UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
7600 Sand Point Way, NE, Bldg 1
Seattle, Washington 98115-0070

November 4, 2020

Refer to NMFS No: WCRO 2020-01366

MEMORANDUM FOR: Allyson Purcell
Branch Chief— Anadromous Production and Inland Fisheries
Sustainable Fisheries Division

FROM: Chris Yates
Assistant Regional Administrator
Protected Resources Division

SUBJECT: Endangered Species Act Section 7(a)(2) Biological for NMFS Sustainable Fisheries Division's determinations on salmon and steelhead hatchery programs in Puget Sound under limit 6 of the ESA 4(d) rules for listed salmon and steelhead in Puget Sound (50 CFR § 223.203(b)(6)).

Thank you for your letter of May 20, 2020, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for NMFS's Sustainable Fisheries Division's (SFD) determinations on salmon and steelhead hatchery programs in Puget Sound. This consultation was conducted in accordance with the 2019 revised regulations that implement section 7 of the ESA (50 CFR 402, 84 FR 45016).

The enclosed document contains a biological opinion (Opinion) prepared by the National Marine Fisheries Service Protected Resources Division (PRD) pursuant to section 7(a)(2) of the ESA on the proposed action. In this Opinion, we conclude that the proposed action is not likely to jeopardize the continued existence of Puget Sound/Georgia Basin yelloweye rockfish (*Sebastes ruberrimus*) or bocaccio (*Sebastes paucispinis*). We also conclude that the proposed action is not likely to destroy or adversely modify designated critical habitat of these two species.

Furthermore, we conclude that the proposed action may affect but is not likely to adversely affect the following species and designated critical habitat:

Southern Resident killer whales (SRKW) (*Orcinus orca*)
Green sturgeon (*Acipenser medirostris*)
Pacific eulachon (*Thaleichthys pacificus*)

Please contact Grace Ferrara, Protected Resources Division, Seattle Branch at (206) 526-6172 or grace.ferrara@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Enclosure

cc: Ryan Wulff, Assistant Regional Administrator, Sustainable Fisheries Division
Administrative File: 151422WCR2020PR00125

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion
Salmon and Steelhead Hatchery Releases into Puget Sound

NMFS Consultation Number: *WCRO-2020-01366*

Action Agency: NOAA's National Marine Fisheries Service

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Yelloweye Rockfish (*Sebastes ruberrimus*)	Threatened	Yes	No	No	No
Bocaccio (*Sebastes paucispinis*)	Endangered	Yes	No	No	No
Southern Resident killer whales (*Orcinus orca*)	Endangered	No	No	No	No
Green Sturgeon—Southern Distinct Population Segment (*Acipenser medirostris*)	Threatened	No	No	No	No
Pacific Eulachon/Smelt — Southern Distinct Population Segment (*Thaleichthys pacificus*)	Threatened	No	No	No	No

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

Issued By: Chris E Yates
For Barry A. Thom
Regional Administrator

Date: November 4, 2020

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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 opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402, as amended.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at the Protected Resources Division (PRD) of NMFS in Seattle, WA.

This opinion considers the effects of the proposed action on five ESA-listed species (Table 1-1) and previous consultations have been completed or are ongoing for ESA-listed salmonids as described below.

Table 1-1. Federal Register notices for the final rules that list species, designate critical habitat, or apply protective regulations to a listed species considered in this consultation.

Species	Listing Status	Critical Habitat	Protective Regulations
Rockfish (*Sebastes spp.*)			
Yelloweye Rockfish (*Sebastes ruberrimus*)	Threatened, 75 FR 22276; April 28, 2010	79 FR 68041; November 13, 2014	Not yet developed
Bocaccio (*Sebastes paucispinis*)	Endangered, 75 FR 22276; April 28, 2010	79 FR 68041; November 13, 2014	Not yet developed
Killer Whales (*Orcinus orca*)			
Southern Resident DPS	Endangered, 70 FR 69903; November 18, 2005	71 FR 6905; November 29, 2006	Issued under ESA Section 9; 76 FR 20870; April 14, 2011
Green Sturgeon (*Acipenser medirostis*)			
Southern Resident DPS	Threatened, 71 FR 17757; April 7, 2006	74 FR 52300; October 9, 2009	75 FR 30714; June 2, 2010
Pacific Eulachon (*Thaleicthys pacificus*)			

Southern DPS	Threatened, 75 FR 13012; March 18, 2010	76 FR 6532, October 2, 2011	Not yet developed

1.2. Consultation History

The first hatchery consultations in Puget Sound followed the listing of the Puget Sound Chinook Evolutionarily Significant Unit (ESU) under the ESA (64 FR 14308, March 24, 1999). In 2004, the Washington Department of Fish and Wildlife (WDFW) and the Puget Sound Tribes ("co-managers") completed two resource management plans (RMP) as the overarching frameworks for 114 Hatchery Genetic Management Plans (HGMPs) (PSIT and WDFW 2004; PSTT and WDFW 2004). The HGMPs described how each hatchery program would operate—including what effects the programs would have on listed fish in the Puget Sound region. In 2005, the co-managers submitted the two RMPs and 114 HGMPs to NMFS for ESA review under limit 6 of the ESA 4(d) rule (50 C.F.R. 223.203). Of the 114 HGMPs, 75 were state-operated: 27 Chinook salmon programs, 22 coho salmon programs, 2 pink salmon programs, 4 chum salmon programs, 2 sockeye salmon programs, and 18 steelhead programs. The Puget Sound Tribes submitted 38 HGMPs—14 for Chinook salmon, 13 for coho salmon, 9 for chum salmon, and 2 for steelhead. The U.S. Fish and Wildlife Service (USFWS) submitted one HGMP for its coho salmon program at Quilcene National Fish Hatchery.

After all these plans were submitted to NMFS, the Puget Sound Steelhead Distinct Population Segment (DPS) was listed as "threatened" (72 FR 26722, May 11, 2007). On September 25, 2008, NMFS issued a final 4(d) rule adopting protective regulations for the listed Puget Sound steelhead DPS (73 FR 55451). In the final rule, NMFS applied the same 4(d) protections for steelhead as were already adopted for other ESA-listed Pacific salmonids in the region. Accordingly, the co-manager hatchery plans are now also subject to review for effects on listed steelhead.

Salmon and steelhead HGMPs in Puget Sound are grouped into 19 bundles for ESA review. These bundles are largely structured based on watershed, although some bundles are based on program similarity (i.e., all early-winter steelhead programs were analyzed together). NMFS has completed consultation on 8 of the 19 bundles for ESA-listed salmon and steelhead in conjunction with other federal action agencies, including the Bureau of Indian Affairs and the USFWS. Two of these completed bundles—Dungeness coho and Snohomish— are being re-initiated due to increases in salmon and steelhead hatchery program size (Table 1-2). These site-specific consultations have or will examine the effects of these salmon and steelhead hatchery programs on listed salmon and steelhead in Puget Sound as well as Essential Fish Habitat for salmon, steelhead, and groundfish. These effects include: removal of fish from natural populations for broodstock; the genetic and ecological impacts of the presence of hatchery fish on spawning grounds; competition between natural-origin and hatchery fish in rearing areas and the migratory corridor; the impacts of research, monitoring, and evaluation programs put in place by the hatcheries; and the effects of the operation and maintenance activities associated with hatchery programs and facilities.

However, the effects of salmon and steelhead hatchery programs on other ESA-listed marine species have not been analyzed to date. After reviewing the bundled HGMPs for Puget Sound hatchery releases, we determined that the hatchery fish would overlap in space and time with the ranges of and may affect yelloweye rockfish and bocaccio, Southern Resident killer whales, the

Southern Resident green sturgeon DPS, and the Southern Pacific eulachon DPS. Central America DPS and Mexico DPS humpback whales are also present in the action area. However, due to the nature of the action, the primary pathways of effects (described in Subsection 2.5), and because salmon are not common or consistent prey for humpbacks, we considered the action to have no effect on humpback whales. This consultation was initiated on May 20, 2020 following pre-consultation on the scope of the action and development of specific tools for analyzing effects on larval rockfish.

Table 1-2. Bundles of hatchery and genetic management plans (HGMPs) in Puget Sound, Washington.

HGMP Bundle	HGMP Name	Completion Date
Hood Canal Summer Chum	Quilcene NFH Supplementation	July 2002
	Hamma Hamma FH Supplementation	
	Lilliwaup Creek Supplementation	
	Union/Tahuya Supplementation/Reintroduction	
	Big Beef Creek Reintroduction	
	Chimacum Creek Reintroduction	
	Jimmycomelately Creek Reintroduction	
	Salmon Creek Supplementation	
Lake Ozette Sockeye	Umbrella Ck Supplementation/Reintroduction	May 2003; Reinitiation completed June 2015
Elwha	Lower Elwha Hatchery Native Steelhead	December 2012; Reinitiation completed December 2014
	Lower Elwha Hatchery Elwha Coho	
	Elwha Channel Hatchery Chinook	
	Lower Elwha Hatchery Elwha Chum	
	Lower Elwha Hatchery Pink	
Dungeness	Dungeness River Hatchery Spring Chinook	June 2016; Reinitiated in August 2020 (In Process)
	Dungeness River Hatchery Coho	
	Dungeness River Hatchery Fall Pink	
Snohomish	Tulalip Hatchery Chinook Sub-yearling	October 2017; Reinitiated in September 2020 (In Process)
	Wallace River Hatchery Summer Chinook	
	Wallace River Hatchery Coho	
	Tulalip Hatchery Coho	
	Tulalip Hatchery Fall Chum	
	Everett Bay Net-Pen Coho	
	Wallace River Hatchery Chum Salmon Rescue Program	
Early Winter Steelhead #1	Kendall Creek Winter Steelhead	April 2016
	Dungeness River Early Winter Steelhead	
	Whitehorse Ponds Winter Steelhead	
Early Winter Steelhead #2	Snohomish/Skykomish Winter Steelhead	April 2016
	Snohomish/Tokul Creek Winter Steelhead	

HGMP Bundle	HGMP Name	Completion Date
Hood Canal	Hoodsport Fall Chinook	October 2016
	Hoodsport Fall Chum	
	Hoodsport Pink	
	Enetai Hatchery Fall Chum	
	Quilcene NF Hatchery Coho	
	Quilcene Bay Net-Pens Coho	
	Port Gamble Bay Net-Pens Coho	
	Port Gamble Hatchery Fall Chum	
	Hamma Hamma Chinook Salmon	
	Hood Canal Steelhead Supplementation	
Duwamish/Green	Soos Creek Hatchery Fall Chinook	January 2020
	Keta Creek Coho (w/Elliott Bay Net-pens)	
	Soos Creek Hatchery Coho	
	Keta Creek Hatchery Chum	
	Marine Technology Center Coho	
	Fish Restoration Facility (FRF) Coho	
	FRF Fall Chinook	
	FRF Steelhead	
	Green River Native Late Winter Steelhead	
	Soos Creek Hatchery Summer Steelhead	
Puyallup/White	Clarks Creek Hatchery Chinook	Not Complete
	Voights Creek Hatchery Chinook	
	Voights Creek Hatchery Coho	
	Diru Creek Hatchery Winter Chum	
	Diru Creek Hatchery Late Coho	
	White River Spring Chinook	
	White River Winter Steelhead Supplementation	
	Minter/Hupp White River Spring Chinook	
Nooksack/Georgia Strait	Whatcom Creek Hatchery Pink	Not Complete
	Whatcom Creek Hatchery Chum	
	Glenwood Springs Hatchery Fall Chinook	
	Kendall Creek Hatchery NF Spring Chinook	
	Kendall Creek Hatchery Chum	
	Samish River Hatchery Fall Chinook	
	Skookum Creek Hatchery SF Early Chinook	
	Skookum Creek Hatchery Coho	
	Lummi Bay Hatchery Chum	
	Lummi Bay Hatchery Coho	
	Lower Nooksack Fall Chinook	
Stillaguamish	Stillaguamish Fall Chinook Natural Restoration	April 2020
	Stillaguamish Summer Chinook Natural Restoration	
	Stillaguamish Late Coho	
	Stillaguamish Fall Chum	

HGMP Bundle	HGMP Name	Completion Date
Deep South Sound	Minter Creek Hatchery Coho	In Process
	Minter Creek Hatchery Chum	
	Minter Creek Fall Chinook	
	Tumwater Falls Chinook	
	Chambers Creek Fall Chinook	
	Squaxin/South Sound Net-Pens Coho	
	Deschutes Coho	
Skagit	Upper Skagit Hatchery Chum	In Process
	Skagit River Fall Chinook	
	Skagit River Spring Chinook	
	Skagit River Summer Chinook	
	Skagit River Coho	
	Baker River Sockeye	
	Baker River Coho	
	Chum Remote Site Incubator	
	Skagit River Chum	
Skokomish	McKernan Hatchery Chum	Not Complete
	George Adams Fall Chinook	
	George Adams Coho	
	NF Skokomish Hatchery Coho	
	NF Skokomish Hatchery Steelhead	
	NF Skokomish Hatchery Spring Chinook	
	Cushman (Sportsman's Park) Sockeye	
Nisqually	Nisqually FH Clear Creek/Kalama Creek Fall Chinook	Not Complete
	Kalama Creek Coho	
Summer Steelhead	South Fork Skykomish Summer Steelhead	In Process
East Kitsap	Grovers Creek Hatchery Fall Chinook	In Process
	Grovers Creek Chum	
	Agate Pass Net-Pens Coho	
Lake Washington	Issaquah Hatchery Fall Chinook	In Process
	Issaquah Hatchery Coho	
	Cedar River Hatchery Sockeye	
	UW Coho	
	UW Chinook	

1.3. Proposed Federal Action

Under the ESA, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). The Proposed Action is: NMFS SFD's determinations that salmon and steelhead hatchery programs in Puget Sound meet the criteria described under limit 6 of the ESA 4(d) rules for listed salmon and steelhead in Puget Sound (50 CFR § 223.203(b)(6)). These programs are listed in Table 1-2.

