS surveys and the fisheries assessed as part of the proposed action here are cumulatively projected to result in the mortality of 15 (low), 118 (high), or 1,049 (hotspot/maximum) sunflower sea stars (Table 54). While the hotspot/maximum value is heavily influenced by an anomalously high encounter rate in 2014, values from this scenario are used below as part of a cautionary approach, which includes projections that temperature-related movement of sunflower sea stars into nearshore waters is likely as a consequence of marine heat waves in coming years. Given current population estimates of sunflower sea stars in the action area (Gravem et al. 2021; Lowry et al. 2022), impacts from this level of catch are anticipated to be minimal with regard to overall population viability on both a range-wide and local scale.

Table 54. Summary of anticipated annual halibut fishery and survey take of sunflower sea stars considered as part of the proposed action.

	Low	**High**	**Hotspot/ Maximum**
IPHC FISS (used to inform fishery estimates)	14.5	37	329
Non-tribal Commercial	0	27	240
Tribal	0	54	480
Recreational	0	0	0
Total	15 (rounded)	118	1,049

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 earlier in the discussion of environmental baseline (Section 2.4).

Future state, tribal, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives. Government and private actions may include changes in land and water uses, including ownership and intensity, any of which could impact listed species or their habitat. Government actions are subject to political, legislative, and fiscal uncertainties. These realities, added to the geographic scope of the action area, which encompasses numerous government entities exercising various authorities, make any analysis of cumulative effects difficult and speculative.

A final recovery plan for listed rockfish in the Puget Sound/Georgia basin was released in 2017 (NMFS 2017c). In early 2010, WDFW adopted a series of measures to reduce rockfish mortality from non-tribal fisheries within the Puget Sound/Georgia Basin. These measures include:

1. closure of the entire Puget Sound to the retention of any rockfish species
2. prohibition of fishing for bottom fish deeper than 120 feet (36.6 m)
3. closure of the non-tribal commercial fisheries listed in Section 2.3.4.2

These measures have eliminated future direct harvest of rockfish, and reduced or prevented bycatch from future non-tribal recreational and commercial fisheries within the U.S. portion of the Puget Sound/Georgia Basin. These fishery restrictions are unlikely to be lifted until recovery of ESA-listed rockfishes occurs, given the WDFW's commitment to broadscale ecosystem conservation. Furthermore, in 2014 the WDFW implemented a rule that requires all anglers targeting halibut and bottomfish to have a descending device onboard, rigged, and ready for use to help ameliorate impacts of barotrauma on captured rockfishes of all species. This conservation measure reduces sublethal and lethal impacts from capture, decreasing individual and population-level stress.

A recovery plan for Southern DPS green sturgeon was published in 2018 to address recovery of the species throughout the U.S. West Coast (NMFS 2018c).

In addition, there are ongoing recovery programs for other ESA-listed species that may benefit rockfish and green sturgeon. For more information on the various efforts being made at the local, tribal, state, and national levels to conserve ESA-listed species within the action area, see any of the recent status reviews, Federal Register notices of listings, and recovery planning documents, as well as recent consultations on issuance of section 10(a)(1)(A) research permits, including the Puget Sound Salmon Recovery Plan (SSDC 2007), the Summer Chum Salmon Conservation Initiative (WDFW and PNPTT 2000), the Southern Resident Killer Whale Recovery Plan (NMFS 2008b), the Southern Oregon/Northern California Coast Coho Salmon Recovery Plan (79 FR 58750, September 30, 2014), and the eulachon final recovery plan (NMFS 2017g).

NMFS finds it reasonably certain that state-managed fisheries that affect ESA-listed rockfish and green sturgeon will continue into the future, including the recreational bottomfish and shrimp trawl fisheries in Puget Sound, and the California halibut bottom trawl fishery off the coast of California. Section 2.4, Environmental Baseline, of this opinion briefly summarizes these fisheries and their effects on ESA-listed species. The take of ESA-listed rockfish in the recreational bottomfish and shrimp trawl fisheries in Puget Sound was addressed in an incidental take permit issued to WDFW in 2012 and WDFW is working on a new incidental take permit application (WDFW 2017; Dayv Lowry, NOAA Fisheries, pers. comm.). NMFS is working with the CDFW to analyze and address the take of green sturgeon in the California halibut fishery. We expect that these fisheries are likely to continue at baseline levels into the foreseeable future.

NMFS also finds it reasonably certain that state and private actions associated with marine pollution will continue into the future (e.g., state permits for effluent discharges and the status of currently contaminated sites). Although the Puget Sound Partnership may make progress toward reducing marine pollution (Sanga 2015), measurable change is not reasonably certain to occur in the near term.

Activities occurring in the Puget Sound area were considered in the discussion of cumulative effects in the biological opinion on the Puget Sound Chinook Harvest Resource Management Plan (NMFS 2017f) and the Comprehensive Management Plan for Puget Sound Chinook: harvest management component (Puget sound Indian Tribes and The Washington Department of Fish and Wildlife 2022). These opinions discussed the types of activities taken to protect listed species through habitat restoration, hatchery and harvest reforms, and water resource management actions. Salmon recovery plans for ESA-listed ESUs and projects implemented with Pacific Coastal Salmon Recovery Fund grants helps protect, conserve, and restore salmon populations. Further details on salmon recovery plans are in the environmental baseline section of this opinion.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and habitat features, 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. In marine waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, shoreline growth management, and resource permitting. Private activities include continued resource extraction, vessel traffic, development, and other activities that contribute to non-point source pollution and stormwater run-off.

Non-federal actions are likely to continue affecting listed species. The cumulative effects in the action area are difficult to analyze because of this opinion's geographic scope, the different resource authorities in the action area, the uncertainties associated with government and private actions, and the changing economies of the region. Whether these effects will increase or decrease is a matter of speculation; however, based on the trends identified in the baseline, the adverse cumulative effects are likely to increase. Although state, tribal, and local governments have developed plans and initiatives to benefit listed fish, they must be applied and sustained in a comprehensive way before NMFS can consider them "reasonably foreseeable" in its analysis of cumulative effects.

2.7. Integration and Synthesis

The Integration and Synthesis section is the final step in assessing the risk that the proposed action poses to species and critical habitat. 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.

2.7.1. Puget Sound/Georgia Basin Rockfish

As described above in Section 2.2, Rangewide Status of the Species and Critical Habitat, we conclude that the Puget Sound/Georgia Basin DPSs of yelloweye rockfish and bocaccio are at moderate and high risk of extinction, respectively. Low estimated adult abundance, reduced productivity as a consequence of historical removal of large adults, and a lack of recent recruitment events contribute to this risk in both species. For yelloweye rockfish, genetic evidence has validated the DPS boundaries and regular observation of both juveniles and adults in waters of both the U.S. and Canada suggest that populations are slowly rebuilding. For bocaccio, however, encounter rates have remained near zero and connectivity to coastal populations is poorly understood. With the major threat of fishery impacts minimized since 2010, management practices for both species now focus on researching and minimizing other threats to promote successful recruitment and retention over coming decades as newly settled juveniles mature to reproductive age (NMFS 2017c).

2.7.1.1. Effects on Abundance

Bycatch in fisheries is likely a limiting factor for yelloweye rockfish and bocaccio, though there is uncertainty regarding the degree to which it impacts population recovery (NMFS 2017c). As detailed in Section 2.4, Environmental Baseline, yelloweye rockfish and bocaccio can be caught by anglers targeting salmon and bottomfish, and in the shrimp trawl fishery. To assess if the proposed recreational and commercial halibut fisheries adversely limit the viability of each species, we consider the proposed action in the context of the population-level impact from all fisheries and research combined. Thus, we compare the number of individual fish affected by known sources of mortality/injury (fisheries and scientific research) to the overall size of the population.

To conduct this analysis, we must assess effects on the overall population of the rockfish DPS for both species. However, as described above in Section 2.2, Rangewide Status of the Species and Critical Habitat, there are no reliable estimates of the abundance of either of the ESA-listed rockfish DPSs, which is particularly acute for bocaccio. The best available abundance data for each species come from the WDFW ROV surveys (Pacunski et al. 2013; 2020; WDFW 2017; Lowry et al. 2022), and we use these surveys as a fundamental source to understand the total abundance of the U.S. portion of the DPSs. The structure of this analysis likely underestimates the total abundance of each species within the U.S. portion of the DPS because: (1) we use the lower confidence interval population estimates available for yelloweye rockfish; and (2) we use the WDFW population estimate of bocaccio for the San Juan Island and Eastern Strait of Juan de Fuca area and note that it is generated within only 46% of the estimated habitat of bocaccio within the U.S. portion of the DPS. The rest of the area, including the Main Basin, South Sound, and Hood Canal, were likely the most historically common area used by bocaccio (Drake et al. 2010). The structure of these assessments likely underestimates the total abundance of each DPS, resulting in a minimum abundance scenario and evaluation of cumulative fishery bycatch mortality for each species.

To assess the effect of these mortalities on population viability, we adopted the methodology used by the PFMC for rockfish species. The decline of West Coast groundfish stocks prompted the PFMC to reassess harvest management (Ralston 1998, 2002). The PFMC held a workshop in 2000 to review procedures for incorporating uncertainty, risk, and the precautionary approach in establishing harvest rate policies for groundfish. The workshop participants assessed best available science regarding "risk-neutral" and "precautionary" harvest rates (Scientific and Statistical Committee 2000). The workshop resulted in the identification of risk-neutral harvest rates of 0.75 of natural mortality, and precautionary harvest rates of 0.5 to 0.7 (50% to 70%) of natural mortality for rockfish species. These rates are supported by published and unpublished literature (Scientific and Statistical Committee 2000; Walters and Parma 1996), and guide rockfish conservation efforts in British Columbia, Canada (Yamanaka and Lacko 2001). Fishery mortality of 0.5 (or less) of natural mortality was deemed most precautionary for rockfish species, particularly in data-limited settings, and was considered a rate that would not hinder population viability (Scientific and Statistical Committee 2000; Walters and Parma 1996). Given the similarity of the life histories of yelloweye rockfish and bocaccio to the life histories of coastal rockfish managed by the PFMC, which include coastal populations of both species, we concluded that this method represented the best available scientific information for assessing the effects of fisheries-related mortality on the viability of the listed rockfish.

To assess the population-level effects on yelloweye rockfish and bocaccio from the proposed recreational and commercial halibut fishery, we added the total catch estimate from the recreational and commercial sectors (Table 55).

Table 55. Total annual catch for the recreational and tribal halibut fisheries and percentage of the listed rockfish abundance.

Species	Range of Estimated Lethal Catch (individuals)[a]	Abundance Scenario	Proportion of DPS Killed by Proposed Action
Bocaccio	18	4,606	0.004
Yelloweye Rockfish	270	143,086	0.002

[a] The recreational component of the lethal bycatch is estimated to be 0 bocaccio and up to 23 yelloweye rockfish (see Table 43 and using 28% for yelloweye mortality rates in the recreational fishery, from PFMC 2014). The remaining lethal catch estimate is from commercial fisheries/longline surveys (i.e., the IPHC FISS) (Table 48) and assumes the low impact scenario for bocaccio and the moderate impact scenario for yelloweye.

Annual natural mortality rate for bocaccio is approximately 8% (as detailed in Section 2.2.1, Status of Listed Species) (Palsson et al. 2009); thus, the precautionary level of fishing and research mortality would be 4%. Annual natural mortality rates for yelloweye rockfish range from 2-4.6% (as detailed in Section 2.2.1, Status of Listed Species) (Wallace 2007; Yamanaka and Kronlund 1997); thus, the precautionary level of fishing and research mortality would be 1-2.3%. For yelloweye rockfish (0.2%) and bocaccio (0.4%), estimated mortalities from the recreational and commercial halibut fisheries in the range of the DPSs would be well below the precautionary level as described above (0.5 [or less] of natural mortality).

To assess the population-level effects on yelloweye rockfish and bocaccio from activities within the environmental baseline and fishery catches associated with the Proposed Action, we calculated the total mortalities for all sources (Table 56). We include the bycatch from salmon fisheries in the environmental baseline as an estimate of what may occur during the time period of the proposed action.

Table 56. Total annual lethal catches for fisheries and research within the U.S. portion of the DPS.

Species	Total Lethal Take in Baseline (plus halibut fishery estimate)	Abundance Estimate	Proportion of DPS Killed
Bocaccio	139[a] (+18) = 157	4,606	0.034
Yelloweye Rockfish	207[b] (+270) = 477	143,086	0.003

[a] This includes the following estimated bocaccio mortalities: 77 from the salmon fishery, 45 during research, and 17 in other fisheries (recreational bottomfish and shrimp trawl).

[b] This includes the following estimated yelloweye rockfish mortalities: 66 from the salmon fisheries, 54 during research, and 87 in other fisheries (recreational bottomfish and shrimp trawl).

For yelloweye rockfish, total lethal catch from the recreational and tribal halibut fishery, in addition to previously assessed scientific research and fishery bycatch (detailed in Section 2.4, Environmental Baseline) and potential bycatch from the salmon fishery, would be 0.3%, which is below the precautionary level of 1%–2.3%. For bocaccio, total lethal catch would be 3.4%, which is close to the precautionary level of 4%. We note, however, that the population estimate for bocaccio is from one area of the DPS, the San Juan Island area, which represents approximately 46% of bocaccio habitat in the U.S. portion of the DPS. Bocaccio exist in the rest of the DPS area (they were recently documented in the Main Basin in fisheries and research efforts) and the population estimate used here is an underestimate for which better science does not exist. The percent of the DPS killed would, therefore, be less than calculated and reported in Table 56. In addition, the analysis of potential bycatch from the halibut fishery for each species uses precautionary assumptions and, thus, actual bycatch would likely be lower than estimated. Yelloweye rockfish are likely to be caught at levels below the estimates in Table 55. Some portion of the total population of yelloweye rockfish and bocaccio are too small to enter the fishery for the next several years. As these fish grow, they will have greater risk of bycatch.