The release of hatchery fish into streams and rivers that flow into Puget Sound, as well as from net pens in the marine waters within Puget Sound is an ongoing action. Some programs have been releasing fish for over a century. The goals of these programs are to mitigate for lost habitat, help support Tribal treaty, recreational, and commercial fisheries, and to conserve salmon and steelhead populations. Most releases occur in the spring and early summer, but can vary depending on the life stage of release.

NMFS has already completed or will review HGMPs for compliance with the ESA, including proposed increases in release of some salmon and steelhead from hatcheries in Puget Sound watersheds, and anticipates that the releases at the proposed levels will be fully realized within the next 10 years. Below we provide summaries of numbers of juvenile fish proposed for release and the expected adult returns for the hatchery programs in Puget Sound.

1.3.1 Fish Release and Expected Adult Returns

The consultations listed above include significant detail on the species and numbers of hatchery fish produced, the hatchery practices used, and protections in place for natural origin fish. For this consultation we focus on hatchery production of Chinook and coho salmon hatchery production as these salmon species are most closely connected to ESA-listed species as predators and prey depending on the life stages of both the salmon and also the other species. Below are the estimated ranges of releases and the number of adult Chinook expected to return to the Northern and Southern Puget Sound Regional Mark Information System (RMIS) regions as a result of the number of juvenile hatchery fish released (Table 1-3). The expected adult returns were calculated by using the smolt-to-adult recruit rate (SAR) from brood years 2000-2011 in the RMIS database SAR for each individual program. For those programs where SARs were not available, we combined the SAR estimates of all releases within the seven RMIS regions (i.e., Northern Washington, Skagit, North Puget Sound, Mid Puget Sound, South Puget Sound, Hood Canal, and Strait of Juan de Fuca), and then applied the appropriate regional estimate based on the watershed in which hatchery fish with an unknown SAR were released.

We estimated the number of adult Coho (Table 1-3) expected to return from the number of juvenile hatchery fish released for coho salmon similarly to our method for Chinook salmon with a few exceptions. First, the analysis years were for release years 2006-2015. Second, is that for those programs where SARs were not available, we used those programs within close geographic proximity as a surrogate. Third, because coho salmon are generally smaller in size than Chinook salmon and have a more uniform 3-year generation time, the adult equivalent calculations are likely to be a better estimate of the number of adults present in the ocean and interacting with ESA-listed species during the adult life stage than for Chinook salmon.

Table 1-3. Hatchery Chinook and coho salmon releases in Puget Sound (PS) watersheds and estimated adult equivalents over three release scenarios.

Salmon Species	RMIS Region	Run Timing	Current Release Number	Proposed "Low" Release Number	Proposed "High" Release Number[1]	Current Adult Equivalents	Proposed "Low" Adult Equivalents	Proposed "High" Adult Equivalents
Chinook	Northern PS	Spring	2,587,500	11,387,500	14,234,375	10,204	43,764	54,705
		Summer	1,920,000	3,220,000	4,025,000	10,912	15,662	19,578

		Summer/Fall	13,825,000	16,825,000	21,031,250	57,440	75,440	94,300
		Fall	200,000	650,000	812,500	720	2,475	3,094
	Southern PS	Spring	2,470,000	2,470,000	3,087,500	9,466	9,466	11,833
		Fall	30,720,000	35,320,000	44,900,000	160,009	168,639	210,799
	Total	All	51,722,500	69,872,500	88,090,625	248,751	315,446	394,307
Coho	Total	N/A	16,512,000	18,482,000	23,102,500	426,018	465,983	582,479

[1] This was determined by increasing the proposed release number by an additional 25%.

A proportion of the juvenile hatchery fish that are released into freshwater tributaries of Puget Sound are likely to suffer mortality as they migrate to marine waters. This is a difficult value to estimate and likely differs among watersheds. There is some estimate of this mortality in the Skagit River for hatchery sockeye salmon from fry to smolt, and we applied this estimate of freshwater mortality to all of the sockeye salmon releases (Table 1-4). For other salmon and steelhead species, the number of hatchery fish released is likely to be an overestimate of the number of juveniles that successfully migrate into marine waters.

Table 1-4. The number and estimated age of hatchery fish species released throughout Puget Sound once they reach marine waters.

Hatchery Species	Age[1]	Current Release Number		Proposed "Low" Release Number		Proposed "High" Release Number[2]	
		Hood Canal	Rest of Puget Sound	Hood Canal	Rest of Puget Sound	Hood Canal	Rest of Puget Sound
Chinook salmon	Subyearling	7,100,000	43,322,500	7,100,000	60,672,500	8,875,000	76,590,625
Chinook salmon	Yearling	195,000	1,105,000	195,000	1,905,000	243,750	2,381,250
Coho salmon	Smolt	1,285,000	15,227,000	1,285,000	17,197,000	1,606,250	21,496,250
Steelhead	Smolt	56,667	1,311,600	56,667	1,311,600	56,667	1,639,500
Pink Salmon	Fry	500,000	3,600,000	500,000	3,600,000	625,000	4,500,000
Sockeye Salmon	Smolt	0	9,103,100	0	9,103,100	0	11,378,875
Chum salmon	Fry	15,675,000	43,300,000	15,675,000	43,300,000	19,593,750	54,125,000

[1] Estimated at entry into marine water, not synonomous with size at release.
[2] This was determined by increasing the proposed release number by an additional 25%.

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 adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provide an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

NMFS determined the proposed action is not likely to adversely affect Southern Resident killer whales, green sturgeon, or Pacific eulachon, or their critical habitat. Our conclusion is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.13).

2.1. Analytical Approach

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

This biological opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 CFR 402.02).

The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

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

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

- *Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.* Section 2.2 describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. For listed salmon and steelhead, NMFS has developed specific guidance for analyzing the status of the listed species' component populations in a "viable salmonid populations" paper (VSP; McElhany et al. 2000). Similar criteria are used to analyze the status of ESA-listed rockfish because these parameters are applicable for a wide variety of species. The VSP approach considers the abundance, productivity, spatial structure, and diversity of each population as part of the overall review of a species' status. For listed salmon and steelhead, the VSP criteria therefore encompass the species' "reproduction, numbers, or distribution" (50 CFR 402.02). In describing the rangewide status of listed species, we rely on viability assessments and criteria in technical recovery team documents and recovery plans, and other information where available, that describe how VSP criteria are applied to specific populations, major population groups, and species. We determine the rangewide status of critical habitat by examining the condition of its physical or biological features (also called "primary constituent elements" or PBFs in some designations) which were identified when the critical habitat was designated.

- *Describe the environmental baseline in the action area.* The environmental baseline (Section 2.4) includes the past and present impacts of Federal, state, or private actions and other human activities in the action area. It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process.
- *Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.* In this step (Section 2.5), NMFS considers how the proposed action would affect the species' reproduction, numbers, distribution, and other relevant characteristics. NMFS also evaluates the proposed action's effects on critical habitat features.
- *Describe any cumulative effects in the action area.* Cumulative effects (Section 2.6), as defined in our implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation.
- *Integrate and synthesize the above factors* by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat. (Section 2.7).
- *Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.* These conclusions (Section 2.8) flow from the logic and rationale presented in the Integration and Synthesis section (2.7).
- *If necessary, define a reasonable and prudent alternative to the proposed action.* If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative (RPA) to the action in Section 2.9. The RPA must not be likely to jeopardize the continued existence of listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

This biological opinion is based on information provided by NMFS Sustainable Fisheries Division evaluating the ecological effects of increased salmon hatchery production. The focus of this biological opinion includes the role of the hatchery produced fish in the ecosystem as predators and prey and the potential for contaminants transfer through the food web.

2.2. Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would 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 section also helps to inform the description of the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of 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 Puget Sound/Georgia Basin Yelloweye Rockfish and Bocaccio

Detailed assessments of yelloweye rockfish and bocaccio can be found in the recovery plan (NMFS 2017f) and the 5-year status review (NMFS 2016a) which covers both species, and which are summarized here. We describe the status of yelloweye rockfish and bocaccio with nomenclature referring to specific areas of Puget Sound. Puget Sound is the second largest estuary in the United States, located in northwest Washington State and covering an area of about 900 square miles (2,330 square km), including 2,500 miles (4,000 kilometers(km)) of shoreline. Puget Sound is part of a larger inland waterway, the Georgia Basin, situated between southern Vancouver Island, British Columbia, Canada, and the mainland coast of Washington State. We subdivide the Puget Sound into five interconnected basins because of the presence of shallow areas called sills: (1) the San Juan/Strait of Juan de Fuca Basin (also referred to as "North Sound"), (2) Main Basin, (3) Whidbey Basin, (4) South Sound, and (5) Hood Canal. We use the term "Puget Sound proper" to refer to all of these basins except the San Juan/Strait of Juan de Fuca Basin.

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

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

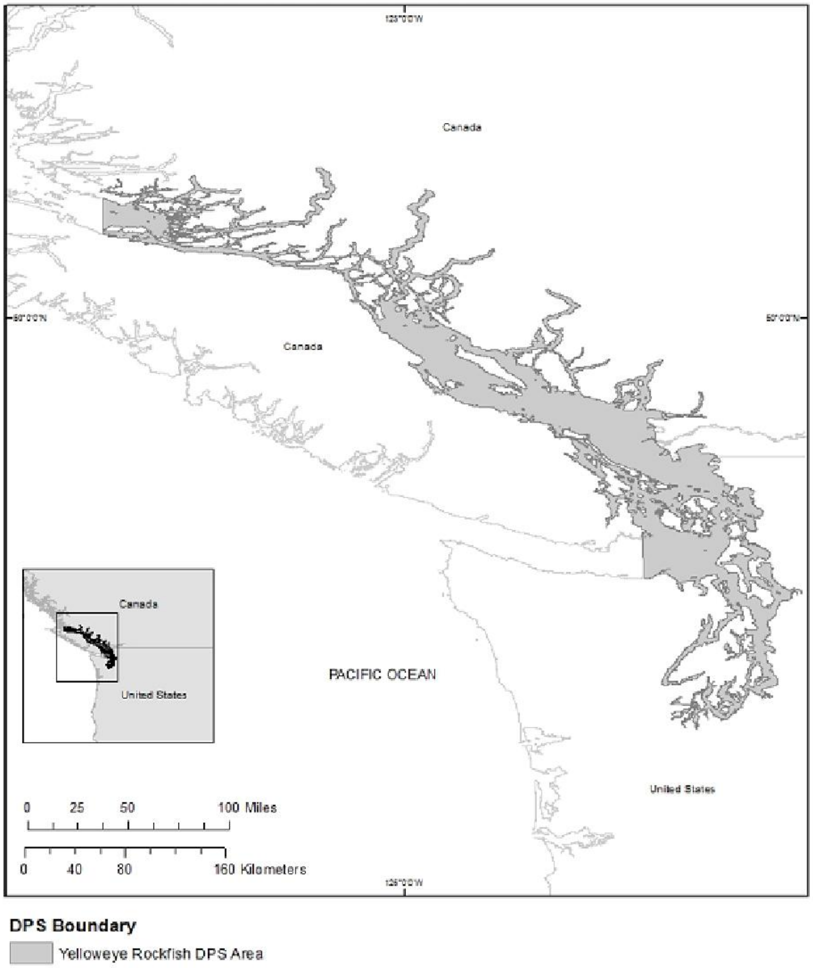

Figure 1-1. Yelloweye rockfish DPS area.

Figure 1-2. Bocaccio DPS area.

The life histories of yelloweye rockfish and bocaccio include a pelagic larval stage followed by a juvenile stage, and subadult and adult stages. Much of the life history and habitat use for these two species is similar, with important differences noted below. Rockfish fertilize their eggs internally and the young are extruded as larvae. Individual mature female yelloweye rockfish and bocaccio produce from several thousand to over a million eggs each breeding cycle (Love et al. 2002). Larvae can make small local movements to pursue food immediately after birth (Tagal et al. 2002), but are likely initially passively distributed with prevailing currents until they are large enough to progress toward preferred habitats. Larvae are observed under free-floating algae, seagrass, and detached kelp (Shaffer et al. 1995; Love et al. 2002), but are also distributed throughout the water column (Weis 2004). Unique oceanographic conditions within Puget Sound proper likely result in most larvae staying within the basin where they are released (e.g., the South Sound) rather than being broadly dispersed (Drake et al. 2010).

When bocaccio larvae reach sizes of 1 to 3.5 inches (3 to 9 centimeters (cm)), or approximately 3 to 6 months old, they swim down from the water column to settle onto shallow nearshore waters in rocky or cobble substrates with or without kelp (Love et al. 1991; Love et al. 2002). These habitat features offer a beneficial mix of warmer temperatures, food, and refuge from predators (Love et al. 1991). Areas with floating and submerged kelp species support the highest densities of most juvenile rockfish (Carr 1983; Halderson and Richards 1987; Matthews 1989; Hayden-

Spear 2006). Unlike bocaccio, juvenile yelloweye rockfish do not typically occupy shallow waters (Love et al. 1991; Studebaker et al. 2009), but settle in 98 to 131 feet (30 to 40 m) of water near the upper depth range of adults (Yamanaka and Lacko 2001).

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

Yelloweye rockfish are one of the longest-lived of the rockfishes, with some individuals reaching more than 100 years of age. They reach 50 percent maturity at sizes around 16 to 20 inches (40 to 50 cm) and ages of 15 to 20 years (Rosenthal et al. 1982; Yamanaka and Kronlund 1997). The maximum age of bocaccio is unknown, but may exceed 50 years, and they reach reproductive maturity near age 6[1].

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

Abundance and Productivity

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

Catches of yelloweye rockfish and bocaccio have declined as a proportion of the overall rockfish catch (Palsson et al. 2009; Drake et al. 2010). Yelloweye rockfish were 2.4 percent of the harvest in North Sound during the 1960s, occurred in 2.1 percent of the harvest during the 1980s, but then decreased to an average of 1 percent from 1996 to 2002 (Palsson et al. 2009). In Puget Sound

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

proper, yelloweye rockfish were 4.4 percent of the harvest during the 1960s, only 0.4 percent during the 1980s, and 1.4 percent from 1996 to 2002 (Palsson et al. 2009).

Bocaccio consisted of 8 to 9 percent of the overall rockfish catch in the late 1970s and declined in frequency, relative to other species of rockfish, from the 1970s to the 1990s (Drake et al. 2010). From 1975 to 1979, bocaccio averaged 4.6 percent of the catch. From 1980 to 1989, they were 0.2 percent of the 8,430 rockfish identified (Palsson et al. 2009). In the 1990s and early 2000s, bocaccio were not observed by WDFW in the dockside surveys of the recreational catches (Drake et al. 2010), but a few have been observed in recent remotely operated vehicle (ROV) surveys and other research activities.

Productivity is the measurement of a population's growth rate through all or a portion of its life cycle. Life history traits of yelloweye rockfish and bocaccio suggest generally low levels of inherent productivity because they are long-lived, mature slowly, and have sporadic episodes of successful reproduction (Tolimieri and Levin 2005; Drake et al. 2010). Overfishing can have dramatic impacts on the size or age structure of the population, with effects that can influence ongoing productivity. When the size and age of females decline, there are negative impacts on reproductive success. These impacts, termed maternal effects, are evident in a number of traits. Larger and older females of various rockfish species have a higher weight-specific fecundity (number of larvae per unit of female weight) (Boehlert et al. 1982; Bobko and Berkeley 2004; Sogard et al. 2008). A consistent maternal effect in rockfishes relates to the timing of parturition. The timing of larval birth can be crucial in terms of corresponding with favorable oceanographic conditions because most larvae are released typically once annually, with a few exceptions in southern coastal populations and in yelloweye rockfish in Puget Sound (Washington et al. 1978). Several studies of rockfish species have shown that larger or older females release larvae earlier in the season compared to smaller or younger females (Nichol and Pikitch 1994; Sogard et al. 2008). Larger or older females provide more nutrients to larvae by developing a larger oil globule released at parturition, which provides energy to the developing larvae (Berkeley et al. 2004; Fisher et al. 2007), and in black rockfish enhances early growth rates (Berkeley et al. 2004).

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

Future climate-induced changes to rockfish habitat could alter their productivity (Drake et al. 2010). Harvey (2005) created a generic bioenergetic model for rockfish, showing that their productivity is highly influenced by climate conditions. For instance, El Niño-like conditions generally lowered growth rates and increased generation time. The negative effect of the warm water conditions associated with El Niño appear to be common across rockfishes (Moser et al. 2000). Recruitment of all species of rockfish appears to be correlated at large scales. Field and

Ralston (2005) hypothesized that such synchrony was the result of large-scale climate forcing. Exactly how climate influences rockfish in Puget Sound is unknown; however, given the general importance of climate to rockfish recruitment, it is likely that climate strongly influences the dynamics of listed rockfish population viability (Drake et al. 2010), although the consequences of climate change to rockfish productivity during the course of the Proposed Action will likely be small.

Yelloweye Rockfish Abundance and Productivity

Yelloweye rockfish within the Puget Sound/Georgia Basin (in U.S. waters) are very likely the most abundant within the San Juan Basin. The San Juan Basin has the most suitable rocky benthic habitat (Palsson et al. 2009) and historically was the area of greatest numbers of angler catches (Moulton and Miller 1987; Olander 1991).

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

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

Bocaccio Abundance and Productivity

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

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

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

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

Spatial Structure and Connectivity

Spatial structure consists of a population's geographical distribution and the processes that generate that distribution (McElhany et al. 2000). A population's spatial structure depends on habitat quality, spatial configuration, and dynamics as well as dispersal characteristics of individuals within the population (McElhany et al. 2000). Prior to contemporary fishery removals, each of the major basins in the range of the DPSs likely hosted relatively large populations of yelloweye rockfish and bocaccio (Washington 1977; Washington et al. 1978; Moulton and Miller 1987). This distribution allowed each species to utilize the full suite of available habitats to maximize their abundance and demographic characteristics, thereby enhancing their resilience (Hamilton 2008). This distribution also enabled each species to potentially exploit ephemerally good habitat conditions, or in turn receive protection from smaller-scale and negative environmental fluctuations. These types of fluctuations may change prey abundance for various life stages and/or may change environmental characteristics that influence the number of annual recruits. Spatial distribution also provides a measure of protection from larger scale anthropogenic changes that damage habitat suitability, such as oil spills or hypoxia that can occur within one basin but not necessarily the other basins. Rockfish population resilience is sensitive to changes in connectivity among various groups of fish (Hamilton 2008). Hydrologic connectivity of the basins of Puget Sound is naturally restricted by relatively shallow sills located at Deception Pass, Admiralty Inlet, the Tacoma Narrows, and in Hood Canal (Burns 1985). The Victoria Sill bisects the Strait of Juan de Fuca and runs from east of Port Angeles north to Victoria, and regulates water exchange (Drake et al. 2010). These sills regulate water exchange from one basin to the next, and thus likely moderate the movement of rockfish larvae (Drake et al. 2010). When localized depletion of rockfish occurs, it can reduce stock resiliency (Hilborn et al. 2003; Hamilton 2008).

The effects of localized depletions of rockfish are likely exacerbated by the natural hydrologic constrictions within Puget Sound.

Yelloweye Rockfish Spatial Structure and Connectivity

Yelloweye rockfish spatial structure and connectivity is threatened by the reduction of fish within each basin. This reduction is likely most acute within the basins of Puget Sound proper. Yelloweye rockfish are probably most abundant within the San Juan Basin, but the likelihood of juvenile recruitment from this basin to the adjacent basins of Puget Sound proper is naturally low because of the generally retentive circulation patterns that occur within each of the major basins of Puget Sound proper.

Bocaccio Spatial Structure and Connectivity

Most bocaccio may have been historically spatially limited to several basins. They were historically most abundant in the Main Basin and South Sound (Drake et al. 2010) with no documented occurrences in the San Juan Basin until 2008[2]. 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 (Figure 2-1). Recreationally caught yelloweye rockfish in the 1970s spanned a broad range of sizes. By the 2000s, there was some evidence of fewer older fish in the population (Drake et al. 2010). No adult yelloweye rockfish have been observed within the WDFW ROV surveys and all observed fish in 2008 in the San Juan Basin were less than 8 inches long (20 centimeters(cm)) (Pacunski et al. 2013). Since these fish were observed several years ago, they are likely bigger. However, Pacunski et al. (2013) did not report a precise size for these fish; thus, we are unable to provide a precise estimate of their

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

likely size now. As a result, the reproductive burden may be shifted to younger and smaller fish. This shift could alter the timing and condition of larval release, which may be mismatched with habitat conditions within the range of the DPS, potentially reducing the viability of offspring (Drake et al. 2010). Recent genetic information for yelloweye rockfish further confirmed the existence of fish genetically differentiated within the Puget Sound/Georgia Basin compared to the outer coast (NMFS 2016b) and that yelloweye rockfish in Hood Canal are genetically divergent from the rest of the DPS. Yelloweye rockfish in Hood Canal are addressed as a separate population in the recovery plan (NMFS 2017f).

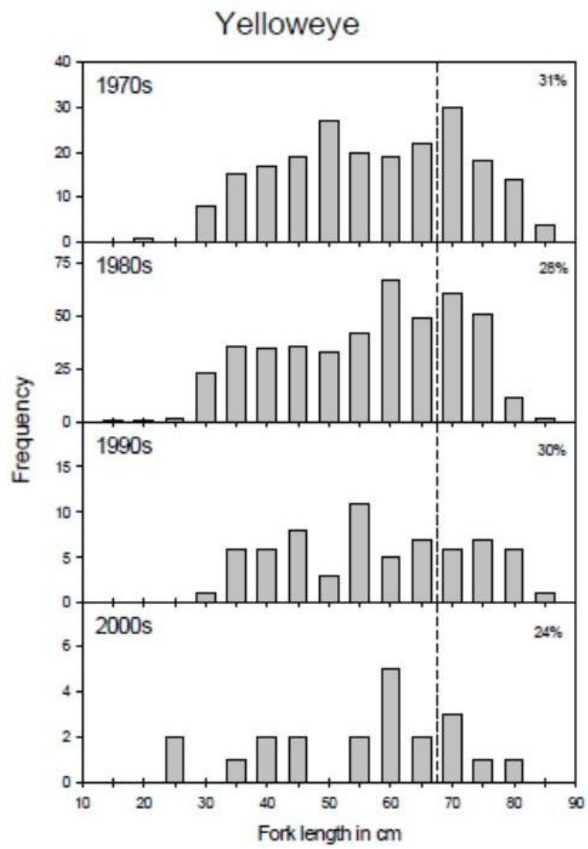

Figure 2-1. Yelloweye rockfish length frequency distributions (cm) binned within four decades.

<u>Bocaccio Diversity</u>

Size-frequency distributions for bocaccio in the 1970s indicate a wide range of sizes, with recreationally caught individuals from 9.8 to 33.5 inches (25 to 85 cm) (Figure 2-2). This broad size distribution suggests a spread of ages, with some successful recruitment over many years. A similar range of sizes is also evident in the 1980s' catch data. The temporal trend in size distributions for bocaccio also suggests size truncation of the population, with larger fish becoming less common over time. By the decade of the 2000s, no size distribution data for bocaccio were available. Bocaccio in the Puget Sound/Georgia Basin may have physiological or behavioral adaptations because of the unique habitat conditions in the range of the DPS. The potential loss of diversity in the bocaccio DPS, in combination with their relatively low productivity, may result in a mismatch with habitat conditions and further reduce population viability (Drake et al. 2010).

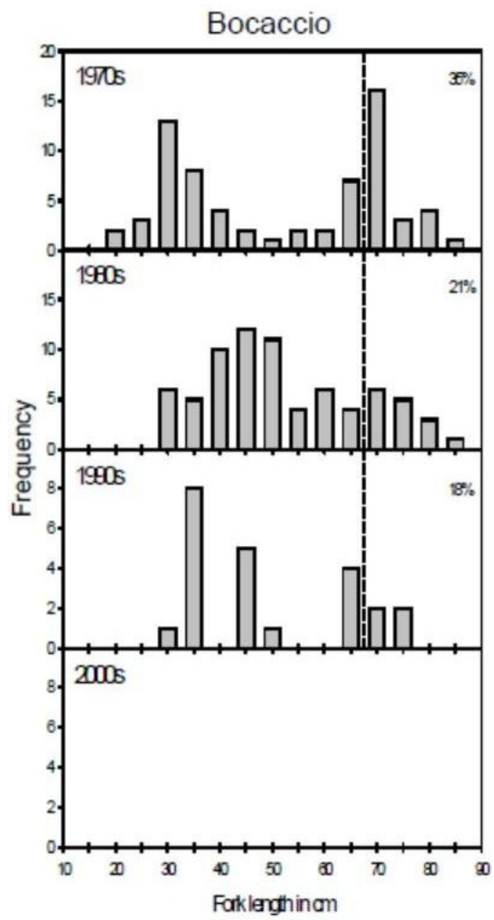

Figure 2-2. Bocaccio length frequency distributions (cm) within four decades. The vertical line depicts the size at which about 30 percent of the population comprised fish larger than the rest of the population in the 1970s, as a reference point for a later decade.

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

Limiting Factors

Climate Change and Other Ecosystem Effects

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

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

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

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

Commercial and Recreational Bycatch

Listed rockfish are caught in some recreational and commercial fisheries in Puget Sound. Recreational fishermen targeting bottom fish in shrimp trawl fishery in Puget Sound can incidentally catch listed rockfish. In 2012, we issued an incidental take permit (ITP) to the WDFW for listed rockfish in these fisheries (Table -1) and the WDFW is working on a new ITP application (WDFW 2017a). If issued, the new permit would be in effect for up to 15 years.

Table 2-1. Anticipated Maximum Annual Takes for Bocaccio, Yelloweye Rockfish by the fisheries within the WDFW ITP (2012 – 2017) (WDFW 2012).