Potential bycatch and research effects in the environmental baseline also consist of precautionary assumptions and the actual impacts on each species would very likely be less. These precautionary assumptions include that, of the previously analyzed research projects, the actual catches of yelloweye rockfish and bocaccio is well below the permitted take. As an example, since bocaccio were listed in 2010, only four fish have been caught in research projects (compared to the permitted take of 58 fish, and 27 mortalities in 2017 alone) within the U.S. portion of the DPS area. Similarly, estimates of catches in some fisheries may also be an underestimate as no yelloweye rockfish or bocaccio were reported as caught in the shrimp trawl fishery from 2012 to 2017 (WDFW 2017).

2.7.1.2. Effects on Productivity, Diversity, and Spatial Structure

As discussed in Section 2.5.1, Puget Sound/Georgia Basin Rockfish, bycatch has the potential to impact productivity, diversity, and spatial structure of yelloweye rockfish and bocaccio. Bycatch is likely to affect older and more productive yelloweye rockfish and bocaccio. The removal of larger and older fish of each species would have a disproportionate impact on population productivity by reducing the total number of larvae released. Yelloweye rockfish are a common component of longline catch, particularly in areas with maturing and mature fish. Thus, the impacts of the proposed action on yelloweye rockfish demographics and productivity would be more acute than on bocaccio (which are rarely caught in the halibut fishery). Impacts on spatial structure of yelloweye rockfish and bocaccio would not occur in most of the U.S. portion of the DPSs for each species; no bycatch would occur in the South Sound, much of the Main Basin, and all of Hood Canal as the halibut fishery is concentrated in the San Juan and Eastern Strait of Juan de Fuca Area. As such, effects on spatial structure are not likely to be large enough to impact the viability for each species.

2.7.1.3. Effects of Derelict Fishing Gear

In addition to fishery mortality, rockfish are killed by derelict fishing gear (Good et al. 2010; Drinkwin et al. 2023), though we are unable to quantify the number of yelloweye rockfish and bocaccio killed by pre-existing derelict nets or new nets that would occur as part of some on-going commercial fisheries. New derelict fishing gear (recreational hooks and line, and commercial longlines) associated with the proposed action would occur annually, though, as described in Section 2.5.1.3, Fishery Effects on Listed Rockfish Population Demographics and Productivity, of this opinion, this type of derelict gear is only anticipated to result in small and localized adverse effects on rockfish critical habitat.

Despite these data limitations, it is unlikely that mortality associated with derelict gear would occur at levels that exceed the precautionary or risk-adverse levels. This is because: (1) the removal of thousands of nets has restored approximately 650 acres of the benthic habitat of Puget Sound and likely reduced mortality levels for each species (Drinkwin et al. 2023); (2) most new derelict gear would become entangled in habitats less than 100 feet (30.5 m) deep (and thus avoid most adult yelloweye rockfish and bocaccio); and (3) the recent and ongoing programs to provide outreach to fishermen are expected to reduce loss of nets.

2.7.1.4. Effects on Rockfish Critical Habitat

We also assessed the effects of the action on yelloweye rockfish and bocaccio habitat in the context of the status of critical habitat to evaluate whether the effects of the proposed fishing are likely to reduce the value of critical habitat for the conservation of each species. The main potential effect of the proposed fishing on listed rockfish critical habitat would result from lost fishing gear. As discussed in Section 2.2, Rangewide Status of the Species and Critical Habitat, and Section 2.4, Environmental Baseline, of this opinion, critical habitat features in the action area (i.e., prey resources, water quality, and complex bottom habitats) may be affected by non-point source and point source discharges, hypoxia, oil spills, dredging projects and dredged material disposal activities, nearshore construction projects, renewable ocean energy installations, and climate change in addition to lost fishing gear. As described directly above and in Section 2.5.1.3, Fishery Effects on Listed Rockfish Population Demographics and Productivity, of this opinion, we would expect the proposed fishing to result in minimal additional impacts on a subset of these features (complex bottom habitats). Thus, the proposed fishing is not likely to reduce the value of critical habitat for the conservation of yelloweye rockfish and bocaccio of the Puget Sound/Georgia Basin DPSs.

In summary, the effects of the Proposed Action (Section 2.5), when added to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), and taking into account the status of the species and critical habitat (Section 2.2), would not reduce appreciably the likelihood of either the survival or recovery of yelloweye rockfish or bocaccio of the Puget Sound/Georgia Basin DPS in the wild by reducing their numbers, reproduction, or distribution (abundance, productivity, spatial structure, and diversity); or appreciably diminishes the value of designated critical habitat for the conservation of each species.

2.7.2. Southern DPS Green Sturgeon

As described above in Section 2.2, Rangewide Status of the Species and Critical Habitat, we conclude that Southern DPS green sturgeon are at moderate risk of extinction because of the low estimated adult abundance, restriction of spawning to one segment of the mainstem Sacramento River and in some years in its tributaries, the Yuba and Feather rivers, potentially reduced productivity and genetic diversity because of the population's low abundance and restricted spawning habitat, and entrainment as well as stranding in flood diversions during high water events. However, there is uncertainty regarding the species' status because of the lack of information regarding productivity and abundance.

2.7.2.1. Effects on Abundance

The Proposed Action could reduce the abundance or productivity of individuals caught in the fishery. We expect this reduction in abundance or productivity to be very small (up to three fish encountered and up to one fish killed per year), with no green sturgeon encountered or killed in most years.

Overall fisheries catch of green sturgeon in recent years has been much reduced compared to historical levels and prohibitions on retention of green sturgeon have likely reduced fisheries-related mortality, although incidental catch continues to impose additional mortality on the species. In the fisheries for which data are available (excluding the Pacific halibut fishery), we estimate that 837 to 1,604 Southern DPS green sturgeon (adults and subadults) are incidentally captured each year (Table 57). This represents 4.5%–21% of the total subadult and adult population, depending on if the high estimates of abundance (i.e., 18,537 subadults and adults, combined) or the low estimates of abundance (i.e., 7,786 subadults and adults, combined) are used.

Of these incidental captures, we estimate that 48-119 Southern DPS green sturgeon (adults and subadults) are killed each year. This represents additional mortality of 0.3%–1.5% on the combined subadult and adult population. This estimated additional mortality imposed by incidental catch in these fisheries (excluding the Pacific halibut fishery) is likely not affecting the continued survival and recovery of Southern DPS green sturgeon. This is because Beamesderfer et al. (2007) estimated that additional mortality of 5%–10% on fish 46–72 inches (117–183 cm) in length (i.e., subadults and small adults) or additional mortality of 7%–25% on fish greater than 65 inches (165 cm) in length (i.e., adults) would reduce the species' reproductive potential below the minimum needed to maintain (20% of maximum potential) (Goodyear 1993) or rebuild (50% of maximum potential) (Boreman et al. 1984) sturgeon populations.

There is a high degree of uncertainty regarding these estimates. First, the level of incidental catch in these fisheries may be overestimated, particularly for the Washington State fisheries. We included high estimates in order to be conservative in our analysis. Second, the estimated abundance of adults and subadults is uncertain and in need of further refinement. The population estimates are the best estimates available to date, but do not consider the number of spawning adults that may be in the lower Feather River or potentially in the lower Yuba River each year. Third, individual fish may be recaptured in the same or different fisheries within a year, reducing the number of individual fish actually encountered. Comparing the estimates of abundance and incidental catch of Southern DPS green sturgeon in coast-wide fisheries emphasizes the uncertainty in both estimates. It is possible that the fisheries encounter a large portion of the adult and subadult population, given the high degree of spatial overlap between the fisheries and green sturgeon distribution along the coast, particularly in areas of relatively high green sturgeon presence (e.g., the Columbia River estuary, Willapa Bay, Grays Harbor, San Francisco Bay-Delta and Sacramento River system, and coastal waters adjacent to San Francisco Bay). However, these fisheries are all much reduced from historical levels and are now regulated in ways that minimize impacts on green sturgeon. Given these uncertainties, additional information is needed to more accurately assess the effects of the status, environmental baseline, and cumulative effects on the species for future analyses.

Adding the effects of the Proposed Action to the status, environmental baseline, and cumulative effects would result in a comparatively small increase in the mortality imposed on the subadult and adult population. We expect few encounters with green sturgeon in the proposed fishery (i.e., zero to three encounters per year, with no encounters in most years) and all of the green sturgeon to be released alive and to survive. At the most, we would expect incidental take of up to three Southern DPS adults and/or subadults per year, with 0.078 mortalities (conservatively translated to one mortality) per year. This would result in a relatively small increase in the mortality imposed on the species, compared to the levels estimated by Beamesderfer et al. (2007) that would substantially reduce reproductive potential.

Sublethal effects resulting from incidental capture and release in the fishery may also reduce the species' reproductive potential by disrupting the spawning migrations of adults and the growth and reproductive development of subadults. We expect few incidental captures (zero to three per year), only a portion of which would be adults. Given the geographic distribution (northern California to Washington) and general seasonality (March through October) of the proposed fishery, we would expect that adults encountered would most likely be post-spawn adults. The fishing gear used in the proposed fishery (hook-and-line, longline, and troll) would be expected to have lower impacts on green sturgeon than other fishing gear (e.g., bottom trawl).

Table 57. Summary of estimated incidental catch and mortality of Southern DPS (sDPS) green sturgeon (number of fish) per year in commercial and recreational fisheries occurring within and outside of the action area, excluding the Pacific halibut fishery.

	Estimated SDPS Incidental Catch		**Estimated SDPS Mortalities**	
Fishery	**Low estimate**	**High estimate**	**Low estimate**	**High estimate**
California halibut bottom trawl fishery	28	631	3	65
Pacific coast groundfish fishery	22	40	0	4
Central Valley, California, recreational fisheries	89	202	3	5
Oregon recreational fisheries	0	33	0	2
Lower Columbia River recreational fisheries	52	52	7	11
Lower Columbia River commercial fisheries	271	271	14	14
Washington State fisheries	375	375	18	18
Total	**837**	**1,607**	**48**	**119**

2.7.2.2. Effects on Productivity, Diversity and Spatial Structure

The Proposed Action is not likely to further restrict the spatial structure of the species (e.g., extent of spawning habitat, geographic distribution along the coast), but may affect productivity of individual fish by altering or disrupting the spawning migration of adults that are caught incidentally in the fishery and released.

2.7.2.3. Effects on Critical Habitat

As discussed in Section 2.2, Rangewide Status of the Species and Critical Habitat, and Section 2.4, Environmental Baseline, of this opinion, critical habitat features in the action area (i.e., gear impacts and prey resources) may be affected. We would expect the proposed fishing to result in minimal additional impacts on a subset of these features. Thus, the proposed fishing is not likely to reduce the value of critical habitat for the conservation of green sturgeon.

In summary, the effects of the Proposed Action (Section 2.5), when added to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), and taking into account the status of the species and critical habitat (Section 2.2), would not reduce appreciably the likelihood of both the survival and recovery of Southern DPS green sturgeon in the wild by reducing their numbers, reproduction, or distribution (abundance, productivity, spatial structure, and diversity); or appreciably diminishes the value of designated critical habitat for the conservation of each species. In summary, the lack of substantial impacts on the Southern DPS green sturgeon based on the low expected catches and sublethal and lethal impacts of the fishery supports the conclusion that the proposed fishing will not appreciably reduce the likelihood of survival and recovery of the species.

2.7.3. Puget Sound Chinook Salmon

To assess the effects of the Proposed Action on the survival and recovery of the listed Puget Sound Chinook ESU, we considered the effects on abundance, productivity, spatial structure, and diversity. The Proposed Action is not likely to further restrict the spatial structure or diversity of the species given the effects occur entirely in marine waters, affect only a few fish in any year and those fish are likely represent different populations each year. However, the Proposed Action could reduce the population abundance or productivity if individuals are killed as a result of being encountered and killed in the fishery. We considered these effects within the context of the status of the species and the environmental baseline.

As described above in Section 2.2, Rangewide Status of the Species and Critical Habitat, the Puget Sound ESU includes 22 populations across 5 geographical regions (Ford 2022). Three of the five regions (Strait of Juan de Fuca, Georgia Basin, and Hood Canal) contain only two populations, both of which must be recovered to viability to recover the ESU (NMFS 2006b). In general, the Strait of Juan de Fuca, Georgia Basin, and Hood Canal regions are at greater risk than the other regions. In addition, spatial structure, or geographic distribution, of the White, Skagit, Elwha, and Skokomish Rivers populations has been substantially reduced or impeded by the loss of access to the upper portions of those tributary basins because of flood control activities and hydropower development. It is likely that genetic diversity has also been reduced by this habitat loss.

The Environmental Baseline, Section 2.4, describes the effects of many activities that occur across the action area considered in this Opinion. We describe the on-going and anticipated temperature, freshwater, and marine effects of climate change. Because the impacts of climate change are ongoing, the effects are reflected in the most recent status of the species. Urbanization, agriculture, hydropower, forest practices and past harvest and hatchery practices have adversely affected the four ESUs discussed in this Opinion and their habitat prior to considering the effects of the Proposed Action. Within the action area, available knowledge and techniques are insufficient to discern the role and contribution of hatchery fish to density dependent interactions affecting salmon growth and survival in the Pacific Ocean. From the scientific literature, the general conclusion is that the influence of density dependent interactions on growth and survival is likely immeasurably small. Fishing-related mortality and interaction with fishing gear is the primary activity affecting salmon within the action area. Those fisheries are a mix of fisheries directed at salmon and non-salmon species. Salmon fisheries have the largest impacts of those fisheries and are generally managed under comprehensive management frameworks with stock-specific impact limits. Impacts of non-salmon fisheries result in very low mortality on the Puget Sound Chinook ESU (i.e., in the tenths of a percent or less). NMFS has previously consulted on the effects of the fisheries described in the environmental baseline and determined they would not jeopardize the Puget Sound Chinook Salmon ESU.