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

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

Other Limiting Factors

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

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

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

2.2.2 Status of Critical Habitat

Section 3(5)(A) of the ESA defines critical habitat as "(i) the specific areas within the geographical area occupied by the species, at the time it is listed . . . on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed . . . upon a determination by the Secretary that such areas are essential for the conservation of the species."

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

2.2.2.1 Status of Puget Sound/Georgia Basin Yelloweye Rockfish and Bocaccio

Critical habitat was designated for three species of rockfish in 2014 under section 4(a)(3)(A) of the ESA (79 FR 68041, November 13, 2014), and critical habitat for canary rockfish was removed when the species was delisted on January 23, 2017 (82 FR 7711). The specific areas designated for bocaccio include approximately 1,083.11 square miles (1,743.10 sq. km) of deepwater (< 98.4 feet [30 meters(m)]) and nearshore (> 98.4 feet [30 m]) marine habitat in Puget Sound. The specific areas designated for yelloweye rockfish include 438.45 square miles (705.62 sq. km) of deepwater marine habitat in Puget Sound, all of which overlap with areas designated for bocaccio.

Critical habitat is not designated in areas outside of U.S. jurisdiction; therefore, although waters in Canada are part of the DPSs' ranges for each species, critical habitat was not designated in that area. We also excluded 13 of the 14 Department of Defense Restricted Areas, Operating Areas, and Danger Zones, and waters adjacent to tribal lands from the critical habitat designation (Figure 2-3).

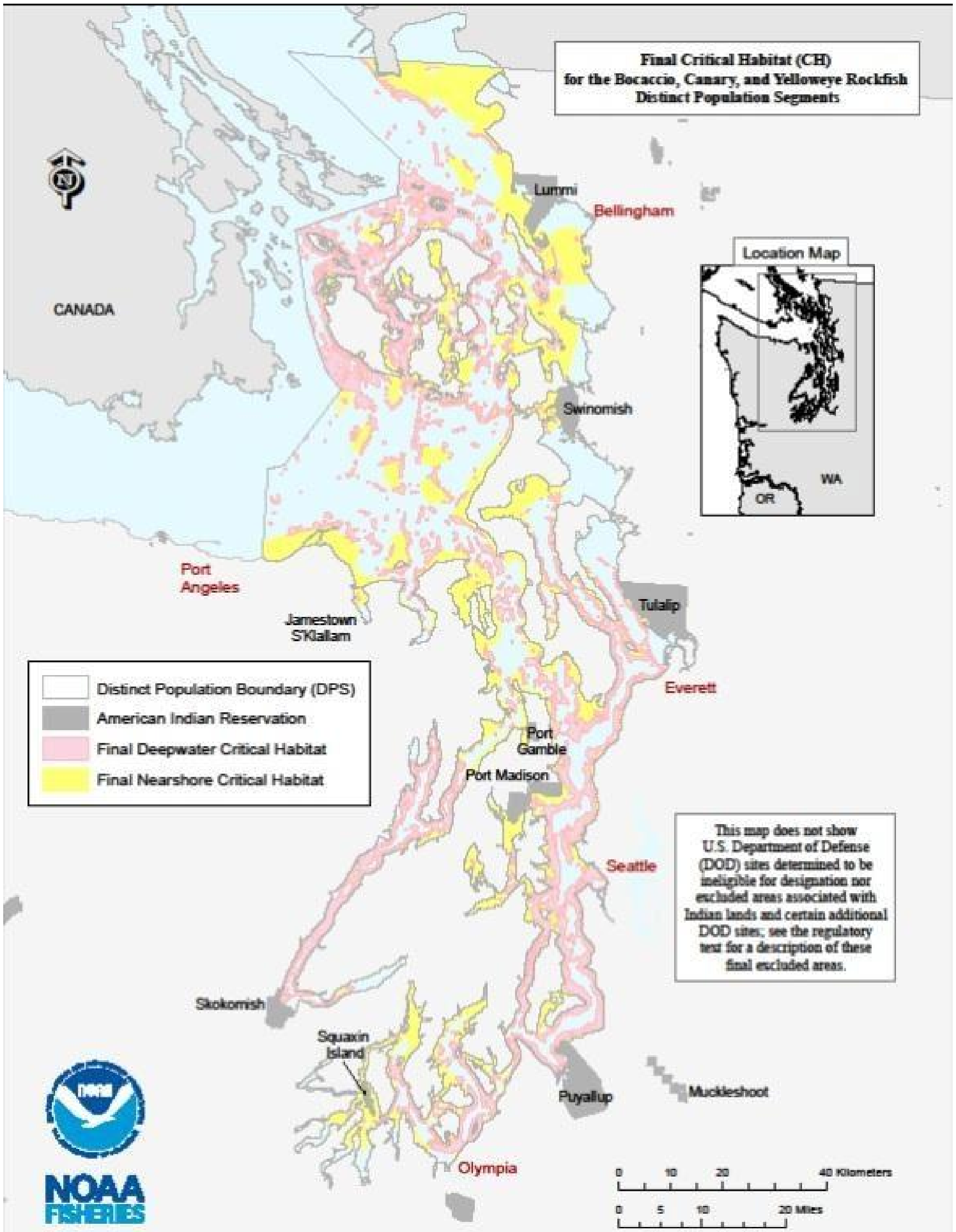

Figure 2-3. ESA-listed rockfish critical habitat in the Puget Sound area.

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

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

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

Rockfish are viviparous, with eggs developing and hatching internally, and free-swimming larvae are released into the water. Larval rockfish are ubiquitous, found throughout all the basins of Puget Sound (Figure 2-4, Greene and Godersky 2012), but are difficult to identify to species. Mature yelloweye rockfish can produce between 1,200,000 and 2,700,000 larvae per year, and Bocaccio produce between 20,000 and 2,298,000 eggs per year (Love et al. 2002). The number and survival of larvae released by adult female rockfish varies by age and body size (NMFS 2017f), with older and larger females having greater fecundity. Rockfish larvae have high natural mortality (Greene and Godersky 2012), so females produce a high number of larvae annually, and rely on episodic survival in good years to lead to successful recruitment (NMFS, 2017f). Recruitment of rockfish is poorly understood in Puget Sound, but climate is believed to influence recruitment success (Drake et al. 2010). Despite the volume of larvae produced each year, only a small fraction of individuals survive to juvenile stages (Gertseva and Cope 2017).

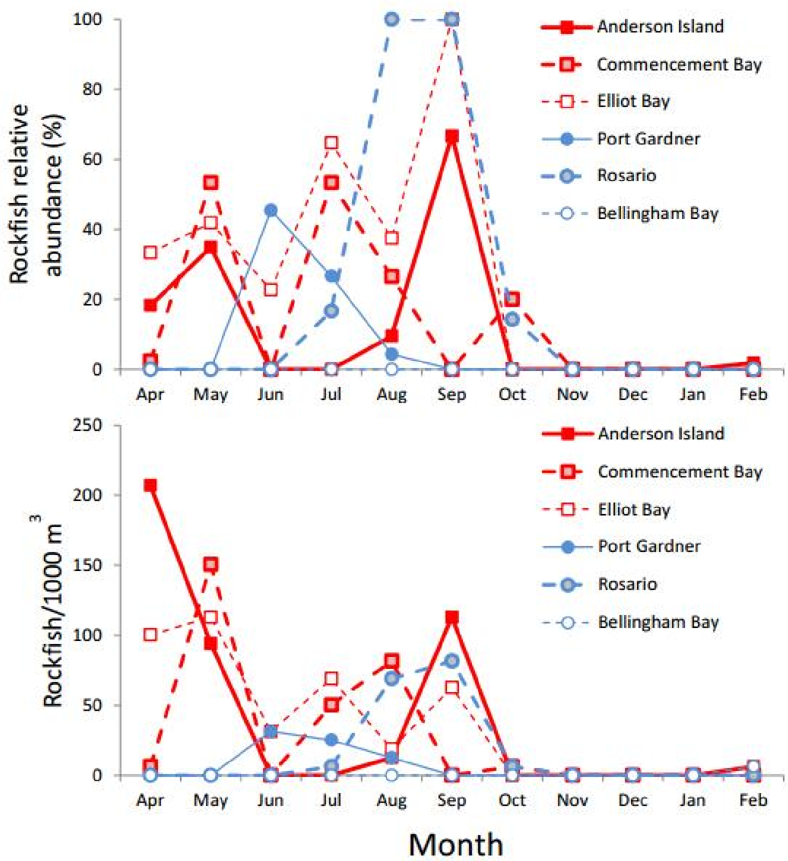

Figure 2-4. Relative abundance (% of all specimens identified as rockfish) and density (rockfish larvae/1000 m3) at index sites from April 2011 through February 2012. Image from Greene and Godersky (2012).

Habitats of ESA-listed rockfish DPSs can be divided into the nearshore, demersal, and pelagic zones. The nearshore refers to intertidal waters to roughly 90 feet deep, which is typically the deepest extent of photosynthesis. The demersal zone refers to the water column near the sea-bottom, and the pelagic zone refers to the water column off bottom. These habitats have been influenced by a number of human-induced alterations, and we discuss the environmental baseline of the pelagic and demersal zones in more detail than the nearshore, as these habitats are most affected by the proposed action.

Once rockfish reach a size suitable for bottom habitats they leave the water column and settle in demersal and nearshore environments. Listed rockfish are linked to numerous other fish species in Puget Sound through the food web. Groundfish (often referred to as demersal fish, or bottom fish), make up the majority of the estimated 211 species of fish within Puget Sound (Donnelly and Burr 1995) and comprise the largest number of species in the action area. Groundfish collectively occupy habitats ranging from intertidal zones to the deepest waters of the region. WDFW estimated that the biomass of benthic bottom fishes in Puget Sound is 220 million pounds (WDFW 2010). Rockfish are prey for many marine fish, mammals, and birds (Palsson 2009).

Juvenile and young-of-year (or early settled) rockfish use nearshore rocky habitats for refuge and foraging, and are found amongst floating kelp, understory kelp, and mixed drifting vegetation

(NMFS 2017f, Calloway et al. 2020). Floating kelp (*Nereocystis luetkeana*) in particular is a dominant habitat used by early settling rockfish (NMFS 2017f, Doty et al. 1995). Kelp beds have historically been an abundant habitat in Puget Sound, at one time present along 26% of the shoreline (Berry et al. in review), but have decreased across the region by 62% in the past 150 years. Bocaccio are known to utilize kelp for their early life history (Love et al. 2002), before migrating to deep water rocky habitats as they grow. The loss of kelp habitats presents an additional challenge to recovery efforts for ESA-listed rockfish.

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

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

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area for this action includes the places within or near the Puget Sound Region where salmon and steelhead originating from the hatchery programs (listed in Table 1-2) would migrate and spawn naturally, as well as marine waters of the Salish Sea to Cape Flattery off the Washington Coast in the Pacific Ocean. This area overlaps in space and time with two ESA-listed DPSs of rockfish: Puget Sound/Georgia Basin yelloweye rockfish and bocaccio, which are found in waters of Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca east of Victoria Sill (Figure 1-1 and Figure 1-2). The action area for the rockfish analysis is the same as the range for the two DPSs. Hatchery fish are also likely to migrate into coastal waters, however, where they mature and overlap with other species as described in the "Not Likely to Adversely Affect" Determinations section (Section 2.13).

2.4. Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

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

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

2.4.1 Puget Sound/Georgia Basin Rockfish

Benthic habitats within Puget Sound have been influenced by a number of factors. The degradation of some rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality are threats to marine habitat in Puget Sound (Palsson et al. 2009; Drake et al. 2010). Some benthic habitats have been impacted by derelict fishing gear that include lost fishing nets, and shrimp and crab pots (Good et al. 2010). Derelict fishing gear can continue *ghost* fishing and is known to kill rockfish, salmon, birds, 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 lost nets have been documented within Puget Sound and most have been found in the San Juan Basin and the Main Basin. The Northwest Straits Initiative has operated a program to remove derelict gear throughout the Puget Sound region. In addition, WDFW and the Lummi, Stillaguamish, Tulalip, Nisqually, and Nooksack Tribes and others have supported or conducted derelict gear prevention and removal efforts. Net removal has mostly concentrated in waters less than 100 feet (30.5 m) deep where most lost nets are found (Good et al. 2010). The removal of over 4,600 nets and over

3,000 derelict pots have restored over 650 acres of benthic habitat[3], though many derelict nets and crab and shrimp pots remain in the marine environment. Several hundred derelict nets have been documented in waters deeper than 100 feet deep (NRC 2014). Over 200 rockfish have been documented within recovered derelict gear. Because habitats deeper than 100 feet (30.5 m) are most readily used by adult yelloweye rockfish and bocaccio, there is an unknown impact from deepwater derelict gear on rockfish habitats within Puget Sound.

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

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

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

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

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

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

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

There is no data available to evaluate baseline levels of wild salmon predation on larval rockfish, and we previously had no method to estimate predation from hatchery salmon. For the analysis developed here, we estimate the impacts from both the current levels of hatchery production and the proposed levels, as a method to evaluate impacts.
The DPS area for yelloweye rockfish and bocaccio includes areas of the Georgia Strait, thus the status of the environmental baseline and rockfish management influences fish within Puget Sound. Fisheries management in British Columbia, Canada, has been altered to better conserve rockfish populations. In response to declining rockfish stocks, the government of Canada initiated comprehensive changes to fishery policies beginning in the 1990s (Yamanaka and Logan 2010). Conservation efforts were focused on four management steps: (1) accounting for all catch, (2) decreasing total fishing mortality, (3) establishing areas closed to fishing, and (4) improving stock assessment and monitoring (Yamanaka and Lacko 2001). The Department of Fisheries and Oceans (DFO) adopted a policy of ensuring that inshore rockfish are subjected to fisheries mortality equal to or less than half of natural mortality.

These efforts led to the 2007 designation of a network of Rockfish Conservation Areas (RCAs) that encompasses 30 percent of rockfish habitat of the inside waters of Vancouver Island (Yamanaka and Logan 2010). The Department of Fisheries and Oceans (DFO) defined and mapped "rockfish habitat" from commercial fisheries log Catch Per Unit Effort (CPUE) density data as well as change in slope bathymetry analysis (Yamanaka and Logan 2010). These reserves do not allow directed commercial or recreational harvest for any species of rockfish, or the harvest of other marine species if that harvest may incidentally catch rockfish. Because the RCAs are relatively new it is uncertain how effective they have been in protecting rockfish populations (Haggarty 2013), but one analysis found that sampled RCAs in Canada had 1.6 times the number of rockfish compared to unprotected areas (Cloutier 2011). There are anecdotal reports that compliance with the RCAs may be poor and that some may contain less than optimum areas of rockfish habitat (Haggarty 2013). Systematic monitoring of the RCAs may be lacking as well (Haggarty 2013). The DFO, WDFW, and NMFS conducted fish population surveys of some of the RCAs in 2018 but the results of these surveys are still being processed. Outside the RCAs, recreational fishermen generally may keep one rockfish per day from May 1 to September 30. Commercial rockfish catches in Area 4(b) are managed by a quota system (DFO 2011).

The listed rockfish in this opinion are the subject of scientific research and monitoring activities. Most biological opinions issued by NMFS have conditions requiring specific monitoring, evaluation, and research projects to gather information to aid the preservation and recovery of listed species. The impacts of these research activities pose both benefits and risks. In the short term, take may occur in the course of scientific research. However, these activities have a great potential to benefit ESA-listed species in the long-term. Most importantly, the information gained during research and monitoring activities will assist in planning for the recovery of listed species. Research on the listed fish species in the Action Area is currently provided coverage under Section 7 of the ESA or the 4(d) research Limit 7, or included in the estimates of fishery mortality discussed in the Effects of the Proposed Action in this opinion.

NMFS has issued several section 10(a)(1)(A) scientific research permits allowing lethal and non-lethal take of listed species (Table 2-2). In a separate process, NMFS also has completed the review of the state and tribal scientific salmon and research programs under ESA section 4(d) Limit 7. Table displays the total take for the ongoing research authorized under ESA sections 4(d) and 10(a)(1)(A) for the listed Puget Sound/Georgia Basin rockfish species DPS.

Table 2-2. Average annual take allotments for research on listed species in 2014-2020 (Dennis 2020).

Species	Production/Origin	Life Stage	Total Take	Lethal Take
PS/GB Bocaccio	Natural	Juvenile	76	28
		Subadult	2	1
		Adult	38	21
PS/GB Yelloweye Rockfish	Natural	Juvenile	52	28
		Subadult	2	1
		Adult	40	22

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

2.5. Effects of the Action

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

The proposed action is likely to impact listed species in Puget Sound through three main pathways of effects: (1) juvenile hatchery fish as predators in the Puget Sound ecosystem, which is the focus of the rockfish effects analysis below; (2) juvenile and adult hatchery fish as prey in the ecosystem; and (3) the introduction and bioaccumulation of contaminants in hatchery fish (pathways 2 and 3 are addressed in the "Not Likely to Adversely Affect" Determinations section (Section 2.13)).

2.5.1 Fish Release and Predation

As described in the Proposed Action, NMFS ESA review of HGMPs includes proposed increases in hatchery production for some programs. The current and proposed levels of hatchery releases are listed in Table 1-3. For this consultation we focus on hatchery production of Chinook and coho salmon hatchery production as these salmon species are most closely connected to ESA-listed species as predators and prey depending on the life stages of both the salmon and also the other species.

Hatchery released Chinook salmon and coho are predators of certain life stages of rockfish, which varies depending on their habitat use patterns. Wild (unmarked) and hatchery juveniles exhibited distinct habitat use patterns during emigration, with unmarked fish captured more frequently in tidally influenced freshwater and mesohaline emergent marsh areas, while hatchery fish were caught more often in the nearshore intertidal zone (Davis et al. 2018). A review by Weitkamp et al. (2014) found that the primary prey consumed by salmon and steelhead in tidal freshwater are aquatic and terrestrial insects (e.g., dipterans, hemipteran), amphipods, mysids and freshwater crustaceans. In the brackish waters, primary prey are larval and juvenile fish, amphipods, insects, krill (euphasiids), and copepods. In the estuary, the diets of Chinook and coho salmon and steelhead are dominated by amphipods and dipteran insects. Consequently, hatchery fish were less likely to consume the energy-dense terrestrial insects that were more common in freshwater and brackish marshes. Stable isotope signatures from muscle and liver tissues corroborated this finding, showing that unmarked juveniles had derived 24–31% of their diets from terrestrially sourced prey, while terrestrial insects only made up 2–8% of hatchery fish diets. This may explain why unmarked fish were in better condition than hatchery fish (also see Daly et al. 2012; Daly et al. 2014) and had stomach contents that were 15% more energy-rich than those of hatchery fish.

Schabetsberger et al. (2003) found that juvenile salmonids in the Columbia River plume tend to feed selectively on highly pigmented and relatively large prey (i.e., crab larvae, amphipods, adult krill), even though these species are less dominant than other zooplankton. The threshold size for piscivory was 80 mm fork length (Keeley and Grant 2001; Schabetsberger et al. 2003), with a large fish component in the diets of Chinook and coho salmon exceeding that length. The richer diet consumed in the ocean may confer survival benefits on juveniles that move quickly through the estuary (Daly et al. 2014).

Chinook and coho salmon off the coasts of Oregon and Washington ate primarily the same prey in May and June (Brodeur et al. 2011). Diet was comprised of adult krill, and juvenile sand lance (*Ammodytes hexapturus*), rockfish (*Sebastes* spp.), and greenling (*Hexagrammos* spp.). However, Chinook salmon also ate sculpin (cottids) and amphipods, while coho salmon also ate crab larvae (*Cancer* spp.). As salmon continued to grow during their residence in coastal marine waters, diet shifts occurred based on size of these fish. Coho salmon shifted from a diet of mainly rockfish, crab larvae and adult krill to predominately juvenile forage fish when they reached a size of 240 mm fork length. For Chinook salmon, fish comprised 55% of their diet from 80-100 mm fork length and 95% of their diet at > 375 mm fork length (Daly et al. 2009; Daly et al. 2014). There was no difference in diet between natural and hatchery fish (based on one year of data; Daly et al. 2014).

In Puget Sound, a proportion of the Chinook and coho salmon juveniles leave freshwater, but then remain in the semi-estuarine waters of Puget Sound until they mature before returning to freshwater to spawn (Chamberlin et al. 2011; Rohde et al. 2014). For hatchery Chinook salmon, about 24% of the fish from coded-wire tag (CWT) recoveries were classified as residents. This is likely an overestimation of the percentage of fish displaying this distribution pattern because the proportion of fish with a CWT varies by hatchery program, and the authors chose a conservative time period for classifying fish as residents. Release location was identified as the strongest factor in determining if hatchery fish displayed the residency life history type, with higher residency proportions in the South and Middle Sound, and Hood Canal than in the Strait of Juan de Fuca and Nooksack River regions (Chamberlin et al. 2011).

A second study using the Fishery Regulation and Assessment Model (FRAM) found that residency was correlated with age at which Chinook salmon emigrated from freshwater. During the non-migrating winter months, 29% of the Puget Sound Chinook salmon that emigrated as subyearlings, and 46% of the Puget Sound that emigrated as yearlings were caught by fisheries in the inland marine waters of Washington and British Columbia. This result suggests that yearling fish may be more likely to become residents than subyearlings (O'Neill and West 2009).

Unfortunately, comparison of residency proportions in hatchery-origin Chinook salmon to natural-origin Chinook salmon in Puget Sound is not possible at this time. This is because of the 31 release groups of natural fish, 27 of them were from a single River system (Skagit River), and too few tags were recovered. However, unpublished data by the Washington Department of Fish and Wildlife documents year-round fisheries in Puget Sound for Chinook salmon prior to large-scale hatchery production, suggesting that there has been a wild fish component to the Puget Sound resident population historically (Chamberlin et al. 2011).

Using a similar approach to the Chinook salmon analysis with coho salmon, researchers classified 3.4% of the coho salmon recovered with CWT's as residents, 61.3% as migrants, and 35.3% as ambiguous because they were recovered in Puget Sound in September and October, when residents and migrants were mixed. Releases into south Puget Sound produced the highest proportion of residents (Rohde et al. 2014). The authors state that delayed release, rather than rearing type (hatchery versus wild), had a significant impact on residency. Furthermore, the authors suggest that based on available literature, residency in Puget Sound may provide a survival advantage, despite likely resulting in poorer growing conditions. The survival advantage may also be more advantageous for Chinook salmon than coho salmon, because Chinook salmon spend a longer time in marine waters before spawning (Rohde et al. 2014).

2.5.2 Puget Sound/Georgia Basin Rockfish

In order to determine the effects of the proposed action we reviewed the various stages of rockfish life history, along with the life history of salmon. Rockfish have a complex life history that intersects multiple seasons, across several habitat types. Only the larval rockfish in the pelagic zone during summer months will coincide with young salmon (Greene and Godersky 2012). Hatchery released salmon enter marine waters feeding on plankton and small fish, depending on their size. After they pass through Puget Sound, most will leave for open waters along the outer coast of Washington. Chinook and coho salmon prey on larval rockfish in coastal waters of Washington and in Puget Sound (Daly and Brodeur 2015, Litz et al. 2016, Dale et al 2017); but steelhead, sockeye, pink, and chum salmon species are not likely to feed on rockfish in Puget Sound. As young salmon leave Puget Sound, larval rockfish also become too large to eat and settle onto nearshore bottom habitats, and the two species become separated by size and habitat type. Once rockfish reach a larger size they also develop physical features such as dorsal fin spines that protect them from predation, they become cryptic and hide in bottom rock and kelp, and as a result there is no data of salmon predation on non-larval rockfish. Some juvenile and adult rockfish species may feed on young salmon, but adult yelloweye and bocaccio generally live at depths below where sub-yearling salmon swim. Those interactions were not evaluated here.

In general, ichthyoplankton (larval fish) are very data limited. They are difficult to capture, digest quickly as prey, experience high natural mortality, and many species are difficult to distinguish from each other in the larval stage. Because of the paucity of comprehensive local data in Puget Sound, and the inability to effectively measure larval predation from monitoring, we determined the only way to measure the effects of the project was to use models based on the best available data. We worked previously with the United States Geological Society (USGS) on development of the Rockfish Recovery Plan (NMFS 2017f), as they are known to specialize in regionally similar fish diet studies along the west coast, and have demonstrated their expertise on diet studies and modeling through other published papers and grey literature.

To assess the general effects of the proposed action on yelloweye rockfish and bocaccio, NOAA collaborated with the USGS, Northwest Fisheries Science Center (NWFSC), and WDFW to develop a model to quantify the potential existence and magnitude of predation effects by hatchery salmonids on larval rockfish and their populations in the Salish Sea. Several components of rockfish and salmon life history were reviewed to evaluate the population-level impacts to rockfish from the proposed action. These include available information on larval rockfish life history in the range of the DPS and elsewhere, data on salmon consumption rates and bioenergetics simulations, and quantification of larval yelloweye rockfish and bocaccio consumed. Throughout, we identify data gaps and uncertainties, and explain how we base assumptions in our analysis on the best available science.

Larval Rockfish

Several components of the proposed action are likely to result in interactions between released salmon and larval rockfish. After young rockfish settle out of the water column they are unlikely to be encountered by salmon, and likewise salmon will not harm adult rockfish because they generally occupy separate habitats and are too large for predation. Thus, these later life history stages are not analyzed further.

Rockfish have an approach to recruitment that involves the release of millions of larvae, with very few reaching juvenile life history stages, and even fewer surviving to reach maturity. They offset the losses from high early mortality by being generally long-lived, and rely on episodic years with good climatic conditions and food availability to maintain the population over time (Drake et al. 2010, Tolimieri and Levin 2005, NMFS 2017f). Yelloweye rockfish can produce between 1,200,000 and 2,700,000 larvae per year per female, and Bocaccio produce between 20,000 and 2,298,000 eggs per year per female (Love et al. 2002). While very little is known about larval survival in the pelagic habitats of the action area, in a laboratory setting rockfish larvae experienced up to 70% mortality 7 to 12 days after birth (Canino and Francis 1989), and we can infer from stock assessment models of yelloweye rockfish along the outer Pacific coast that only a small fraction of individuals survive to reach the juvenile life history stage (Gertseva and Cope 2017).