2.7.3.1. Effects on Abundance and Productivity

The effects of the Proposed Action would result in an extremely small increase in the mortality imposed on the ESU. We expect very low mortality on salmon overall in the proposed fisheries (i.e., one to four Chinook salmon per year, Table 49). Of these, the mortality of listed fish (hatchery and wild) is expected to average less than two Puget Sound Chinook salmon per year. The mortality of a listed Puget Sound Chinook salmon in the proposed fishery for which take has been prohibited is even lower (less than one fish). Additionally, the impact would likely affect different populations in each year — the death of up to 2 ESA-listed Puget Sound Chinook salmon per year, even if accruing to a single population, would not substantially affect any of the populations or the regions in the ESU.

The number of Puget Sound Chinook salmon killed in the halibut fishery are so small that impacts on this ESU from the halibut fishery are not likely to have any meaningful effects on any population of Puget Sound Chinook, and are therefore unlikely to have any effect on the abundance or productivity of the ESU. Therefore, the lack of any meaningful impacts on the Puget Sound Chinook Salmon ESU, based on the low expected impacts of the fishery, supports the conclusion that the proposed fishing will not appreciably reduce the likelihood of survival and recovery of the species.

2.7.3.2. Effects on Critical Habitat

We also assessed the effects of the action on Puget Sound Chinook salmon critical habitat in the context of the status of critical habitat, the environmental baseline, and cumulative effects, to evaluate whether the effects of the proposed fishing are likely to reduce the value of designated critical habitat for the conservation of listed Puget Sound Chinook salmon. Critical habitat as defined under the ESA for the Puget Sound Chinook Salmon ESU does not include marine areas within the action area. Halibut fisheries within Puget Sound occur in deeper water beyond designated critical habitat along the nearshore. Any impact on water quality from vessels transiting critical habitat areas on their way to the fishing grounds would be very short-term and transitory in nature and minimal compared to the number of other vessels in the area (NMFS 2004b). Thus, the proposed fishing is not likely to reduce the value of designated critical habitat for the conservation of the Puget Sound Chinook Salmon ESU.

In summary, the effects of the Proposed Action (Section 2.5), when added to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), and taking into account the status of the species and critical habitat (Section 2.2), would not (1) reduce appreciably the likelihood of both the survival and recovery of the Puget Sound Chinook Salmon ESU in the wild by reducing their numbers, reproduction, or distribution (abundance, productivity, spatial structure, and diversity); or (2) appreciably diminish the value of designated critical habitat for the conservation of the species.

2.7.4. Lower Columbia River Chinook Salmon

To assess the effects of the Proposed Action on the survival and recovery of Lower Columbia River Chinook salmon, we considered the effects on abundance, productivity, spatial structure, and diversity. The Proposed Action is not likely to further restrict the spatial structure or diversity of the species given the effects occur entirely in marine waters, affect only a few fish in any year and those fish are likely to represent different populations each year. However, the Proposed Action could reduce the population abundance or productivity if individuals are killed as a result of being encountered and killed in the fishery. We considered these effects within the context of the status of the species and the environmental baseline.

As described above in Section 2.2, Rangewide Status of the Species and Critical Habitat, the Lower Columbia River Chinook Salmon ESU is composed of 32 historical populations. The populations are distributed through three ecological zones and six MPGs. Relative to baseline VSP levels identified in the recovery plan, there has been an overall improvement in the status of a number of spring and fall-run populations, although many of the populations in this ESU remain at "high risk," with low natural-origin abundance levels. There is considerable uncertainty whether the Gorge MPG now persists, and whether the low abundances observed represent native natural origin abundances.

The Environmental Baseline, Section 2.4, describes the effects of many activities that occur across the action area considered in this Opinion. We describe the on-going and anticipated temperature, freshwater, and marine effects of climate change. Because the impacts of climate change are ongoing, the effects are reflected in the most recent status of the species. Urbanization, agriculture, hydropower, forest practices and past harvest and hatchery practices have adversely affected the four ESUs discussed in this Opinion and their habitat prior to considering the effects of the Proposed Action. Within the action area, available knowledge and techniques are insufficient to discern the role and contribution of hatchery fish to density dependent interactions affecting salmon growth and survival in the Pacific Ocean. From the scientific literature, the general conclusion is that the influence of density dependent interactions on growth and survival is likely immeasurably small. Fishing-related mortality and interaction with fishing gear is the primary activity affecting salmon within the action area. Those fisheries are a mix of fisheries directed at salmon and non-salmon species. Salmon fisheries have the largest impacts of those fisheries and are generally managed under comprehensive management frameworks with stock-specific impact limits. Impacts of non-salmon fisheries result in very low mortality on the Lower Columbia River Chinook Salmon ESU (i.e., in the tenths of a percent or less). NMFS has previously consulted on the effects of the fisheries described in the environmental baseline and determined they would not jeopardize the Lower Columbia River Chinook Salmon ESU.

2.7.4.1. Effects on Abundance and Productivity

The effects of the Proposed Action would result in an extremely small additional mortality imposed on the ESU. We expect very low mortality on salmon overall in the proposed fisheries (i.e., one to four Chinook salmon per year, Table 49). Of these, the mortality of listed fish (hatchery and wild) is expected to be less than one Lower Columbia River Chinook salmon per year. The impact would likely affect different populations in each year. The loss of one returning Lower Columbia River Chinook salmon per year as a result of encounters in the halibut fishery would not result in a noticeable effect on any of the populations in the ESU, and so would not have an effect on any MPG. It is therefore unlikely to have any effect on the abundance or productivity of the ESU. Therefore, the lack of meaningful impacts on the Lower Columbia River Chinook Salmon ESU based on the low expected impacts of the fishery supports the conclusion that the proposed fishing will not appreciably reduce the likelihood of survival and recovery of the species.

2.7.4.2. Effects on Critical Habitat

Marine areas within the action area are not part of critical habitat defined under the ESA for Lower Columbia River Chinook salmon. The Proposed Action would have no effect on Lower Columbia River Chinook salmon critical habitat.

In summary, the effects of the Proposed Action (Section 2.5), when added to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), and taking into account the status of the species and critical habitat (Section 2.2), would not (1) reduce appreciably the likelihood of both the survival and recovery of the Lower Columbia River Chinook salmon ESU in the wild by reducing their numbers, reproduction, or distribution (abundance, productivity, spatial structure, and diversity); or (2) appreciably diminish the value of designated critical habitat for the conservation of the species.

2.7.5. Lower Columbia River Coho Salmon

The Proposed Action is not likely to further restrict the spatial structure or diversity of the species given the effects occur entirely in marine waters, affect only a few fish in any year and those fish are likely to represent different populations each year. However, the Proposed Action could reduce the population abundance or productivity if individuals are killed as a result of being encountered and killed in the fishery. We considered these effects within the context of the status of the species and the environmental baseline.

2.7.5.1. Effects on Abundance and Productivity

As described above in Section 2.2, Rangewide Status of the Species and Critical Habitat, the Lower Columbia River coho salmon ESU is composed of 24 historical populations and three MPGs. The most recent status review concluded that the LCR Coho Salmon ESU is still at very high risk although total of 6 of the 23 populations in the ESU are at or near their recovery viability.

The Environmental Baseline, Section 2.4, describes the effects of many activities that occur across the action area considered in this Opinion. We describe the on-going and anticipated temperature, freshwater, and marine effects of climate change. Because the impacts of climate change are ongoing, the effects are reflected in the most recent status of the species. Urbanization, agriculture, hydropower, forest practices and past harvest and hatchery practices have adversely affected the four ESUs discussed in this Opinion and their habitat prior to considering the effects of the Proposed Action. Within the action area, available knowledge and techniques are insufficient to discern the role and contribution of hatchery fish to density dependent interactions affecting salmon growth and survival in the Pacific Ocean. From the scientific literature, the general conclusion is that the influence of density dependent interactions on growth and survival is likely immeasurably small. Fishing-related mortality and interaction with fishing gear is the primary activity affecting salmon within the action area. Those fisheries are a mix of fisheries directed at salmon and non-salmon species. Salmon fisheries have the largest impacts of those fisheries and are generally managed under comprehensive management frameworks with stock-specific impact limits. Impacts of non-salmon fisheries result in very low mortality on the Lower Columbia River Coho Salmon ESU (i.e., in the tenths of a percent or less). NMFS has previously consulted on the effects of the fisheries described in the environmental baseline and determined they would not jeopardize the Lower Columbia River Coho Salmon ESU.

The effects of the Proposed Action would result in extremely small additional mortality imposed on the ESU. We expect very low mortality on salmon overall in the proposed fisheries (i.e., one to four coho salmon per year, Table 49). Of these, the mortality of listed fish (hatchery and wild) is expected to be one Lower Columbia River coho per year. The loss of one returning Lower Columbia River coho salmon per year as a result of encounters in the halibut fishery would not result in a meaningful effect on any of the populations in the ESU, and so would not have an effect on any MPG. It is therefore unlikely to have any effect on the abundance or productivity of the ESU. Therefore, the lack of noticeable impacts on the Lower Columbia River Coho Salmon ESU based on the low expected impacts of the halibut fishery supports the conclusion that the proposed fishing will not appreciably reduce the likelihood of survival and recovery of the species.

2.7.5.2. Effects on Critical Habitat

Marine areas within the action area are not part of designated critical habitat for Lower Columbia River coho salmon as defined by the ESA. The Proposed Action would have no effect on LCR coho salmon critical habitat.

In summary, the effects of the Proposed Action (Section 2.5), when added to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), and taking into account the status of the species and critical habitat (Section 2.2), would not (1) reduce appreciably the likelihood of both the survival and recovery of the Lower Columbia River Chinook Salmon ESU in the wild by reducing their numbers, reproduction, or distribution (abundance, productivity, spatial structure, and diversity); or (2) appreciably diminishes the value of designated critical habitat for the conservation of the species.

2.7.6. Snake River Fall Chinook Salmon

To assess the effects of the Proposed Action on the survival and recovery of Snake River fall Chinook salmon, we considered the effects on abundance, productivity, spatial structure, and diversity. The Proposed Action is not likely to further restrict the spatial structure or diversity of the species given the effects occur entirely in marine waters and are estimated to affect at most one fish per year. However, the Proposed Action could reduce the population abundance or productivity if individuals are killed as a result of being encountered and killed in the fishery. We considered these effects within the context of the status of the species and the environmental baseline.

As described above in Section 2.2, Rangewide Status of the Species and Critical Habitat, the Snake River fall Chinook salmon ESU is composed of one MPG, with an extant natural-origin population (Lower Mainstem Snake River population) and one extirpated population (Middle Snake River population). The Lower Mainstem Snake River fall Chinook salmon population is currently rated as viable, with a low risk of extinction within 100 years. However, the single population delisting options provided in the Snake River Fall Chinook Salmon Recovery Plan would require the population to meet or exceed minimum requirements for a risk rating of

"Highly Viable with a high degree of certainty". Considering the most recent information available, an increase in estimated productivity (or a decrease in the year-to-year variability associated with the estimate) would be required to achieve delisting status for the ESU, assuming that natural-origin abundance of the single extant SRFC population remains relatively high.

The Environmental Baseline, Section 2.4, describes the effects of many activities that occur across the action area considered in this Opinion. We describe the on-going and anticipated temperature, freshwater, and marine effects of climate change. Because the impacts of climate change are ongoing, the effects are reflected in the most recent status of the species. Urbanization, agriculture, hydropower, forest practices and past harvest and hatchery practices have adversely affected the four ESUs discussed in this Opinion and their habitat prior to considering the effects of the Proposed Action. Within the action area, available knowledge and techniques are insufficient to discern the role and contribution of hatchery fish to density dependent interactions affecting salmon growth and survival in the Pacific Ocean. From the scientific literature, the general conclusion is that the influence of density dependent interactions on growth and survival is likely immeasurably small. Fishing-related mortality and interaction with fishing gear is the primary activity affecting salmon within the action area. Those fisheries are a mix of fisheries directed at salmon and non-salmon species. Salmon fisheries have the largest impacts of those fisheries and are generally managed under comprehensive management frameworks with stock-specific impact limits. Impacts of non-salmon fisheries result in very low mortality on the Snake River Chinook Salmon ESU (i.e., in the tenths of a percent or less). NMFS has previously consulted on the effects of the fisheries described in the environmental baseline and determined they would not jeopardize the Snake River Salmon ESU.

2.7.6.1. Effects on Abundance and Productivity

The effects of the Proposed Action would result in an extremely small increase in the mortality imposed on the ESU. We expect very low mortality on salmon overall in the proposed fisheries (i.e., one to four Chinook salmon per year, Table 49). Of these, the mortality of listed fish (hatchery and wild) is expected to be less than one Snake River fall Chinook salmon per year. A reduction of impacts on Snake River fall Chinook salmon will make a negligible difference to the escapement, status, or exploitation rate on the remaining population or the ESU. Therefore, the lack of meaningful impacts on the Snake River Fall Chinook Salmon ESU based on the low expected impacts of the halibut fishery supports the conclusion that the proposed fishing will not appreciably reduce the likelihood of survival and recovery of the species.

2.7.6.2. Effects on Critical Habitat

Marine areas within the action area are not part of critical habitat for Snake River fall Chinook salmon. The Proposed Action would have no effect on Snake River fall Chinook salmon critical habitat.

In summary, the effects of the Proposed Action (Section 2.5), when added to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), and taking into account the status of the species and critical habitat (Section 2.2), would not (1) reduce appreciably the likelihood of both the survival and recovery of the of Snake River fall Chinook salmon ESU in the wild by reducing their numbers, reproduction, or distribution (abundance, productivity, spatial structure, and diversity); or (2) appreciably diminishes the value of designated critical habitat for the conservation of the species.

2.7.7 Sunflower Sea Stars

As described above in Section 2.2, Rangewide Status of the Species and Critical Habitat, sunflower sea stars suffered from a severe population decline due to sea star wasting syndrome between 2013 and 2017. Information on life history, as well as historical and contemporary abundance is severely lacking, leaving very little information for an environmental baseline.

2.7.7.1. Effects on Abundance

The Proposed Action could reduce abundance or productivity of sunflower sea stars by gear interactions and handling mortality. Catches in most years from the proposed action are around 15 sunflower sea stars. There are some years that comparatively large catches of sunflower sea stars may occur (up to potentially 1,049 sunflower sea stars); however, these are the result of single longline sets and are rare (1 occurrence in 14 years). A conservative approach is applied here, assuming that these high catches will occur in the future. We anticipate annual combined take of sunflower sea stars as associated with the proposed operation of the Pacific halibut fishery will be 1,049 individuals, with sublethal handling occurring in some cases. Due to the lack of established mortality rates, however, a conservative approach is applied here in that all catches are assumed to result in mortality. Actual mortality rates are likely to be low considering the resiliency of sunflower sea stars to handling stress and their ability to regrow limbs after injury or autotomy. How handling affects susceptibility to SSWS is unknown, and this uncertainty further justifies our conservative assumption about all encounters being lethal.

The portion of the stock south of Cape Flattery, WA, does not constitute a significant portion of the range of the species and catches there are unlikely to have a major impact on the population. The portion of the species range in Washington inland marine waters is a potentially biologically significant source population; however, takes are low enough that the proposed action is not anticipated to have a noticeable effect on the population.

2.7.7.2. Effects on Critical Habitat

As discussed in Section 2.2 Rangewide Status of the Species and Critical Habitat, and Section 2.4, Environmental Baseline, of this opinion, critical habitat cannot be designated for the sunflower sea star at this time because PBFs pertinent to the survival and persistence of the species have not been identified. The sunflower sea star is a broad habitat generalist.

In summary, the effects of the proposed action (Section 2.5), when added to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), and taking into account the status of the species, would not reduce the likelihood of both the survival and recovery of sunflower sea stars by reducing their numbers, reproduction, or distribution. Critical habitat has not been designated for this species, and will not be in the foreseeable future. Lack of substantial impacts on sunflower sea stars, based on the impacts of the fishery, supports the conclusion that the proposed fishing will not appreciably reduce the likelihood of survival and recovery of the species.

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 the cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of Puget Sound/Georgia Basin DPSs of yelloweye rockfish and bocaccio, the Southern DPS for green sturgeon, the Puget Sound Chinook salmon ESU, the Lower Columbia River Chinook salmon ESU, the Snake River fall Chinook salmon ESU, or the Lower Columbia River coho salmon ESU. We reach this conclusion because the mortality resulting from the Proposed Action, when combined with the mortality from other fishing and research within the environmental baseline, is unlikely to exceed levels that would hinder population viability.

Further, it is NMFS's biological opinion that the Proposed Action is not likely to destroy or adversely modify the critical habitat of the Puget Sound/Georgia Basin DPSs of yelloweye rockfish and bocaccio, the Southern DPS for green sturgeon, and the Puget Sound Chinook salmon ESU. The Proposed Action would have no effect to the designated critical habitat of the Snake River fall Chinook salmon ESU, the Lower Columbia River Chinook salmon ESU, or the Lower Columbia River coho salmon ESU.

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). "Harass" is further defined by interim guidance as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." "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 detailed below.

2.9.1.1. Puget Sound/Georgia Basin Rockfish

We anticipate that take of yelloweye rockfish and bocaccio of the Puget Sound/Georgia Basin DPSs will occur as a result of the proposed operation of the Pacific halibut fishery (the directed commercial halibut fishery, the tribal fishery, the IPHC FISS, and the recreational fishery). Incidental take of each species is expected to occur in the form of fatal injury as a result of incidental capture and handling in the fishery resulting from encounters with fishing gear and/or removal of captured fish from the water. Incidental take of each species under the proposed fishing is not expected to exceed 270 yelloweye rockfish and 40 bocaccio annually, all killed.

2.9.1.2. Southern Green Sturgeon

We anticipate that take of threatened Southern DPS green sturgeon will occur as a result of the proposed operation of the Pacific halibut fishery (the directed commercial halibut fishery, the tribal fishery, the IPHC FISS, and the recreational fishery). Incidental take of Southern DPS green sturgeon is expected to occur in the form of injury as a result of incidental capture and handling in the fishery, and with death resulting from encounter with fishing gear and/or removal of captured fish from the water. We expect incidental take of both adult and subadult Southern DPS green sturgeon. Incidental take of Southern DPS green sturgeon under the proposed fishing is not expected to exceed three fish per year. Lethal take of Southern DPS green sturgeon in the proposed fishing is not expected to exceed one fish per year. Lethal takes are expected to be delayed mortalities after release of the fish back into the water.

2.9.1.3. Puget Sound Chinook Salmon, Lower Columbia River Chinook and Coho Salmon, and Snake River Fall Chinook Salmon

We anticipate that take of listed Chinook and coho salmon will occur as a result of the proposed operation of the Pacific halibut fishery (the directed commercial halibut fishery, the tribal fishery, the IPHC FISS, and the recreational fishery). Salmon may be caught on the same fishing trip as halibut when both seasons coincide, but impacts on listed salmon stocks from that harvest have been evaluated in biological opinions for those salmon fisheries and are not part of the proposed action. We expect incidental take to occur in the form of injury and death from encounters with fishing gear and handling during times and areas where salmon fishing is otherwise closed. As discussed in Sections 2.7.3 through 2.7.6, and Tables 49-51, up to 18 Chinook and 15 coho (the average annual recreational fishery catch of coho and Chinook salmon) are expected to be encountered on average per year in the halibut recreational fishery. However, of the total Chinook and coho salmon that may be caught, only a small subset would involve take of ESA-listed Puget Sound Chinook salmon, Lower Columbia River Chinook and coho salmon, and Snake River fall Chinook salmon. Encounters at this level are expected to result in the take of less than two ESA-listed Puget Sound Chinook salmon, less than one Lower Columbia River Chinook, and less than one Snake River fall Chinook salmon on average per year. The expected take of ESA-listed Lower Columbia River coho is one fish per year on average. It is not practicable to monitor the take of listed fish, as opposed to Chinook and coho generally, for the following reasons: (1) individual salmon stocks are not visually distinguishable in the fisheries under the proposed action; (2) fish are more likely to survive if released as soon as possible after hooking; (3) because salmon retention is prohibited when salmon fishing is closed, genetic sampling to determine whether fish are listed would need to be done on-board, and would require keeping the fish out of water for a longer period; causing further injury or death. Therefore, we are using the overall number of Chinook and coho caught in the halibut fisheries outside of salmon fishing season as a surrogate for the numbers of listed species taken. We expect that the recreational halibut fishery will encounter a five-year running average not to exceed 18 Chinook and 15 coho encountered in times and areas not coincident with salmon fisheries; historically, these are recreational halibut fisheries in Puget Sound and in ocean waters off of the Washington and Oregon coasts.

2.9.1.4 Sunflower sea star

We anticipate that take of sunflower sea stars will occur as a result of the proposed operation of the Pacific halibut fishery. Sunflower sea stars may be encountered as bycatch in the FISS, non-tribal directed commercial fishery, and tribal commercial fishery. In most years, we expect that these three sources will result in take of as many as 37, 27, and 54 individuals, respectively, for a total of 118 affected sunflower sea stars. In hotspot years, however, these three sources could account for take levels as high as 329, 240, and 480 individuals, respectively, for a total of 1,049 individuals.

As monitoring identified to species is uncertain, and without the ability to predict which years are likely to represent hotspots, we anticipate annual combined take of sunflower sea stars associated with the proposed operation of the Pacific halibut fishery will be 1,049 individuals. Taking a conservative approach, full mortality is assumed.

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

2.9.3.1. Puget Sound/Georgia Basin Rockfish

1. NMFS shall coordinate and track monitoring of listed rockfish encounters in the proposed fisheries and research.
2. NMFS shall continue to coordinate the assessment of the efficacy of fishing regulations for halibut to support listed rockfish survival and recovery.

2.9.3.2. Green Sturgeon

We include the following reasonable and prudent measure to improve our knowledge of the incidental take of Southern DPS green sturgeon in the Proposed Action. Although the expected incidental capture and associated mortality of Southern DPS green sturgeon per year is relatively low, there are uncertainties regarding the number of encounters per year and the life stage and DPS of the green sturgeon encountered.

1. NMFS shall coordinate and track monitoring of green sturgeon encounters in the proposed fisheries and research.

2.9.3.3. Puget Sound Chinook Salmon, Lower Columbia River Chinook and Coho Salmon, and Snake River Fall Chinook Salmon

We include the following reasonable and prudent measure to improve our knowledge of the incidental take of Puget Sound Chinook salmon, Lower Columbia River Chinook and coho salmon, and Snake River fall Chinook salmon in the Proposed Action. Although the expected take of each ESU per year is extremely low, monitoring is important to assess any changes in the level or distribution of take.

1. NMFS shall continue to coordinate monitoring and documentation of salmon caught in the proposed fisheries and research.

2.9.3.4 Sunflower Sea Star

1. NMFS shall coordinate and track monitoring of sunflower sea star encounters in the proposed fisheries and research.
2. NMFS shall work with fishery regulators and research scientists to enhance identification and species-specific reporting of sunflower sea stars when and where they are encountered.

2.9.4. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. 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.

2.9.4.1. Puget Sound/Georgia Basin Rockfish

Terms and conditions specific to the above identified reasonable and prudent measures for rockfish are identified below.

1. NMFS shall coordinate with the relevant entities (e.g., tribes, state fishery management agencies, IPHC) to develop and implement consistent methods to monitor, document, and report listed rockfish encounters in the proposed fisheries and research. The report should be sent to NMFS by December 31st of each year and include species compositions and locations of encounters (i.e., Marine Catch Areas as defined by the WDFW).
2. NMFS shall continue to coordinate with the relevant entities (e.g., tribes, state fishery management agencies, IPHC) to assess the efficacy of fishing regulations for halibut that support the survival and recovery of listed rockfish. These assessments shall include commercial and recreational sector compliance with regulations, reporting of rockfish bycatch, and spatial analysis of fishing effort and fishing methods.

2.9.4.2. Green Sturgeon

Terms and conditions specific to the above identified reasonable and prudent measure for green sturgeon are identified below.

1. NMFS shall coordinate with the relevant entities (e.g., tribes, state fishery management agencies, IPHC) to develop and implement consistent methods to monitor, document, and report green sturgeon encounters in the proposed fisheries. At a minimum, a description of the monitoring methods and the following data should be recorded and reported to NMFS for the proposed fisheries each year: the number of green sturgeon encountered (including if no green sturgeon were encountered that year); the disposition of the fish (e.g., retained, released dead, released alive); and the date, location, fishery sector, gear used, and any other available information about the capture (e.g., depth fished, fish length).

2.9.4.3. Puget Sound Chinook Salmon, Lower Columbia River Chinook and Coho Salmon, and Snake River Fall Chinook Salmon

Terms and conditions specific to the above identified reasonable and prudent measure for listed Puget Sound Chinook salmon, Lower Columbia River Chinook and coho salmon, and Snake River fall Chinook salmon are identified below.

1. NMFS shall coordinate with the relevant entities (e.g., tribes, state fishery management agencies, IPHC) to develop and implement consistent methods to monitor, document, and report salmon caught in the proposed fisheries and research. At a minimum, a description of the monitoring methods and the following data should be recorded and reported to NMFS for the proposed fisheries each year: the number of salmon encountered by species (including if none were encountered that year); the disposition of the fish (e.g., retained, released dead, released alive); and the date, marine management area, fishery sector, and gear used. This requirement should be coordinated with the similar term and condition for rockfish and green sturgeon described above for efficiency in reporting and workload.

2. The reports described in (a) above should also include a 5-year running average of the number of salmon encountered in the Puget Sound and ocean commercial and recreational halibut fisheries.

2.9.4.4. Sunflower Sea Star

1. NMFS shall coordinate with the relevant entities (e.g., tribes, state fishery management agencies, IPHC) to develop and implement consistent methods to monitor, document, and report sunflower sea stars in the proposed fisheries and research. The report should be sent to NMFS by December 31st of each year and include species compositions and locations of encounters (i.e., Marine Catch Areas as defined by the WDFW).

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).

2.10.1. Listed Rockfish

The following two conservation recommendations are provided to better understand the incidental take of listed rockfish in the proposed fishery and its effects.

1. NMFS should work with the appropriate entities (e.g., tribes, state fishery management agencies, IPHC) to collect information on precisely where the fishery occurs within the rockfish DPSs area. This information would further enable an assessment of the future bycatch risk of the fishery, as well as the future need to develop Rockfish Conservation Areas and other measures to avoid and reduce bycatch to a level that enables population survival and recovery.

2. NMFS should work with the appropriate entities (e.g., tribes, state fishery management agencies, IPHC) on the feasibility of collecting biological samples from any yelloweye rockfish and bocaccio captured in the proposed Pacific halibut fishery in Puget Sound. Information to collect for each fish would include fork length, weight, external tags, and a tissue sample (i.e., a small fin clip for genetic analysis).

2.10.2. Green Sturgeon

The following conservation recommendation is provided to better understand the incidental take of Southern DPS green sturgeon in the proposed fishery and its effects.