Timing of larval release varies between fish species and regions. Within the DPS for the proposed action there are 28 species of rockfish, and many have similar larval periods. Yelloweye rockfish in the Salish Sea appear in pelagic habitats from April through September, with the highest numbers in May and June (Washington et al. 1978, Yamanaka et al. 2006), while bocaccio along the outer Washington State coast first appear as early as January and April (Love et al. 2002). Greene and Godersky (2012) found peak abundance in Puget Sound from July to September across basins, and Chamberlin et al (2004) and Weis (2004) documented larval rockfish in the San Juan Islands from April to July. Once in the water column, rockfish larvae feed and grow until they reach a size suitable to settle into benthic nearshore habitats such as rocky slopes, eelgrass, and kelp. Yelloweye rockfish larvae develop over a course of about 120 days (Shanks and Eckert 2005), while bocaccio may stay in pelagic habitats for upwards of 150 to 170 days (Shanks et al. 2003). The timing of larvae present in the action area coincides with migration of salmon through the region (Figure 2-5, Greene and Godersky 2012).

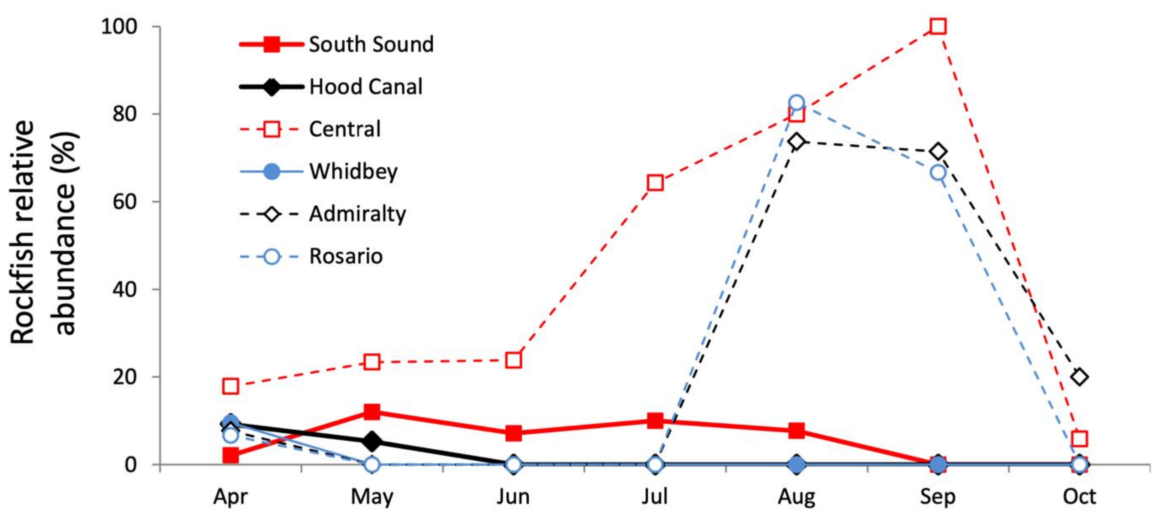

Figure 2-5. Relative abundance of rockfish at a subset of index sites from April through October. Image from Greene and Godersky (2012).

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Little data is available on the size of pelagic larval rockfish in the action area. In the Gulf of Alaska surveys were conducted by surface and midwater trawls during July and August from 2012 through 2017 (Wesley Strasburger, unpublished data). The mean body mass of larval rockfish sampled ranged from 23 to 58 mm fork length (FL), averaging 1.22 g wet weight (WW) in July and 1.55 g WW in August (0.3-3.8 g WW). Data on larval growth rates is also limited, but a lab study of yelloweye rockfish larvae found they reached between 120 to 150 mm total length by 77 days (Plesha and Rust, NMFS unpublished data). These lengths are likely an overestimate based on ideal conditions in a laboratory setting.

In order to determine the proportion of ESA-listed rockfish larvae in the pelagic zone, we used data from WDFW Remote Operated Vehicle (ROV), hook and line, and scuba surveys on adult populations to estimate the percentage of yelloweye rockfish and bocaccio larvae present relative to total rockfish abundance for all species, but there are likely regional differences in the populations. The total abundance estimate for bocaccio is currently based on observations only from the San Juan Islands, and little is known of their abundance in Central Puget Sound other than anecdotal fishing records. Yelloweye rockfish in Hood Canal are considered genetically divergent from the rest of the DPS (NMFS 2016b), and addressed as a separate population in the recovery plan (NMFS 1017f). Despite these regional variations in adults, little is known about the mixing of larvae between Puget Sound basins. Based on best available data for all species of adult rockfish populations in the DPS, and assuming the same relative fraction are present for larval populations, the ESA-listed species fraction of rockfish larvae was determined to be between 0.25 and 3.20 % (yelloweye rockfish and bocaccio combined). This estimate was created using the WDFW ROV survey data between 2008 to 2015, consisting of over 2000 hours of video, by estimating the total identifiable rockfish presence on all rock bottom habitat, and using the proportion of ESA-listed species abundance estimates (WDFW, personal communications). Based on the population estimates for the two species, yelloweye rockfish comprise 96.9% of that fraction, and bocaccio account for 3.1 %. While the high end of the combined species range is an overestimate resulting from excluding a disproportionate amount of coppers and quillbacks in some regions, the 3.20 % value is used for analysis here as a precautionary measure.

Salmon Diet and Rockfish Predation

In Puget Sound, Chinook salmon become piscivorous at relatively small sizes initially in nearshore habitats, then revert to deeper pelagic invertebrates and gradually become more piscivorous in pelagic habitats later in summer; however, the timing and degree of pelagic piscivory varies among regions (Duffy et al. 2010, Beauchamp and Duffy 2011). Juvenile Chinook salmon exhibit much higher levels of piscivory within the Salish Sea starting near the San Juan Islands and extending northward through the Strait of Georgia, in part due to earlier herring spawning and other environmental factors to the north (Chamberlin et al. 2017, Davis et al. 2020). While salmon can be found at depths greater than 120 feet in the nearshore, they are not considered bottom fish, and instead feed in the pelagic water column of nearshore habitats. As such their diets consist primarily of invertebrate and ichthyoplankton upon first entering marine waters, and they become piscivorous as they grow (Duffy et al. 2010).

Prior to release from the hatchery, salmon are fed a commercial food mix of fish meal and fish oil. The company Bio-Oregon that provides the feed meets industry standards for sustainable fisheries and aquaculture, and the sources of fish for the pellets do not come from resources that would compete for the diet of yelloweye rockfish or bocaccio. Therefore, increased feed provided for the proposed hatchery numbers would also not affect availability of prey for adult rockfish.

Steelhead, sockeye, pink, and chum salmon are not considered serious predation threats to larval rockfish in Puget Sound due to either low abundance, short residence time within Puget Sound, or non-piscivorous diets. Most of these species are known to prey on larval rockfish to some extent in the Strait of Georgia (Osgood et al. 2016), but due to differences described here it is unlikely to find rockfish in their diet within the action area, and there are no observations of predation on rockfish by these species in Puget Sound. Although steelhead can become piscivorous at relatively early life stages, juveniles (~150-250 mm fork length) move rapidly out of Puget Sound, generally within two weeks of marine entry in May or early June while remaining extremely close to the surface (depths < 3 m), undergo heavy acute mortality during this migration, and are at very low abundance in relation to other Pacific salmon (Goetz et al. 2015; Moore et al. 2012, 2015). Therefore, steelhead are unlikely to prey on rockfish in Puget Sound. Similarly, juvenile sockeye salmon enter Puget Sound in relatively low numbers during mid to late May and rapidly emigrate from Puget Sound as inferred by their absence in extensive marine nearshore and pelagic sampling records spanning the past 20 years. Juvenile pink and chum salmon can be very abundant in both nearshore habitats in spring and then pelagic habitats of Puget Sound during summer but exhibit diets composed exclusively of invertebrate prey during these life stages (Duffy 2003, Beauchamp and Duffy 2011).

Chinook and coho consumption of larval rockfish during the spring and summer months varies annually, with some years comprising as much as 10.2 to 40.8% of their total diet during peak seasons along the California coast (Brodeur et al. 2011, Daly et al. 2013). Within the action area, hatchery released Chinook salmon enter the action area as early as May, and leave the area by October, with peak marine entry in June and most emigrating to the ocean in September (Beauchamp et al. 2020). While a small fraction of salmon may stay in Puget Sound as residents, they no longer feed on larval rockfish due to larvae settling onto bottom habitats in the early fall. There is no data for second-year resident salmon predation on larval rockfish, but it is also not likely based on diet shifts in salmon targeting larger prey to meet their growth needs. Coho have a shorter migration period than Chinook, but for this analysis the total period of time for Chinook is used as a precautionary measure to capture the total time that rockfish larvae may be consumed by salmon.

Salmon Diet Surveys in Puget Sound

In order to quantify a relative estimate for rockfish consumption we evaluated existing data on salmon diet composition and developed a framework to model the likelihood of occurrence (Beauchamp et al. 2020). The steps to determine this included: (1) identifying presence of larval rockfish in salmon diets within the pelagic habitats of Puget Sound across years, and divide observed predation into estimates of monthly diet composition of Chinook and coho salmon; (2) estimating monthly, size-structured, population-level biomass of larval rockfish consumed by the relevant segments of Puget Sound Chinook and coho populations; (3) generating scenarios for salmon predation on ESA-listed rockfish based on assumptions of the proportion of ESA-listed rockfish in the pool of all pelagic larval rockfish, the size and body weight of rockfish that correspond to the estimated periods of predation by salmon, and different hatchery release strategies for Chinook and coho salmon in Puget Sound. By comparing the estimated number of larvae consumed to the average larval production of individual female rockfish, we were able to estimate an adult equivalent of take.

Across the analysis we reviewed the range of estimates, but always used the worst-case scenarios as a precautionary measure to evaluate potential effects on the species. The analysis included the *high* levels of proposed salmon hatchery releases, the *low* levels of rockfish larval production, the *high* estimates for percent mortality for each DPS, and the *high* estimates for rockfish adult equivalents to estimate levels of take. By taking a precautionary approach to estimate larval rockfish consumption by salmon, we were able to determine any population-level impacts to yelloweye rockfish and bocaccio.

Existing data and archived samples were analyzed to determine seasonal and size-dependent diet composition of juvenile Chinook and coho from pelagic habitats in Puget Sound. There were three primary sources of data from 2001 to 2019.

First was depth-stratified midwater trawling cruises of the *R/V Ricker* by the Department of Fisheries and Oceans Canada (DFO). These surveys were conducted in mid-late July and late September/early October. Data were available from cruises conducted from 2001 to 2009, except for 2003. The midwater trawl sampled Admiralty Inlet and the Central Basin of Puget Sound. South Puget Sound was also sampled infrequently. The *Ricker* cruises continued from 2010 to 2016 with less frequency, but with additional tows in the Whidbey Basin and Saratoga Passage, and additional months were sampled, including November 2015, February 2010, and March 2008. These samples targeted juvenile salmon, primarily sub-yearling Chinook, pink, and chum, and yearling coho, but also captured Pacific herring, other forage fishes, other miscellaneous fish species, and small numbers of the older resident Chinook and coho salmon.

A second major source of pelagic diet samples provided finer-resolution temporal coverage as part of the Salish Sea Marine Survival Project (Gamble et al. 2018; Connelly et al. 2018). Surveys were conducted twice-monthly by purse seine, from mid-May through mid-August in 2014 and 2015. The purse seine was deployed in marine waters within estuarine deltas for four watersheds (the Nisqually, Snohomish, Skagit, and Nooksack rivers) and along Rosario Strait. The purse seine similarly targeted juvenile salmon, herring, and other forage fishes, but also included small numbers of resident Chinook and coho salmon.

Thirdly, data was collected from microtrolling surveys (e.g., Duguid and Juanes 2017; Beauchamp et al. 2020) conducted weekly from late May through mid-September in 2018 and 2019. Microtrolling is a method of using specialized equipment to target a smaller number of juveniles for non-lethal diet analysis. Sampling locations in 2018 were limited to Possession Bar south of Whidbey Island and at Jefferson Head. In 2019, sites including Duwamish Head (from May-June) and Shilshole (sampled throughout the season) were added. These surveys targeted the larger resident forms of Chinook and coho salmon.

Stomach contents were collected either via dissection or gastric lavage. Invertebrate prey were identified to functional group, whereas all fish prey were identified to species whenever possible. Partially-digested remains were identified using diagnostic bones or other calcified hard parts. The proportional weight of prey species (Beauchamp et al. 2020) to the diets of individual salmon were measured as blotted wet weights (WW) or visually approximated as biovolumes (for on-board processing from *R/V Ricker* cruises).

Predatory salmonids are generally capable of consuming prey fishes up to 50% of their own body length (Beauchamp et al. 2007; Duffy et al. 2010). Observations from salmon sampled in the surveys found Chinook salmon ranging from 100-200 mm FL, with 71% greater than 120 mm. coho sampled were primarily 200-350 mm FL. Based on available larval rockfish length data described above, almost all observed salmon were assumed to be capable of preying on rockfish larvae available in pelagic habitats of the action area.

2.5.3 Predation Estimates and Effects on Abundance

Given the diets of Chinook and coho salmon in Puget Sound coinciding with available larval rockfish in the water column, it is likely that a small fraction of total rockfish larvae will be consumed, and a proportion of those larvae may be yelloweye rockfish or bocaccio.

For data sets from sub-yearling salmon surveys that included observations of larval rockfish predation, we calculated monthly mean diet composition for the species, size classes, and years corresponding with the highest level of predation as a precautionary measure. Data for monthly prey was then quantified using a bioenergetics model combining timing, diet composition, age growth estimates, water temperatures, and energy requirements for the consumer (Beauchamp et al. 2007). The model results provide an energy balance equation based on the amount of food needed by juvenile Chinook and coho salmon in order to satisfy growth rates over the season (Beauchamp 2009). To determine the quantity of predation on rockfish, we used the bioenergetic simulations constructed for sub-yearling Chinook salmon cohorts described in Beauchamp and Duffy (2011).