1. NMFS should work with the appropriate entities (e.g., tribes, state fishery management agencies, IPHC) on the feasibility of collecting biological sampling information from any green sturgeon captured in the proposed Pacific halibut fishery. Information to collect for each fish would include fork length, a tissue sample (a small fin clip, for genetic analysis), and fish condition (e.g., alive, dead, any injuries). A photograph of the animal on a length board is also considered useful when feasible. This information would allow determination of whether the fish is an adult or subadult and to which DPS it belongs.

2.11. "Not Likely to Adversely Affect" Determinations

2.11.1. Southern DPS Green Sturgeon Critical Habitat

Designated critical habitat for Southern DPS green sturgeon includes coastal marine waters shallower than 60 fathoms (approximately 360.89 feet or 110 m) from Monterey Bay, California to the Canadian border, including Monterey Bay and the Strait of Juan de Fuca (74 FR 52300, October 9, 2009). The PBFs essential for species conservation are: (a) a migratory pathway necessary for the safe and timely passage of Southern DPS green sturgeon within marine habitat and between estuarine and marine habitats; (b) suitable water quality (e.g., adequate dissolved oxygen levels and acceptably low levels of contaminants that may disrupt the normal behavior, growth, and viability of subadult and adult green sturgeon); and (c) food resources, likely to include benthic invertebrates and fish species similar to those fed upon by green sturgeon in bays and estuaries, including crangonid and callianassid shrimp, Dungeness crab, mollusks, amphipods, and small fish such as sand lances (*Ammodytes* spp.) and anchovies (Engraulidae) (Moyle 2002; Dumbauld et al. 2008).

The recreational and commercial fisheries, as well as the IPHC FISS, described in the Proposed Action would occur in designated critical habitat for green sturgeon, but would not be expected to measurably change the PBFs or disrupt the ability of Southern DPS green sturgeon to use these habitats for feeding and migration. Jigs, weights, and hooks used by recreational anglers and commercial fishermen have the potential to alter benthic habitats by snagging structure, and some gear could be lost. However, we expect impacts on benthic habitat to be minimal, short-term, transitory, and limited to very small spatial scales given the gear used in the fishery. Pacunski et al. (2013) evaluated the effects of lost recreational fishing gear in WDFW habitat surveys in Puget Sound and did not observe adverse effects on the seafloor from this gear. We would also expect little to no effects on benthic habitat in coastal marine waters. In addition, we would expect minimal impacts of the proposed fishing on green sturgeon prey resources, because the fish species typically caught in the fishery are not species preyed upon by green sturgeon. We conclude that any effects on green sturgeon critical habitat would be insignificant, and therefore the Proposed Action is not likely to adversely affect designated green sturgeon critical habitat.

2.11.2. Salmon and Steelhead (15 Salmon ESUs and 11 Steelhead DPSs) and Designated Critical Habitat

Fishing effort and distribution described in the proposed action is anticipated to be similar to that of the period used in the analysis, discussed in previous sections of this opinion. Fishing vessels and gear would have a short-term presence in any specific location. Commercial fishing seasons are very short, and operate in waters up to 150 fathoms (274 m) in open waters, and the IPHC FISS and tribal fishery have a similarly low impact. Gear used in the recreational fishery are not expected to impact critical habitat. The following analyses are based on this assumption.

Based on the low potential for exposure, as described in the effects analysis in Section 2.5.3, listed salmon ESUs or steelhead DPSs, other than the Snake River fall Chinook salmon, Puget Sound Chinook salmon, Lower Columbia River Chinook salmon, and Lower Columbia River coho salmon ESUs, are not expected to be taken. Any encounters with these ESUs and DPS would be rare and the effects discountable in the proposed fisheries. Therefore, we determine that the proposed fishing may affect, but is not likely to adversely affect, any of those other salmon ESUs or steelhead DPSs or their critical habitat (see Table 58).

None of the listed salmon ESUs or steelhead DPSs include marine areas as part of their designated critical habitat. The fisheries in Puget Sound under the Proposed Action occur in deeper waters beyond the boundaries of critical habitat defined for the Puget Sound Chinook and Hood Canal Summer Chum Salmon ESUs. or the Puget Sound Steelhead DPS. As a result, the proposed fisheries will have no effect on the critical habitat of those other salmon ESUs or steelhead DPSs.

Table 58. Listing status and critical habitat designations for salmon species considered in this opinion (listing status: "T" means listed as threatened under the ESA; "E" means listed as endangered). Bolded rows are considered further in this Biological Opinion in Section 2.

Species	Listing Status	Critical Habitat
Chinook salmon (*Oncorhynchus tshawytscha*)		
Puget Sound	**T: 6/28/05 (70 FR 37160)**	**09/02/05 (70 FR 52488)**
Upper Columbia River spring-run	E: 6/28/05 (70 FR 37160)	09/02/05 (70 FR 52488)
Snake River spring/summer run	T: 6/28/05 (70 FR 37160)	10/25/99 (64 FR 57399)
Snake River fall-run	**T: 6/28/05 (70 FR 37160)**	**12/28/93 (58 FR 68543)**
Upper Willamette River	T: 6/28/05 (70 FR 37160)	09/02/05 (70 FR 52488)
Lower Columbia River	**T: 6/28/05 (70 FR 37160)**	**09/02/05 (70 FR 52488)**
California Coastal	T: 6/28/05 (70 FR 37160)	09/02/05 (70 FR 52488)
Central Valley spring-run	T: 6/28/05 (70 FR 37160)	09/02/05 (70 FR 52488)
Sacramento River winter-run	E: 6/28/05 (70 FR 37160)	06/16/93 (58 FR 33212)
Chum salmon (*O. keta*)		
Hood Canal summer-run	T: 6/28/05 (70 FR 37160)	09/02/05 (70 FR 52488)
Columbia River	T: 6/28/05 (70 FR 37160)	09/02/05 (70 FR 52488)
Coho salmon (*O. kisutch*)		
Lower Columbia River	**T: 6/28/05 (70 FR 37160)**	**02/24/16 (81 FR 9252)**
Oregon Coast	T: 2/11/08 (73 FR 7816)	2/11/08 (73 FR 7816)
S. Oregon/ N. California Coast	T: 6/28/05 (70 FR 37160)	05/5/99 (64 FR 24049)
Central California Coast	E: 6/28/05 (70 FR 37160)	05/5/99 (64 FR 24049)
Sockeye salmon (*O. nerka*)		
Ozette Lake	T: 6/28/05 (70 FR 37160)	09/02/05 (70 FR 52488)
Snake River	E: 6/28/05 (70 FR 37160)	12/28/93 (58 FR 68543)
Steelhead *(O. mykiss)*		
Puget Sound Steelhead	T: 5/11/07 (72 FR 26722)	02/24/16 (81 FR 9252)
Upper Columbia River	T: 8/24/09 (74 FR 42605)	09/02/05 (70 FR 52488)
Snake River Basin	T: 1/5/06 (71 FR 834)	09/02/05 (70 FR 52488)
Middle Columbia River	T: 1/5/06 (71 FR 834)	09/02/05 (70 FR 52488)
Upper Willamette River	T: 1/5/06 (71 FR 834)	09/02/05 (70 FR 52488)
Lower Columbia River	T: 1/5/06 (71 FR 834)	09/02/05 (70 FR 52488)

Species	Listing Status	Critical Habitat
Northern California	T: 1/5/06 (71 FR 834)	09/02/05 (70 FR 52488)
California Central Valley	T: 1/5/06 (71 FR 834)	09/02/05 (70 FR 52488)
Central California Coast	T: 1/5/06 (71 FR 834)	09/02/05 (70 FR 52488)
South-Central California Coast	T: 1/5/06 (71 FR 834)	09/02/05 (70 FR 52488)
Southern California	E: 1/5/06 (71 FR 834)	09/02/05 (70 FR 52488)

2.11.3. Marine Mammals and Sea Turtles

In this section, we analyze effects of the proposed action on ESA-listed marine mammals and sea turtles (blue whales, fin whales, humpback whales, Northern Pacific right whales, sei whales, sperm whales, Southern Resident killer whales and their critical habitat, Western North Pacific (WNP) gray whales, Guadalupe fur seals, green sea turtles, olive ridley sea turtles, loggerhead sea turtles, and leatherback sea turtles and their critical habitat) (Table 59). We first discuss the status and the likelihood of occurrence for ESA-listed marine mammals and sea turtles in the action area, and then discuss the potential effects of the Proposed Action.

Table 59. ESA-listed marine mammals and sea turtles occurring in the action area and not likely to be adversely affected.

ESA-Listed Species	Status
Blue whales (*Balaenoptera musculus*)	Endangered
Fin whales (*Balaenoptera physalus*)	Endangered
Humpback whales (*Megaptera novaeangliae*) Central American DPS	Endangered
Humpback whales (*Megaptera novaeangliae*) Mexico DPS	Threatened
North Pacific right whales (*Eubalaena japonica*)	Endangered
Sei whales (*Balaenoptera borealis*)	Endangered
Southern Resident killer whales (*Orcinus orca*)	Endangered
Sperm whales (*Physeter microcephalus*)	Endangered
Western North Pacific Gray whales (*Eschrichtius robustus*)	Endangered
Guadalupe fur seals (*Arctocephalus townsendi*)	Threatened
Green sea turtles (*Chelonia mydas*) East Pacific DPS	Endangered
Leatherback sea turtles (*Dermochelys coriacea*)	Endangered
Loggerhead sea turtles (*Caretta caretta*) North Pacific DPS	Threatened
Olive ridley sea turtles (*Lepidochelys olivacea*)	Endangered

2.11.3.1. Status and Occurrence within the Action Area

Blue Whales

Blue whales were listed as endangered worldwide under the precursor to the ESA, the Endangered Species Conservation Act (ESCA) of 1969, and remained on the list of threatened and endangered species after the passage of the ESA in 1973. Currently, there is no designated critical habitat for blue whales. We issued the final recovery plan for blue whales in July 1998 (NMFS 1998).

Blue whales make seasonal migrations between feeding and breeding locations, with their distribution often being linked to the patterns of aggregated prey. Like other baleen whales, the seasonal and inter-annual distribution of blue whales is strongly associated with both the static and dynamic oceanographic features such as upwelling zones that aggregate their prey (krill, *Euphausia pacifica*) (see Croll et al. 2005 for a recent review).

Blue whales are currently separated into two populations; the eastern and western north Pacific (Carretta et al. 2017). Their population structure has been studied through photo identification, acoustic, and genetic analyses showing both geographic isolation and overlap of some subpopulations. The blue whales most likely to be observed within the action area are identified as part of the Eastern North Pacific (ENP) stock. The ENP stock of blue whales ranges from the northern Gulf of Alaska to the eastern tropical Pacific (Carretta et al. 2017). Nine biologically important areas for blue whale feeding are identified off the California coast (Calambokidis et al. 2015). Most of this stock is believed to migrate south to spend the winter and spring in high productivity areas off Baja California, in the Gulf of California, and on the Costa Rica Dome. Blue whales occur primarily in offshore deep waters (but sometimes near shore, e.g., the deep waters in Monterey Canyon, CA) and feed almost exclusively on euphausiids.

The best estimate of blue whale abundance in the U.S. West Coast feeding stock component of the Eastern North Pacific stock is 1,647 for 2008 to 2011 (Calambokidis and Barlow 2013; Carretta et al. 2017). The minimum population size is approximately 1,551 blue whales with a calculated potential biological removal (PBR, which is defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population) allocation for U.S. waters of 2.3 whales per year (Carretta et al. 2017). The observed annual incidental mortality and serious injury rate from ship strikes (0.9 per year) is less than the calculated PBR for this stock. This rate, however, does not include unidentified large whales struck by ships, nor does it include undetected and unreported ship strikes of blue whales. In the California Current, the number of blue whales struck by ships likely exceeds the PBR for this stock (Redfern et al. 2013). To date, no blue whale mortality has been associated with U.S. west coast fisheries; therefore, total fishery mortality is approaching a zero mortality and serious injury rate (a standard under the MMPA) (Carretta et al. 2017). However, in 2015 and 2016, NMFS received the first confirmed reports of entangled blue whales along the U.S. west coast, although the ultimate fate of these animals is unknown, and these events have not yet been evaluated for potential mortality and serious injury (NMFS WCR stranding data, 2017).

Fin Whales

Fin whales were listed as endangered worldwide under the precursor to the ESA, the ESCA of 1969, and remained on the list of threatened and endangered species after the passage of the ESA in 197. Currently, there is no designated critical habitat for fin whales. We issued the final recovery plan for fin whales in July 2010 (NMFS 2010c).

Fin whales are distributed widely in the world's oceans and occur in both the Northern and Southern Hemispheres. In the northern hemisphere, they migrate from high Arctic feeding areas to low latitude breeding and calving areas. The North Pacific population summers from the Chukchi Sea to California, and winters from California southward. Fin whales have also been observed in the waters around Hawaiʻi. Fin whales can occur year-round off California, Oregon, and Washington (Carretta et al. 2017), with recent information suggesting that fin whales are present year-round in southern California waters, as evidenced by individually identified whales being photographed in all four seasons (Falcone and Schorr 2013). The fin whales most likely to be observed within the action area are identified as part of the CA/OR/WA stock.

The best estimate of fin whale abundance in California, Oregon, and Washington waters out to 300 nautical miles is 9,029 whales for 2014, based on trend-model analysis of line-transect data from 1991 through 2014 (Nadeem et al. 2016). The minimum population estimate is 8,127 fin whales with a calculated PBR of 81 whales per year (Carretta et al. 2017). The total documented incidental mortality and serious injury (2.0 per year) because of fisheries (0.2 per year) and ship strikes (1.8 per year) is less than the PBR (Carretta et al. 2017). Fin whales were involved in 23 ship strikes on the U.S. West Coast since 2008 with 19 reported in California and four reported in Washington (Carretta et al. 2022; NMFS WCR Stranding database).

There have been nine reports of fin whale entanglements in the U.S. West Coast since 1999 (Saez et al. 2021; Carretta et al. 2022). All of these reports, except one, have been in unidentified fishing gear. Additionally, all of the entanglements have been reported in California with the exception of a 2006 report in Washington. Carretta et al. (2022) estimates a mean annual mortality and serious injury of 0.64 whales for the CA/OR/WA fin whale stock from fishery interactions.

Humpback Whales (Central American DPS, Mexico DPS)

Humpback whales were listed as endangered under the ESCA in June 1970 (35 FR 18319, December 2, 1970), and remained on the list of threatened and endangered species after the passage of the ESA in 1973. A recovery plan for humpbacks was issued in November 1991 (NMFS 1991).

On September 8, 2016, NMFS published a final rule to divide the globally listed endangered humpback whale into 14 DPSs and listed four DPSs as endangered and one as threatened (81 FR 62259). NMFS has identified three DPSs of humpback whales that may be found off the coasts of Washington, Oregon, and California. These are the Hawaiian DPS (found predominately off Washington and southern British Columbia [SBC]) which is not listed under the ESA; the Mexico DPS (found all along the U.S. west coast), which is listed as threatened under the ESA; and the Central America DPS (found predominantly off the coasts of Oregon and California), which is listed as endangered under the ESA. Humpback whales are found in all oceans of the world and migrate from high latitude feeding grounds to low latitude calving areas. Humpbacks primarily occur near the edge of the continental slope and deep submarine canyons where upwelling concentrates zooplankton near the surface for feeding. Humpback whales feed on euphausiids and various schooling fishes, including herring, capelin, sand lance, and mackerel (Clapham 2009).

Current MMPA Stock Assessment Reports (SARs) for humpback whales on the west coast of the United States do not reflect the new ESA listings; thus, we will refer in part to the status of the populations that are found in the action area using the existing SARs (Carretta et al. 2017). The CA/OR/WA stock spends the winter primarily in coastal waters of Mexico and Central America, and the summer along the West Coast from California to British Columbia. As a result, both the endangered Central America DPS and the threatened Mexico DPS both at times travel and feed off the U.S. west coast. The Central North Pacific stock primarily spends winters in Hawaii and summers in Alaska, and its distribution may partially overlap with that of the CA/OR/WA stock off the coast of Washington and British Columbia (Clapham 2009). There is some mixing between these populations, though they are still considered distinct stocks. Seven biologically important areas for humpback whale feeding are identified by Calambokidis et al. (2015), including five in California, one in Oregon, and one in Washington.

Based on the presence of both listed DPSs along the West Coast of the U.S. (Wade et al 2016) this analysis evaluates impacts on both the Central American and Mexico DPSs of humpback whales, as both are expected to occur in the action area.

Current estimates of abundance for the Central America DPS range from approximately 400 to 600 individuals (Bettridge et al. 2015; Wade et al. 2016). The size of this population is relatively low compared to most other North Pacific breeding populations. The population trend for the Central America DPS is unknown (Bettridge et al. 2015). The Mexico DPS, which also occurs in the action area, is estimated to be 6,000 to 7,000 from the SPLASH project (Calambokidis et al. 2008) and in the status review (Bettridge et al. 2015). The estimate for the abundance of the CA/OR/WA stock, which combines members of several different humpback whale DPSs, is 1,918 animals (Carretta et al 2017).

The impact of fisheries on the CA/OR/WA humpback whale stock is likely underestimated, since the serious injury or mortality of large whales due to entanglement in gear may go unobserved because whales swim away with a portion of the net, line, buoys, or pots. Pot and trap gear are the most commonly documented source of mortality and serious injury to humpback whales off the U.S. West Coast (Carretta et al. 2022a; Carretta et al. 2022b) and entanglement reports have increased considerably since 2014. Between 2016 and 2020, 257 large whales were reported as having human-caused serious injuries or mortalities. Of these, 153 were humpback whales (Carretta et al. 2022a). An additional 34 humpback whales were confirmed as entangled from 2021 to 2022 (NOAA Fisheries 2022; 2023). There was a record high of 53 reported entanglements in 2016, of which 48 were confirmed (Saez et al. 2021). From 2015-19, the mean serious injury/ mortality estimates for the CA/OR/WA stock due to commercial fishery entanglements (at least 24.9/yr30), non-U.S. commercial sources (1.4/yr31) and estimated ship strikes (22/yr) equals 48.3 animals, which exceeds the stock's Potential Biological Removal (PBR) of 29.4 animals in U.S. waters (Carretta et al. 2022b). Based on strandings and at-sea observations, annual humpback whale mortality and serious injury in commercial fisheries (24.9/yr) is less than the PBR of 29.4; however, if methods were available to correct for undetected serious injury and mortality, total fishery mortality and serious injury would likely exceed PBR. The estimates of whale entanglements are minimum counts since many of these interactions likely go unnoticed. Tackaberry et al. (2022) found that the entangled whales were resighted less often than control groups. They also found that the risk of entanglement may be higher for younger whales than for mature individuals who may be able to self-release from gear more successfully.

Vessel strikes are likely the second greatest cause of death for humpback whales along the U.S. west coast, behind entanglements (Rockwood et al. 2017). Humpback whales, especially calves and juveniles, are highly vulnerable to ship strikes (Stevick et al. 1999) and other interactions with non-fishing vessels. Humpback whales spend the vast majority of their time within 30 meters of the sea surface (90 percent at night and 69 percent during daytime), increasing their risk of vessel strike (Calambokidis et al. 2019). Off the U.S. west coast, humpback whale distribution overlaps significantly with the transit routes of large commercial vessels, including cruise ships, large tug and barge transport vessels, and oil tankers, along with fishing vessels (Rockwood et al. 2017; Greig et al. 2020; Redfern et al. 2020). Rockwood et al. (2017) modeled ship strikes along the west coast and determined there were an average of 2.8 humpback whale strikes per year from 2006 to 2016, with a minimum of 8.2 and a best estimate of 28 deaths over the 10-year time period based on carcass buoyancy; however, this may be underestimating the avoidance behavior of humpback whales (Lesage et al. 2017; Garrison et al. 2022; Schuler et al. 2019). San Francisco Bay, Santa Barbara Channel, and the Strait of Juan de Fuca have all been identified as high risk areas of vessel strike for humpback whales (Nichol et al. 2017; Rockwood et al. 2020; 2021).

North Pacific Right Whales

We listed northern right whales as endangered under the ESCA in December 1970 (35 FR 18319, December 2, 1970). In 2008, NMFS reclassified the northern right whale as two separate endangered species, North Pacific right whale (*E. japonica*) and North Atlantic right whale (*E. glacialis*) (73 FR 12024, March 6, 2008). We issued the final recovery plan for North Pacific right whales in June 2013 (NMFS 2013b).

Right whales primarily occur in coastal or shelf waters, although movements over deep waters are known. Sightings have been reported as far south as central Baja California in the eastern North Pacific, as far south as Hawaii in the central North Pacific, and as far north as the subarctic waters of the Bering Sea and Sea of Okhotsk in the summer (Herman et al. 1980; Berzin and Doroshenko 1982; Brownell et al. 2001). However, most recent sightings have occurred in the southeast Bering Sea and in the Gulf of Alaska (Waite et al. 2003; Shelden et al. 2005; Wade et al. 2011a, 2011b). Migratory patterns of the North Pacific right whale are unknown, although it is thought the whales spend the summer on high-latitude feeding grounds and migrate to more temperate waters during the winter, possibly well offshore (Braham and Rice 1984; Scarff 1986; Clapham et al. 2004).

Mark-recapture estimates of abundance of right whales in the Bering Sea and Aleutian Islands using photographic and genotype data through 2008 resulted in 31 and 28 right whales, respectively (Wade et al. 2011a). The minimum population estimate is 26 whales with a calculated PBR of 0.05 (Muto et al. 2017). Although gillnets were implicated in the death of a right whale off Russia in 1989 (Kornev 1994), a photograph in the catalogue shows potential fishing gear entanglement (A. Kennedy, NMFS-AFSC-MML, pers. comm., September 21, 2011), and a photograph from October 2013 off British Columbia and northern Washington State showed potential fishing gear entanglement (Ford et al. 2016a), there are no records of fisheries mortalities of eastern North Pacific right whales. However, given the remote nature of the known and likely habitats of North Pacific right whales, it is very unlikely that any mortality in this population would be observed. Consequently, it is possible that the current absence of reported deaths in this stock is not a reflection of the true situation (Muto et al. 2017).

Sei Whales

We listed sei whales as endangered under the ESCA in December 1970 (35 FR 18319, December 2, 1970). The ESA replaced the ESCA in 1973 and continued to list sei whales as endangered. We issued the final recovery plan for sei whales in December 2011 (NMFS 2011d).

Sei whales have a worldwide distribution, but are found primarily in cold temperate to subpolar latitudes rather than in the tropics or near the poles (Horwood 2009). Sei whales spend the summer months feeding in subpolar higher latitudes and return to lower latitudes to calve in the winter. There is some evidence from whaling catch data of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males. For the most part, the location of winter breeding areas is unknown (Horwood 2009). Sei whales are most often found in deep, oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins situated between banks and ledges. On feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood 2009). In the North Pacific, sei whales feed along the cold eastern currents (Perry et al. 1999). Prey includes calanoid copepods, krill, fish, and squid.

Sei whales in the Eastern North Pacific are considered a separate stock (Carretta et al. 2017). The best estimate of abundance for California, Oregon, and Washington waters out to 300 nautical miles is 519 sei whales, the unweighted geometric mean of the 2008 and 2014 estimates (Barlow 2016). The minimum population estimate is 374, with a calculated PBR of 0.75 sei whales per year (Carretta et al. 2017). Total estimated fishery mortality is zero and therefore is approaching zero mortality and serious injury rate. One ship strike death was reported in Washington in 2003. Although sei whales may account for some of the unidentified large whales reportedly injured by ship strikes, the average observed annual mortality due to ship strikes is zero for the period 2010 to 2014 (Carretta et al. 2017).

Southern Resident Killer Whales

The Southern Resident killer whale DPS was listed as endangered on February 16, 2006 (70 FR 69903), and a recovery plan was completed in 2008 (NMFS 2008b). A 5-year review under the ESA completed in 2021 concluded that Southern Residents should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2021f). Critical habitat in inland waters of Washington was designated on November 29, 2006 (71 FR 69054).

Several factors identified in the final recovery plan for Southern Resident killer whales may be limiting recovery including quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. It is likely that multiple threats are acting together to impact the whales. Although it is not clear which threat or threats are most critical to the survival and recovery of Southern Residents, all of the threats identified are potential limiting factors in their population dynamics (NMFS 2008b).

Southern Resident killer whales consist of three pods (J, K, and L) and inhabit 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 2008b; Hanson et al. 2013, Carretta et al.

2017). During the spring, summer, and fall months, the whales spend a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Hauser et al. 2007; Bigg 1982; Ford 2000; Krahn et al. 2002; Hanson and Emmons 2010; Whale Museum unpubl. data). All three pods generally remain in the Georgia Basin through October and make frequent trips to the outer coasts of Washington and southern Vancouver Island and are occasionally sighted as far west as Tofino and Barkley Sound (Ford 2000; Hanson and Emmons 2010, Whale Museum unpubl. data).

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

Southern Resident killer whales consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998; Ford 2000; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016b), but salmon are identified as their primary prey. Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. Scale and tissue sampling from May to September indicate that their diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90%) (Hanson et al. 2010; Ford et al. 2016b). The diet data also indicates that the whales are consuming mostly larger (i.e., older) Chinook. 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. (2016b) confirmed the importance of Chinook salmon to the Southern Residents in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98% of the inferred diet, of which almost 80% were Chinook salmon. Coho salmon and steelhead are also found in the diet in spring and fall months when Chinook salmon are less abundant. Specifically, coho salmon contribute to over 40% of the diet in late summer, which is evidence of prey shifting at the end of summer towards coho salmon (Ford et al. 1998; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016b). Less than 3% each of chum salmon, sockeye salmon, and steelhead were observed in fecal DNA samples. Observations of whales overlapping with salmon runs (Wiles 2004, Zamon et al. 2007, Krahn et al. 2009) and collection of prey and fecal samples have also occurred in the winter months. Preliminary analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicated the majority of prey samples were Chinook salmon (80% of prey remains and 67% of fecal samples were Chinook salmon), with a smaller number of steelhead, chum salmon, and halibut (NWFSC unpubl. data). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring Chinook salmon in their diet (Hanson et al. 2013). Chinook genetic stock identification included 12 U.S. west coast stocks, and over half the Chinook salmon consumed originated in the Columbia River (NWFSC unpubl. data).

NMFS has continued to fund the Center for Whale Research to conduct an annual census of the Southern Resident population. As of July 2017, Southern Residents totaled 77 individuals (24 in J pod, 18 in K pod, and 35 in L pod). Since the July census, an additional member died and the current population totals 76 individuals. The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated the work on population viability analyses conducted for the 2004 Status Review for Southern Resident Killer Whales and a science panel review of the effects of salmon fisheries (Krahn et al. 2004; Hilborn et al. 2012; Ward et al. 2013). Following from that work, the data now suggests a downward trend in population growth projected over the next 50 years (Figure 40). As the model projects out over a longer time frame (50 years) there is increased uncertainty around the estimates; however, if all of the parameters in the model remain the same, the overall trend shows a decline in later years. This downward trend is in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed over the period from 2011 to 2016 (Figure 2-15, NMFS 2016d). Recent evidence indicates pregnancy hormones (progesterone and testosterone) can be detected in Southern Resident killer whale feces and have indicated several miscarriages, particularly in late pregnancy (Wasser et al. 2017). The authors suggest this reduced fecundity is largely due to nutritional limitation.