The model simulations were run for a year from May 1 to April 30, to fit annual growth increments. However, the only evidence for predation on larval rockfish was observed in sub-yearling Chinook diets from the *R/V Ricker* midwater trawl surveys in July and September. Therefore, prey consumption estimates were only examined for the results for June through October, marking the peak entry of sub-yearling Chinook to pelagic marine habitats, through the end of ocean-bound migration, also representing the period that was relevant to rockfish larval presence. A portion of the unidentifiable *Other Fish* diet category relative to the known rockfish proportion was allocated to the worst-case estimates for monthly proportions of larval rockfish in the diet as a precautionary measure to capture unidentified rockfish. The estimated biomass of larval rockfish consumed each month was divided by the mean individual body mass of larval rockfish, converting biomass of total rockfish consumed to a numerical estimate of ESA-listed larval rockfish consumption by sub-yearling Chinook and coho salmon. This model was run four times, once for each salmon species, and for current versus proposed *high* hatchery release scenarios (Table 2-3). The *high* release numbers are described in the proposed action as increasing incrementally over a number of years, but for the analysis here they are used as the worst-case scenario of the maximum hatchery releases and predation.

Table 2-3. Current and proposed total hatchery release numbers for Chinook and coho salmon, provided by the Washington State Hatchery Genetic Management Plan (HGMP) in the proposed action.

Salmon Species	Current Release Numbers	Proposed *Low* Release Numbers	Proposed *High* Release Numbers
Chinook	51,722,500	69,872,500	88,090,625
Coho	16,512,000	18,482,000	23,102,500

The starting value in the model for sub-yearling Chinook and coho salmon released was set to current or proposed *high* release values provided in the Puget Sound Hatchery Genetic Management Plans (HGMPs). The population-level monthly estimates for sub-yearling salmon were structured to account for survival from hatchery to marine entry (50%), and then a marine survival from marine entry to adult return (1% total or daily mortality of 0.0056). The per capita caloric needs (in grams) for individual fish were than multiplied by the observed proportion of rockfish in the diet surveys, times the monthly salmon population estimates to produce the estimated total grams of rockfish consumed per month. The caloric needs for coho was estimated to be 10% more, based on their larger size entering marine waters. This is likely an overestimate, intended to compensate for the assumed slightly higher consumption rate. The estimated biomass of all species of larval rockfish consumed was then multiplied by the fraction of the larval rockfish population estimated to be ESA-listed species (0.032), and the monthly mean body mass of larval rockfish (1.55 grams) was used to estimate the total number of ESA-listed rockfish larvae consumed (Tables 2-4 through 2-7). The total for the season was then separated into the fraction of yelloweye rockfish and bocaccio based on adult abundance estimates (Tables 2-8 and 2-9). The predation scenario was structured to incorporate the effects of bioenergetic physiology, temporal shifts in diet, and thermal experience.

Table 2-4. Monthly population-level consumption of ESA-listed rockfish, using the current hatchery release estimate for Chinook of 51,722,500.

Month	Hatchery released sub-yearling salmon population estimate	Caloric needs (g) per fish	Proportion of rockfish in diet	Total predation (g) on rockfish/month	Fraction of ESA-listed (g RF/mo)	# ESA-listed rockfish larvae
Marine Entry	25,861,250	87.7	-	-	-	-
June	23,774,962	104.0	-	-	-	-
July	20,093,726	121.7	0.0001	220,909	7,069	4,561
August	16,982,480	139.8	0.0120	28,589,878	914,876	590,243
September	14,352,969	154.2	0.0290	64,193,021	2,054,177	1,325,275

October	3,639,181	164.2	0.0145	8,662,106	277,187	178,831

Table 2-5. Monthly population-level consumption of ESA-listed rockfish, using the proposed *high* hatchery release estimate for Chinook of 88,090,625.

Month	Hatchery released sub-yearling salmon population estimate	Caloric needs (g) per fish	Proportion of rockfish in diet	Total predation (g) on rockfish/month	Fraction of ESA-listed (g RF/mo)	# ESA-listed rockfish larvae
Marine Entry	44,045,313	87.7	-	-	-	-
June	40,492,073	104.0	-	-	-	-
July	34,222,415	121.7	0.0001	376,239	12,040	7,768
August	28,923,530	139.8	0.0120	48,692,546	1,558,161	1,005,265
September	24,445,106	154.2	0.0290	109,329,660	3,498,549	2,257,128
October	6,198,032	164.2	0.0145	14,752,773	472,089	304,573

Table 2-6. Monthly population-level consumption of ESA-listed rockfish, using the current hatchery release estimate for coho of 16,512,000.

Month	Hatchery released sub-yearling salmon population estimate	Caloric needs (g) per fish	Proportion of rockfish in diet	Total predation (g) on rockfish/month	Fraction of ESA-listed (g RF/mo)	# ESA-listed rockfish larvae
Marine Entry	8,256,000	96.5	-	-	-	-
June	7,589,969	114.4	-	-	-	-
July	6,414,763	133.9	0.0001	77,576	2,482	1,602
August	5,421,523	153.7	0.0120	10,039,802	321,274	207,273
September	4,582,072	169.6	0.0290	22,542,427	721,358	465,392
October	1,161,780	180.6	0.0145	3,041,840	97,339	62,799

Table 2-7. Monthly population-level consumption of ESA-listed rockfish, using the proposed *high* hatchery release estimate for coho of 23,102,500.

Month	Hatchery released sub-yearling salmon population estimate	Caloric needs (g) per fish	Proportion of rockfish in diet	Total predation (g) on rockfish/month	Fraction of ESA-listed (g RF/mo)	# ESA-listed rockfish larvae
Marine Entry	11,551,250	96.5	-	-	-	-
June	10,619,383	114.4	-	-	-	-
July	8,975,113	133.9	0.0001	108,539	3,473	2,241
August	7,585,437	153.7	0.0120	14,047,028	449,505	290,003
September	6,410,933	169.6	0.0290	31,539,875	1,009,276	651,146
October	1,625,486	180.6	0.0145	4,255,941	136,190	87,865

Yelloweye Rockfish

The seasonal total number of ESA-listed rockfish larvae consumed was multiplied by the fraction of yelloweye rockfish, based on adult population estimates (96.9%). We used the annual estimated consumption numbers of yelloweye rockfish from sub-yearling Chinook and coho salmon combined to estimate the total larval mortality (Table 2-8). The level of take on the larval population is equivalent to the typical cohort of larvae from individual females (on an annual basis), if we assume that the removal of larvae is synonymous with direct removal of fecundity. We then divided that total by the high and low estimates of larvae produced per female (Section 2.5.1), to determine the adult equivalents of fish killed in the DPS, such that low larval output would result in a higher estimate for fish killed, assuming salmon consumption rates remain equal. The adult equivalents of fish killed were then divided by the total population abundance to determine the percent mortality, or percent of DPS killed. In the scenario where rockfish larval output is low, salmon consumption pressure is greater, resulting in the higher estimated percent mortality.

Table 2-8. Yelloweye rockfish larval consumption estimates. The low estimate DPS killed and percent mortality are both based on the high estimate of larval production, and subsequently the high estimates were produced using the low estimate for documented larval production.

Yelloweye	Adult Abundance Scenario	Number Larval Mortalities	Adult Equivalents of DPS killed (low estimate)	Adult Equivalents of DPS killed (high estimate)	Low Estimated Percent Mortality	High Estimated Percent Mortality
Current Hatchery Release	143,086	2,747,531	1.02	2.29	0.001%	0.002%
Proposed Hatchery Release	143,086	4,462,344	1.65	3.72	0.001%	0.003%

Bocaccio

The seasonal total number of ESA-listed rockfish consumed was multiplied by the fraction of bocaccio, based on adult population estimates (3.1%). We used the annual estimated consumption numbers of bocaccio from sub-yearling Chinook and coho combined to estimate the total larval mortality (Table 2-9). The level of take on the larval population is equivalent to the typical cohort of larvae from individual females (on an annual basis), if we assume that the removal of larvae is synonymous with direct removal of fecundity. We then divided that total by the high and low estimates of larvae produced per female (Section 2.5.1), to determine the adult equivalents of fish killed in the DPS, such that low larval output would result in a higher estimate for fish killed, assuming salmon consumption rates remain equal. The adult equivalents of fish killed were then divided by the total population abundance to determine the percent mortality, or percent of DPS killed. In the scenario where rockfish larval output is low, salmon consumption pressure is greater, resulting in the higher estimated percent mortality.

Table 2-9. Bocaccio larval consumption estimates. The low estimate DPS killed and percent mortality are both based on the high estimate of larval production, and subsequently the high estimates were produced using the low estimate for documented larval production.

Bocaccio	Adult Abundance Scenario	Number Larval Mortalities	Adult Equivalents of DPS killed (low estimate)	Adult Equivalents of DPS killed (high estimate)	Low Estimated Percent Mortality	High Estimated Percent Mortality
Current Hatchery Release	4,606	88,444	0.04	4.42	0.001%	0.096%
Proposed Hatchery Release	4,606	143,645	0.06	7.18	0.001%	0.156%

Effects on Populations

To assess the effect of the mortalities expected to result from the proposed actions on population viability, we adopted methodologies used by the PFMC for rockfish species. The decline of West Coast groundfish stocks prompted the PFMC to reassess harvest management (Ralston 1998; Ralston 2002). The PFMC held a workshop in 2000 to review procedures for incorporating uncertainty, risk, and the precautionary approach in establishing mortality rate policies for groundfish. The workshop participants assessed best available science regarding *risk-neutral* and *precautionary* mortality rates (PFMC 2000). The workshop resulted in the identification of risk-neutral mortality rates of 0.75 of natural mortality, and precautionary mortality rates of 0.5 to 0.7 (50 to 70 percent) of natural mortality for rockfish species. These rates are supported by published and unpublished literature (Walters and Parma 1996; PFMC 2000), and guide rockfish conservation efforts in British Columbia, Canada (Yamanaka and Lacko 2001; Department of Fish and Oceans 2010). Mortality of 0.5 (or less) of natural mortality was deemed most precautionary for rockfish species, particularly in data-limited settings, and was considered a rate that would not hinder population viability (Walters and Parma 1996; PFMC 2000).

Annual natural mortality rates for yelloweye rockfish range from 2 to 4.6 percent (as detailed in Section 2.2.1) (Yamanaka and Kronlund 1997; Wallace 2007); thus, the precautionary range of mortality would be 1 to 2.4 percent and risk-neutral would be 1.5 to 3.45 percent (Table 2-10). Lethal takes from the proposed actions of *high* increased hatchery production in the DPS would be below the precautionary and risk-neutral levels (0.001 – 0.003 %) for each of the abundance scenarios.

Annual natural mortality rate for bocaccio is approximately 8 percent (as detailed in Section 2.2.1) (Palsson et al. 2009); thus, the precautionary level of mortality would be 4 percent and risk-neutral would be up to 6 percent (Table 2-10). Lethal takes from the proposed actions of *high* increased hatchery production would be well below the precautionary and risk-neutral levels (0.001 – 0.156%) for each of the abundance scenarios.

Table 2-10. Estimated natural mortality rates, precautionary and risk-neutral ranges, and estimated range of percent taken for each species of rockfish.

Species	Abundance Scenario	Natural Mortality	Low Precautionary Range of Mortality	Risk-Neutral Range of Mortality	Range of Percent of DPS Killed
Yelloweye Rockfish	143,086	2.0-4.6%	1.0-2.4%	1.5-3.45%	0.001 to 0.003
Bocaccio	4,606	8%	4%	6%	0.001 to 0.156

2.5.4 Effects on Spatial Structure and Connectivity

Larval rockfish have been documented throughout all major basins of Puget Sound (Greene and Godersky 2012). Due to their limited swimming abilities in the water column, it is difficult to predict larval distribution patterns (Weis 2004). The lack of consistent population abundance estimates from the individual basins of Puget Sound proper complicates this type of assessment. Yelloweye rockfish are the most susceptible to spatial structure impacts because of their sedentary nature. Localized losses of yelloweye rockfish are less likely to be replaced by roaming fish, compared to bocaccio, which are better able to recolonize habitats due to the propensity of some individuals to travel long distances. There is evidence that abundance for both species varies between regions within the DPS (NMFS 2017f), yelloweye rockfish in Hood Canal are a genetically divergent population from Puget Sound, and limited adult movement can influence connectivity, but impacts to spatial structure for each species has been largely attributed to fishery removals of adults (Palsson et al. 2009; Drake et al. 2010).

Yelloweye Rockfish

Total abundance estimates for the species are based on WDFW ROV surveys across years, habitat types, and regions. Genetic studies of yelloweye rockfish have identified Hood Canal as a separate population within the DPS (as discussed in the Rockfish Recovery Plan, NMFS 2017f). There do not appear to be major differences in the abundance of fish between Hood Canal (13,739) and central Puget Sound (21,568), but as discussed previously abundance for yelloweye rockfish is believed to be highest in the San Juan basin resulting from the greater availability of preferred adult habitat. A relatively shallow sill near the mouth of Hood Canal limits tidal exchange of deep marine waters (Drake et al. 2010), and while this feature may restrict larval movement, there is no evidence to support any difference in salmon predation rates on larval rockfish between regions. For the analysis of the proposed action here, all of the observed predation on rockfish larvae occurred within Puget Sound, and mostly within Admiralty Inlet, thus the worst-case scenario for larval consumption estimates are likely to not impact the individual population of yelloweye rockfish in Hood Canal.