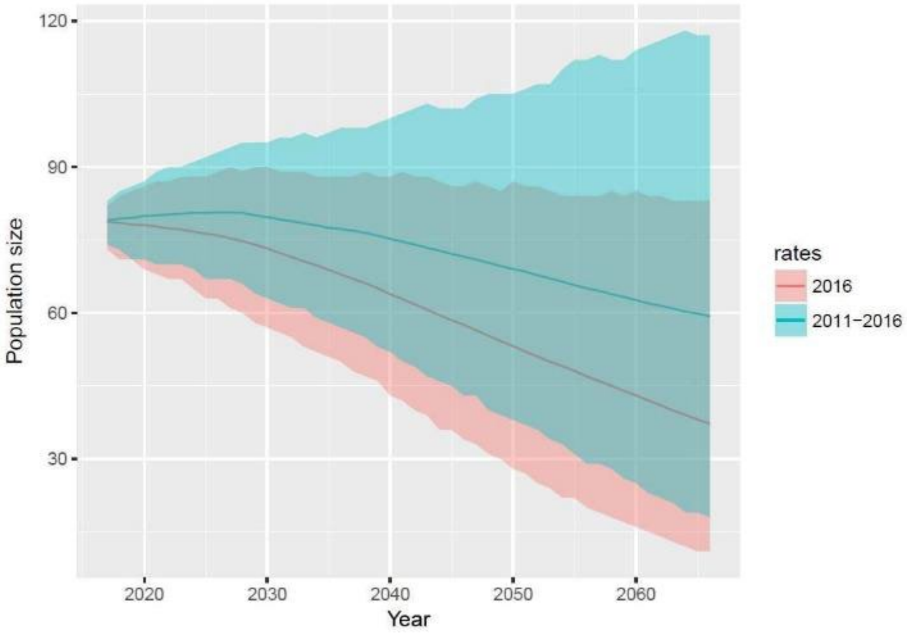

Figure 40. Southern Resident killer whale population size projections from 2016 to 2066 using 2 scenarios: (1) projections using demographic rates held at 2016 levels, and (2) projections using demographic rates from 2011 to 2016. The pink line represents the projection assuming future rates are similar to those in 2016, whereas the blue represents the scenario with future rates being similar to 2011 to 2016. (NMFS 2016d)

To explore potential demographic projections, Lacy et al. (2017) constructed a population viability assessment that considered sublethal effects and the cumulative impacts of threats (contaminants, acoustic disturbance, and prey abundance). They found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate. Furthermore, they suggested in order for the population to reach the recovery target of 2.3% 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).

The most recent PBR level for this stock is 0.14 whales per year, which was based on the minimum population size of 81 whales from the 2015 census. Total observed fishery mortality and serious injury for this stock is zero. There were no non-fishery human-caused mortalities or serious injuries reported from 2008–2014. The total estimated annual human-caused mortality and serious injury for this stock is, therefore, zero and does not exceed PBR (Carretta et al. 2017). In December 2016, a young adult male from J pod was struck and killed by a vessel in inland waters of British Columbia (DFO 2016).

Sperm Whales

We listed sperm whales as endangered under the ESCA in June 1970 (35 FR 18319, December 2, 1970). The ESA replaced the ESCA in 1973 and continued to list sperm whales as endangered. We issued the final recovery plan for sperm whales in December 2010 (NMFS 2010d).

As described by Carretta et al. (2017, and citations therein), populations of sperm whales exist in waters of the California Current Ecosystem throughout the year. They are distributed across the entire North Pacific and into the southern Bering Sea in summer, but the majority are thought to be south of 40ºN in winter. Sperm whales are found year-round in California waters, but they reach peak abundance from April through mid-June and from the end of August through mid-November. Acoustic detections of sperm whales in the offshore waters of the outer Washington coast occurred all months of the year, with peak occurrence April to August. Detections inshore from April to November were generally faint enough to suggest that the whales were offshore (Oleson et al. 2009). Sperm whales consume numerous varieties of deepwater fish and cephalopods.

The most recent abundance estimates for sperm whales off California, Oregon, and Washington out to 300 nautical miles were derived from trend-model analysis of line-transect data collected during six surveys from 1991 to 2008. Using this method, estimates ranged from 2,000 to 3,000 animals (Moore and Barlow 2014). The best estimate for the California Current (2,106 sperm whales) is the trend-estimate that corresponds with the 2008 survey (Carretta et al. 2017). The minimum population estimate is 1,332 whales and the calculated PBR is 2.7 sperm whales per year (Carretta et al. 2017; Moore and Barlow 2014). The mean annual estimated mortality and serious injury attributable to commercial fisheries interactions was 1.7 sperm whales per year, based on observer and stranding data from 2001 to 2012. There were no documented mortalities or serious injuries of sperm whales because of ship strikes from 2008 to 2012. The annual fishery-related and ship strike mortality and serious injury is less than PBR, but greater than 10 percent of PBR (Carretta et al. 2017).

Western North Pacific Gray Whales

Western North Pacific (WNP) gray whales were originally listed as endangered under the Endangered Species Conservation Act in June 1970 (35 FR 18319, December 2, 1970). WNP gray whales remain listed as endangered under the ESA (35 FR 8491). Currently, there is no recovery plan for this population.

There are two recognized gray whale stocks in the North Pacific, the WNP and the eastern North Pacific (ENP) which is no longer listed under the ESA after being delisted June 16, 1994 (59 FR 31094). Gray whales occur along the eastern and western margins of the North Pacific, generally migrating between summer feeding grounds in high latitudes and winter breeding grounds in lower latitudes. Gray whale migration is typically limited to relatively near shore areas along the North American west coast during the winter and spring months (November-May). Gray whales are bottom feeders, sucking in sediment and eating benthic amphipods.

Historically, the WNP gray whales were considered geographically isolated from the ENP stock; however, recent information is suggesting more overlap exists between these two stocks with WNP gray whales migrating along the U.S. west coast along with ENP gray whales. During the summer and fall, the WNP stock of gray whales feeds in the Okhotsk Sea, Russia and off Kamchatka in the Bering Sea (Carretta et al. 2017). Known wintering areas include waters off Korea, Japan, and China. However, recent tagging, photo-identification, and genetics studies found some WNP gray whales migrate to the eastern North Pacific in winter, including off Canada, the U.S., and Mexico (Lang et al. 2011; Mate et al. 2011; Weller et al. 2012; Urbán et al. 2013). Combined, these studies have identified 27 individual WNP gray whales in the Eastern North Pacific (Carretta et al. 2017). As a result, a portion of the WNP gray whale population is assumed to have migrated, at least in some years, to the eastern North Pacific during the winter breeding season.

Guadalupe Fur Seals

In the U.S., Guadalupe fur seals were listed as threatened under the ESA on December 16, 1985 (50 C.F.R. § 51252) and consequently are listed as depleted and a strategic stock under the MMPA. The population is considered a single stock because all are recent descendants from one breeding colony at Guadalupe Island, Mexico. Critical habitat has not been designated for this species in the U.S.

Guadalupe fur seals prefer shorelines with abundant large rocks and lava blocks and are often found at the base of steep cliffs and in caves and recesses, which provide protection and cooler temperatures, particularly during the summer breeding season (Aurioles-Gamboa 2015). There is little information on feeding habits of the Guadalupe fur seal, but it is likely that they feed on deep-water cephalopods and small schooling fish like their northern fur seal (*Callorhinus ursinus*) relatives (Seagars 1984). Researchers know little about the whereabouts of Guadalupe fur seals during the non-breeding season from September through May, but they are presumably solitary when at sea. While distribution at sea was relatively unknown until recently, Guadalupe fur seals are known to migrate at least 373 miles (600 km) from the rookery sites, based on observations of individuals by Seagars (1984). Recently, in 2016, satellite tags were attached to five pups on Guadalupe Island. Three pups that departed the island traveled north, from 124 to

808 miles (200 to 1,300 km) before the tags stopped transmitting. One of those pups was eventually found dead and emaciated in Coos Bay, Oregon (Norris et al. 2017). In recent years, Guadalupe fur seals have been increasing in numbers in the Channel Islands and several strandings have been observed along Washington, Oregon, and California coasts (Carretta et al. 2017).

Surveys conducted between 2008 and 2010 resulted in a total estimated population size of approximately 20,000 animals, with a PBR of 542 Guadalupe fur seals per year (Carretta et al. 2017). Between 2010 and 2014, there were 16 records of human-related deaths and/or serious injuries to Guadalupe fur seals from stranding data (Carretta et al. 2017). These strandings included entanglement in marine debris and gillnet of unknown origin, and shootings. The total U.S. fishery mortality and serious injury for this stock (≥ 3.2 animals per year) is less than 10 percent of the calculated PBR for the entire stock, but it is not currently possible to calculate a prorated PBR for U.S. waters with which to compare serious injury and mortality from U.S. fisheries.

Green Sea Turtle

On April 6, 2016, NMFS revised the listing of green sea turtles worldwide to 11 DPSs, including listing the East Pacific DPS as threatened (81 FR 20058). As summarized in the 2015 status review (Seminoff et al. 2015), increases in nesting females from the East Pacific DPS have been seen at the Mexican mainland nesting beaches, and the trend appears to be slightly increasing to stable at other major nesting beaches (e.g., Galápagos Islands, Ecuador). NMFS is currently reviewing the three green sea turtle DPSs found in U.S. waters (including the East Pacific DPS) to determine whether critical habitat should be designated.

Green sea turtles are found throughout the world, occurring primarily in tropical, and to a lesser extent, subtropical waters. The eastern Pacific population includes turtles that nest on the Pacific coast of Mexico, which have been historically listed under the ESA as endangered. Green sea turtles forage coastally from southern California in the northern latitudes to Mejillones, Chile, in the south. Green sea turtles rarely occur in the action area where the proposed fishing would occur.

NMFS and USFWS (2007a) provided population estimates and trend status for 46 green sea turtle nesting beaches around the world. Of these, twelve sites had increasing populations (based upon an increase in the number of nests over 20 or more years ago), four sites had decreasing populations, and ten sites were considered stable. For twenty sites, there are insufficient data to make a trend determination or the most recently available information is too old (15 years or older). A complete review of the most current information on green sea turtles is available in the 2015 Status Review (Seminoff et al. 2015).

Leatherback Sea Turtle

The leatherback sea turtle is listed as endangered under the ESA throughout its global range. On January 26, 2012, NMFS revised critical habitat for leatherback sea turtles to include additional areas within the Pacific Ocean (77 FR 4170). Leatherbacks are found throughout the world and populations and trends vary in different regions and nesting beaches. In the Pacific, leatherback nesting aggregations are found in the eastern and western Pacific. In the eastern Pacific, major nesting sites are located in Mexico, Costa Rica, and to a lesser extent, Nicaragua. Leatherback sea turtles are highly migratory, exploiting convergence zones and upwelling areas for foraging in the open ocean, along continental margins, and in archipelagic waters. Migratory routes of leatherback sea turtles originating from eastern and western Pacific nesting beaches are not entirely known for the entire Pacific population; however, satellite tracking of post-nesting females and foraging males and females, as well as genetic analyses of leatherback sea turtles caught in U.S. Pacific fisheries or stranded on the West Coast of the U.S. indicate that leatherbacks found off the U.S. West Coast are from the western Pacific nesting populations, specifically boreal summer nesters.

In 1980, the leatherback population was estimated at approximately 115,000 (adult females) globally (Pritchard 1982). By 1995, one estimate claimed this global population of adult females had declined to 34,500 (Spotila et al. 1996). In the Pacific, leatherback sea turtle populations are declining at all major Pacific basin nesting beaches, particularly in the last two decades (Spotila et al. 1996; Spotila et al. 2000; NMFS and USFWS 2007b). In the eastern Pacific, nesting counts indicate that the population has continued to decline since the mid-1990s, leading some researchers to conclude that leatherback sea turtles are on the verge of extirpation (Spotila et al. 1996; Spotila et al. 2000). Steep declines have been documented in Mexico and Costa Rica, the two major nesting sites for eastern Pacific leatherbacks. Recent estimates of the number of nesting females/year in Mexico and for Costa Rica is approximately 200 animals or fewer for each county per year (NMFS and USFWS 2013). Estimates presented at international conferences show the numbers declining even more in all of the major nesting sites in the eastern Pacific.

Loggerhead Sea Turtles, North Pacific DPS

Loggerhead sea turtles are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. Major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics. On September 22, 2011, the USFWS and NMFS published a final rule listing nine DPSs of loggerhead sea turtles (76 FR 58868). The North Pacific Ocean DPS of loggerheads, which is the population of loggerheads likely to be exposed to the proposed actions, was listed as endangered.

Loggerhead sea turtles that have been documented off the U.S. west coast are primarily found south of Point Conception, California in the Southern California Bight. Important juvenile turtle foraging areas have been identified off the coast of Baja California Sur, Mexico (Peckham and Nichols 2006; Peckham et al. 2007; Conant et al. 2009). Considerable effort has been spent studying the movements and relationships of juvenile loggerhead sea turtles in the central Pacific and off Baja and the west coast of the U.S. to understand migrations and/or developmental patterns across the North Pacific, but the ecology of juvenile loggerheads in the eastern Pacific is still not well understood.

The North Pacific loggerhead sea turtles DPS nests primarily in Japan (Kamezaki et al. 2003), although low level nesting may occur outside of Japan in areas surrounding the South China Sea (Conant et al. 2009). As discussed in the 2011 final ESA listing determination, current nesting in Japan represents a fraction of historical nesting levels (Conant et al. 2009; 76 FR 58868, September 22, 2011). Nesting declined steeply from an initial peak of approximately 6,638 nests in 1990 to 1991, to a low of 2,064 nests in 1997. Kamezaki et al. (2003) concluded a substantial decline (50 to 90 percent) in the size of the annual loggerhead nesting population in Japan since the 1950s. At the November 2011 Sea Turtle Association of Japan annual sea turtle symposium, the 2011 nesting numbers were reported to be slightly lower at 9,011 (Asuka Ishizaki, pers. comm. November 2011). The total number of adult females in the population was estimated at 7,138 for the period 2008–2010 by Van Houtan and Halley (2011).

Olive Ridley Sea Turtles

A 5-year status review of olive ridley sea turtles was completed in 2014 (NMFS and USFWS 2014). Although the olive ridley sea turtle is regarded as the most abundant sea turtle in the world, olive ridley nesting populations on the Pacific coast of Mexico are listed as endangered under the ESA; all other populations are listed as threatened. The status may be revised if and when the Services consider the significance and discreteness of olive ridleys on a global scale in order to determine whether there may be multiple DPSs.

Olive ridley sea turtles occur throughout the world, primarily in tropical and sub-tropical waters. Like leatherback turtles, most olive ridley sea turtles lead a primarily pelagic existence, migrating throughout the Pacific from their nesting grounds in Mexico and Central America to the deep waters of the Pacific that are used as foraging areas. While olive ridley sea turtles generally have a tropical to subtropical range with a distribution from Baja California, Mexico to Chile, individuals do occasionally venture north, some as far as the Gulf of Alaska. Olive ridleys live within two distinct oceanic regions, including the subtropical gyre and oceanic currents in the Pacific. The gyre contains warm surface waters and a deep thermocline preferred by olive ridley sea turtles.

Globally, olive ridleys are the most abundant sea turtle, but population structure and genetics are poorly understood for this species. It is estimated that there are over 1 million females nesting annually (NMFS and USFWS 2014). According to the Marine Turtle Specialist Group of the International Union for Conservation of Nature and Natural Resources (IUCN), there has been a 50 percent decline in olive ridleys worldwide since the 1960s, although there have recently been substantial increases at some nesting sites (NMFS and USFWS 2007c). The eastern Pacific population is thought to be increasing, while there is inadequate information to suggest trends for other populations. Eastern Pacific olive ridleys nest primarily in large *arribadas* on the west coasts of Mexico and Costa Rica. Since reduction or cessation of egg and turtle harvest in both countries in the early 1990s, annual nest totals have increased substantially. On the Mexican coast alone, in 2004 to 2006, the annual total was estimated at 1,021,500 to 1,206,000 nests annually (NMFS and USFWS 2007c). Eguchi et al. (2007) analyzed sightings of olive ridley sea turtles at sea, leading to an estimate of 1,150,000 to 1,620,000 turtles in the eastern tropical Pacific in 1998 to 2006.

2.11.3.2. Effects on ESA-Listed Marine Mammals and Sea Turtles and their Critical Habitat

The above ESA-listed marine mammals and sea turtles that may occur in the action area may be directly affected by the Proposed Action by interaction with vessels or gear or indirectly affected by reduced prey availability. Below, we describe these direct and indirect effects.

Entanglement of ESA-listed marine mammals is known to be an issue with commercial fishing gear on the U.S. west coast (Saez et al. 2013). Sea turtles are also vulnerable to bycatch in a variety of fisheries, including longline, that are operated on the high seas or in coastal areas throughout the species' range (e.g., Lewison et al. 2004; Peckham et al. 2007). For ESA-listed marine mammals and sea turtles that are likely to co-occur with the proposed fishery, there is a risk of becoming captured/entangled in longline gear. Interactions could result from direct predation of bait or depredation on fish that are already captured by the longline. Although sperm whales and killer whales are known to remove fish caught on longline hooks, potentially making them more susceptible to entanglement or other types of human-interaction (summarized in NWFSC 2012), this kind of depredation behavior is not known or observed to be a widespread problem off the U.S. west coast.

Interactions could also result from marine mammals and sea turtles unknowingly swimming into the gear and becoming entangled. Bottom longlines do present some risk of entanglement because of vertical lines running from the surface to the bottom, but gangions and hooks are relatively low in profile on the bottom and likely less vulnerable to hooking or predation by marine mammals than the profile of hooks suspended in the water column in pelagic longline gear. The general configuration of setting gear at bottom depths in coastal waters of Washington and Oregon also presents very little risk of sea turtle bycatch—sea turtles that may be in the area during the proposed fishing are not likely to spend any time at those bottom depths, and are only really at limited risk of entangling in the buoy lines at each of the longline strings. In a recent study, Saez et al. (2013) ranked the entanglement risk for the Pacific halibut longline fishery relatively low for blue whales, fin whales, humpback whales, and sperm whales (whales considered in their model). They suggested the fishery has a low entanglement risk to these species because of the relatively little overlap between the whales' presence and the fishing effort.

While there is a slight risk for marine mammal and sea turtle interactions with Pacific halibut longline gear, including entanglement in lines and/or being hooked during depredation on the bait or fish captured on the line, there have been no recorded incidents of ESA-listed marine mammal and sea turtle interactions in this fishery to date. The List of Fisheries for 2017 classified the North Pacific halibut longline fishery as a category III (i.e., remote likelihood of/no known incidental mortality or serious injury of marine mammals) as identified in the Federal Register (82 FR 3655, January 12, 2017). At this time, we conclude that the lack of historical incidental capture or entanglements between survey gear and ESA-listed marine mammal and sea turtle species, even when risks of such interactions have been and continue to remain possible, is a reflection of the low co-occurrence of the species and the fishing effort. Given the historical performance of the Pacific halibut fishery, we conclude that the likelihood of incidental capture or entanglement of ESA-listed marine mammals and sea turtles is discountable.

Vessel traffic and fishing effort associated with the proposed fishery are anticipated to be similar to past levels over the broad expanse of the west coast and inland waters of Washington. Vessels and gear would have a short-term presence in any specific location and it is anticipated that this will continue. Furthermore, the vessels involved in the activities will not target marine mammals or sea turtles. Therefore, it is extremely unlikely that the proposed fishing effort will result in interactions with any of the above marine mammal or sea turtle species and the potential for effects are discountable.

The proposed fishing may indirectly affect Southern Resident killer whales by reducing their primary prey, Chinook salmon. The Proposed Action is not anticipated to affect prey quality; however, the project may affect the quantity of prey available to Southern Resident killer whales. This reduction is negligible and an extremely small percent of the total prey available to the whales in the action area. Therefore, NMFS anticipates that any salmonid take up to the aforementioned maximum extent would result in an insignificant reduction in prey resources for Southern Residents that may intercept salmonid species within their range.

Therefore, we find that the potential adverse effects of the proposed fishing on the above identified marine mammal and sea turtle species would be either discountable or insignificant and therefore the proposed fishing may affect, but is not likely to adversely affect, blue whales, fin whales, humpback whales (Central America DPS, Mexican DPS), Northern Pacific right whales, sei whales, sperm whales, Southern Resident killer whales, WNP gray whales, Guadalupe fur seals, green sea turtles, olive ridley sea turtles, loggerhead sea turtles, and leatherback sea turtles.

Leatherback Sea Turtle Critical Habitat

We revised the critical habitat for leatherback sea turtles by designating areas within the Pacific Ocean on January 26, 2012. This designation includes approximately 16,910 square miles along the California coast from Point Arena to Point Arguello east of the 1,640-fathom (3,000-m) depth contour, and 25,004 square miles from Cape Flattery, Washington to Cape Blanco, Oregon east of the 1,094-fathom (2,000-m) depth contour. The designated areas compose approximately 41,914 square miles of marine habitat and include waters from the ocean surface down to a maximum depth of 262 feet (80 m). Based on the natural history of leatherback sea turtles and their habitat needs, we identified the feature essential to conservation as the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (e.g., *Chrysaora*, *Aurelia*, *Phacellophora*, and *Cyanea*), of sufficient condition, distribution, diversity, abundance, and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks.

There are no records of bycatch to indicate that the proposed fishing affects the condition, distribution, diversity, abundance, or density of leatherback sea turtle prey. Based on the extremely low potential for scyphomedusae to become bycatch in the proposed fishery, it is extremely unlikely that the proposed fishing effort will result in interactions with leatherback sea turtle critical habitat. Therefore, we find that the potential adverse effects of the proposed fishing on leatherback sea turtle critical habitat would be discountable, and therefore the proposed fishing may affect, but is not likely to adversely affect, leatherback sea turtle critical habitat.

Southern Resident Killer Whale Critical Habitat

Southern Resident killer whale critical habitat includes approximately 2,560 square miles of Puget Sound, excluding areas with water less than 20 feet (6 m) deep relative to extreme high water. The PBFs for Southern Resident killer whale critical habitat are: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development as well as overall population growth, and (3) passage conditions to allow for migration, resting, and foraging.

On January 21, 2014, NMFS received a petition requesting that we revise critical habitat, citing recent information on the whales' habitat use along the west coast of the United States. Center for Biological Diversity proposes that the critical habitat designation be revised and expanded to include areas of the Pacific Ocean between Cape Flattery, Washington, and Point Reyes, California, extending approximately 47 miles (76 km) offshore. NMFS published a 90-day finding on April 25, 2014 (79 FR 22933) that the petition contained substantial information to support the proposed measure and that NMFS would further consider the action. We also solicited information from the public. Based upon our review of public comments and the available information, NMFS issued a 12-month finding on February 24, 2015 (80 FR 9682) describing how we intended to proceed with the requested revision, which is still in development.

The Proposed Action is likely to adversely affect Chinook salmon (the primary prey of Southern Resident killer whales). Any salmonid take up to the aforementioned maximum extent and amount described in the Incidental Take Statement would result in an insignificant reduction in prey resources for Southern Residents that may intercept salmonid species within their range. Therefore, NMFS anticipates that direct or indirect effects on Southern Resident killer whale prey quantity would be insignificant. Additionally, the potential for vessels engaged in the proposed fishing to interfere with Southern Resident killer whale passage is expected to be discountable and insignificant (i.e., fishing vessels will be slow moving and would not target the whales). Therefore, we find that the potential adverse effects of the proposed fishing on Southern Resident killer whale critical habitat are discountable or insignificant and determine that the proposed fishing may affect, but is not likely to adversely affect, Southern Resident killer whale critical habitat.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity," and includes the physical, biological, and chemical properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH [CFR 600.905(b)].

This analysis is based, in part, on the EFH assessment provided by NMFS and descriptions of EFH for Pacific Coast groundfish (PFMC 2005), coastal pelagic species (CPS) (PFMC 1998), Pacific Coast salmon (PFMC 2014), and highly migratory species (HMS) (PFMC 2007) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1. Essential Fish Habitat Affected by the Proposed Action

EFH has been designated by NMFS for various species and life stages of groundfish, coastal pelagic species, and Pacific salmon in sections of Area 2A.

3.2. Adverse Effects on Essential Fish Habitat

The biological opinion above describes effects on habitat (including, but not necessarily restricted to, habitat designated as critical under the ESA) that is essentially identical to EFH. Consistent with that analysis, and summarized here, the longline fishery would result in short-term adverse effects for groundfish EFH in the action area, but not Pacific salmon, highly migratory species, or coastal pelagic species EFH.

There are five west coast groundfish HAPC types: estuaries, canopy kelp, seagrass, rocky reefs, and "areas of interest." Areas of interest can include a variety of submarine features, such as banks, seamounts, and canyons, or other types of spatially-delineated areas. EFH would be altered in several ways by the longline fishery due to bottom contact. Gear used in commercial halibut fisheries could result in small adverse effects on some deepwater areas (greater than 98 feet (30 m)). Alteration to bottom habitats from longline fisheries is likely minimal because the gear is limited in weight and area fished (Morgan and Chuenpagdee 2003). When hauling longlines, there is potential for the hooks to snag structural organisms such as sponges and thus move rocks and/or cause small areas of turbidity (Morgan and Chuenpagdee 2003).

Longline gear that is lost can result in longer-term habitat alterations, though these would be expected to decrease over time as sediments and biota cover the lines. Some longlines can be snagged and lost on the sea floor and thus have the potential to alter habitat in localized areas. However, only five longlines have been documented in the extensive derelict gear surveys or removal efforts in Puget Sound (Antonelis 2014), though analogous data are not available for the rest of the action area, though it is likely that derelict halibut longlines are similarly rare in the rest of Area 2A.

For the reasons described here, the proposed action would have adverse effects on EFH in the action area, as a result of the alteration of benthic habitat during use of longlines, including longlines that become derelict. Similar adverse effects on Pacific salmon, highly migratory species, or coastal pelagic species EFH are not expected from the use of longlines.

3.3. Essential Fish Habitat Conservation Recommendations

As described in the above effects analysis, NMFS has determined that the proposed action would adversely affect EFH for various federally managed fish species within the Pacific Coast Groundfish FMP. Therefore, pursuant to section 305(b)(4)(A) of the MSA, NMFS determined that the following conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the impact of the proposed action on EFH.

1. Small, short-term adverse effects on EFH would occur from the use of longlines associated with the Proposed Action. In order to track the loss and enable eventual removal of lost longlines, such losses should be reported to appropriate authorities.

2. Locations of the fishery should be systematically recorded and provided to fishery managers and NMFS in order to enable further analysis of risk of adverse effects on EFH from the longline fishery in the action area.

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in section 3.2, above, EFH for Pacific Coast groundfish.

3.4. Statutory Response Requirement

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

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

3.5. Supplemental Consultation

NMFS will reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations [50 CFR 600.920(l)].

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended user of this opinion is NMFS. Other interested users could include tribal, commercial, and recreational fishermen, and state and local fishery managers. The document will be available within 2 weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

4.2. Integrity

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

4.3. Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

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