Bocaccio

The population abundance estimates for bocaccio are based solely on observations of fish from the WDFW ROV surveys in the San Juan Islands (WDFW, personal communications). Although historical and anecdotal fishing records suggest bocaccio were also in the Whidbey Island basin (Antonelis et al. 2016), and near Admiralty Inlet, their numbers are currently below a level of detection for adequate abundance estimates. While one bocaccio was observed in the Puget Sound basin in a recent study (WDFW, unpublished data), the corresponding abundance estimate of 359 fish is not considered accurate enough for the model used here, and is also not used in the current total abundance estimates for the species. While little is known about mixing of larvae between regions, it is likely that local larval abundance compared to the region-wide estimate is either similar or lower within central Puget Sound where all salmon predation was observed, suggesting the worst-case scenario for actual bocaccio larval consumption rates may be far lower.

2.5.5 Effects on Diversity and Productivity

The seasonal removal of larval rockfish as a result of salmon predation may vary annually based on the availability of larvae. While the high estimate for percent larval mortality as a result of consumption is based on low potential larval output, rockfish generally produce as many larvae as possible to offset annual variations in climatic conditions, and we estimate at most that the removal of larvae is equivalent to less than one clutch of larvae from four female yelloweye rockfish, and up to seven female bocaccio, but on average it may equate to one female clutch or less for either species. These estimates are below the expected intrinsic growth rate for either species. While continued removal of individual reproductive females from a severely reduced population can result in an Allee effect (NMFS 2017f), or a loss of genetic diversity, salmon diet composition was based on a large enough scale across Puget Sound to suggest that larval consumption is spread across multiple regions of the DPS, and not constricted to an area indicative of singling out individual adult female rockfish. Overall, fewer juveniles in the population can equate to decreased productivity, but the estimated loss from the proposed action is considerably lower than natural mortality or recruitment estimates for either rockfish species.

2.5.6 Effects on Critical Habitat

Critical habitat was designated for all species of listed rockfish in 2014 under section 4(a)(3)(A) of the ESA (79 FR 68041, November 13, 2014). The physical or biological features of rockfish habitat identified as essential to conservation are: (1) quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities (juveniles and adults); (2) water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities (juveniles and adults); and (3) structure and rugosity to support feeding opportunities and predator avoidance (adults only). The hatchery fish produced in the proposed action will overlap with designated critical habitat for rockfish, but predation on larval rockfish occurs in the pelagic zone, which lies off bottom from designated critical habitats. As such, there are no anticipated impacts to water quality or habitat structure/rugosity features of critical habitat, and the action could increase availability of prey for juveniles and adults that may feed on hatchery fish. Therefore, we do not anticipate any adverse effect to rockfish critical habitat to any measurable degree.

2.6. Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02 and 402.17(a)). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

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

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

Activities occurring in the Puget Sound area were considered in the discussion of cumulative effects in the biological opinion on the Puget Sound Harvest Resource Management Plan (NMFS 2011b) and in the cumulative effects sections of several section 7 consultations on large scale habitat projects affecting listed species in Puget Sound including Washington State Water Quality

Standards (NMFS 2008c), Washington State Department of Transportation Preservation, Improvement, and Maintenance Activities (NMFS 2013a), the National Flood Insurance Program (NMFS 2008d), the Elwha River Fish Restoration Plan (Ward et al. 2008), and the Howard Hansen Dam Operations and Maintenance (NMFS 2019e). We anticipate that the effects described in these previous analyses will continue into the future and therefore we incorporate those discussions by reference here. Those opinions discussed the types of activities taken to protect listed species through habitat restoration, hatchery and harvest reforms, and water resource management actions.

A Recovery Plan for Puget Sound/Georgia Basin Yelloweye Rockfish and Bocaccio was completed in 2017 (NMFS 2017f) and implementation with state and other partners is ongoing. One action identified in the recovery plan is to improve nearshore habitat, and in particular address kelp conservation. NOAA collaborated with the NW Straits Initiative, Puget Sound Restoration Fund (PSRF), Washington Department of Natural Resources, and Marine Agronomics to develop the Kelp Conservation and Recovery Plan (Calloway et al. 2020). The three-year process was completed in May 2020, and outlines a framework of actions to protect and restore Puget Sound kelp habitats. These actions include current and ongoing restoration research by the PSRF to practice cultivation of kelp in the lab, experimental out-planting of kelp at potential restoration sites, and monitoring annual kelp forests at select index sites in Puget Sound. These actions address knowledge gaps about kelp loss, and hope to improve habitat functions for rockfish, salmon, and other associated kelp habitat species.

2.7. Integration and Synthesis

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

Throughout this document we identify a precautionary approach to determining the effects of the action on rockfish populations. This approach is defined by continuously analyzing the highest potential levels of impacts, using the lowest estimates for larval production, assuming that salmon consumption rates are universal across the region, and identifying that the *high* proposed hatchery release numbers will be reached.

2.7.1 Puget Sound/Georgia Basin Rockfish

Historic fishery removals were a primary reason for depleted listed rockfish populations, but the impact of larvae consumption on reduced larval outputs has not been documented. As detailed in Section 2.3, Environmental Baseline, yelloweye rockfish and bocaccio face a variety of stressors from fisheries bycatch, degradation of habitat, and reduced prey resources. To assess if take as a result of increased hatchery production within the range of the listed rockfish DPSs threatens the viability of each species, in combination with other sources of population pressures, we reviewed the population-level impact from a proposed hatchery production for Chinook and coho salmon.

In order to conduct this analysis, we assessed take numbers relative to the overall population of each rockfish DPS. Despite the volume of larvae produced each year, stock assessment models demonstrate that only a small fraction of individuals are recruited to juvenile stages (Gertseva and Cope 2017), so we estimated larval consumption rates relative to the clutch size for individual female rockfish.

To assess the effect of larval mortalities expected to result from the proposed actions on population viability, we collaborated with USGS, NMFS, and WDFW to develop a model which quantified the potential existence and magnitude of predation effects by hatchery salmonids on larval rockfish and their populations in the Salish Sea (Beauchamp 2020); and compared these estimates with established acceptable rates of mortality (PFMC 2000) to identify any potential impacts on population viability. While data on rockfish population abundance estimates and natural larval mortality is sparse in the DPS, we examined the high end of the range for estimated impacts based on best available science to determine worst-case scenarios as a precautionary measure to determine effects.

We determined the proposed action is unlikely to result in a significant change to either listed rockfish DPS at the population-level. First, the estimated take of larvae by sub-yearling Chinook and coho salmon equates to a worst-case scenario on mortality of approximately 0.003% and 0.156% for yelloweye rockfish and bocaccio respectively (Table 2-11), equivalent to 4 adult yelloweye rockfish and 7 bocaccio, and both values are below the conservative precautionary value for population-level mortality (PFMC 2000). Second, the model included an estimate that 3.20 % of the total rockfish abundance in the range of the DPSs were ESA-listed rockfish, which is likely an overestimate based on higher abundance of dominant populations of copper, quillback, and Puget Sound rockfish. Lastly, there were a number of known factors that could limit prey consumption that were not evaluated, including larval rockfish greater than 50% body length of Chinook salmon and too large to be consumed, regional differences in rockfish larval abundance within the DPS that may result in reduced predation encounters (i.e. Hood Canal for yelloweye rockfish, and the San Juan Islands for bocaccio), and potential annual variations in relative larval rockfish abundance compared to other prey resources available to salmon. We assumed the lowest potential larval output per female for all rockfish in order to determine the highest larval mortality effects despite larger females generally capable of producing more larvae, and we also know that rockfish generally output as many larvae as possible each year, and rely on episodic good climatic conditions for successful recruitment (NMFS 2017f), such that the mortality rates produced here are likely overestimates.

Table 2-11. Estimated total annual lethal take for the salmon hatcheries and percentages of the listed-rockfish.

Species	Range of Estimated Take (adult equivalents)	Abundance Scenario	Natural Mortality	Low Precautionary Level of Acceptable Mortality	Range of Percent of DPS Taken
Yelloweye Rockfish	1 to 4	143,086	2.0-4.6%	1%	0.001 to 0.003
Bocaccio	1 to 7	4,606	8%	4%	0.001 to 0.156

Examining the empirical data from Beauchamp (2020), we found predation of larval rockfish in Puget Sound was very rare by Chinook salmon and was not detected in coho salmon. Rockfish predation was only detected in 3 of 14 years of data examined collectively across the three data sets dedicated to examining diets of different sizes of Chinook and coho salmon across multiple regions. Of these data sets, only the *R/V Ricker* midwater trawling surveys detected predation on larval rockfish, with the majority of incidences in September and only one event reported in July. The majority of estimated predation coincided with the August and September period in Admiralty Inlet through which nearly all ocean-bound Chinook were migrating. No patterns in depths or predator size were evident to support assumptions that might limit predation by sub-yearlings Chinook as the primary predator. While data on yelloweye rockfish and bocaccio larval period in the pelagic habitats of Puget Sound is sparse, there is evidence that both recruit earlier in the season than some other rockfish species (Greene and Godersky 2012), and may be in low abundance and larger size by August. These factors would further limit consumption rates for both species at the time of peak salmon sub-yearling feeding.

Even though diet proportions were lower when pooled across regions, we took as a given that nearly all of the ocean-bound juvenile Chinook and coho would emigrate through Admiralty Inlet, with this emigration being well underway during September. Therefore, the majority of ocean-bound salmon would pass through the Admiralty Inlet region during the period of highest observed predation on larval rockfish. We assumed no difference between the diets of hatchery and wild-origin salmon based on the results of the 2014-15 purse seine diet data. As with Chinook, the monthly diets of marked hatchery coho were similar to those of unmarked coho within each year and exhibited similar interannual shifts in prey composition (Beauchamp 2020).

These scenarios predicted the potential population-level predation effects on juvenile rockfish by hatchery Chinook and coho salmon. The resulting predation impacts estimated that 2.8 million total ESA-listed yelloweye rockfish and bocaccio larvae could be consumed under current hatchery production levels for sub-yearling Chinook salmon and 4.6 million larval fish consumed under the proposed *high* increase in hatchery production. By comparison, individual yelloweye rockfish can produce between 1.2 and 2.7 million larvae, and individual female bocaccio produce between 20,000 and 2.3 million eggs annually (Love et al. 2002). Assuming the actual larval outputs are an average of these ranges, resulting from the full size and age structure of the population, then the larval production is likely around 1.95 million yelloweye rockfish and 1.16 million bocaccio larvae per female per year; such that the consumption rates for the proposed hatchery increase would result in the loss of larval output equivalent to about two yelloweye rockfish and less than one bocaccio per year. Along with the high rates of mortality and low natural intrinsic growth rate of the populations, this is considered a minimal effect.

Effects of All Current Actions

To assess the population-level effects to yelloweye rockfish and bocaccio from activities associated with the research permits within the environmental baseline, take associated with the proposed action, scientific research, and fishery takes within the environmental baseline, we calculated the total mortalities for all sources (Table 2-12).

Table 2-12. Estimated total takes for the salmon fishery and percentages of the listed-rockfish covered in this Biological Opinion in addition to takes within the environmental baseline.

Species	Total Take in Baseline (plus high estimate)	Total Lethal Take in Baseline (plus high estimate)	Abundance Scenario	Percent of DPS Killed (total take)	Levels of Acceptable Mortality
Yelloweye Rockfish	563(+4)	452[a](+4)= 456	143,086	0.32	1 - 3.45%
Bocaccio	208(+7)	160[b](+7)= 167	4,606	3.6	4 - 6%

[a] This includes the following estimated yelloweye rockfish mortalities: 66 from the salmon fishery, 270 from the halibut fisheries, 51 during research, and 65 in other fisheries.
[b] This includes the following estimated bocaccio mortalities: 77 from the salmon fishery, 40 from the halibut fishery, 26 during research, and 17 in other fisheries.

Lethal takes are most relevant for viability analysis. For yelloweye rockfish and bocaccio, the takes from the salmon hatchery proposal, in addition to previously assessed lethal scientific research and fishery bycatch (fishermen targeting bottom fish and halibut) (detailed in Section 2.4, Environmental Baseline), would be below the risk-neutral and precautionary level for each of the abundance scenarios. As described above, our analysis of potential mortality for each species uses precautionary assumptions and thus would likely be lower than estimated. These precautionary assumptions include those of the previously analyzed research projects and that all of the take permitted will actually occur, when in fact the actual take of yelloweye rockfish and bocaccio is likely well below the permitted take. As an example, since bocaccio were listed in 2010, only 3 fish have been taken in research projects (compared to the permitted take of 38 fish, and 21 permitted mortalities in 2020 alone) within the U.S. portion of the DPS area.

In addition to fishery mortality, rockfish are killed by derelict fishing gear (Good et al. 2010), though we are unable to quantify the number of yelloweye rockfish and bocaccio killed. Despite these data limitations, it is unlikely that mortality associated with derelict gear would cause mortality levels of yelloweye rockfish and bocaccio to exceed the precautionary or risk-adverse levels. This is because the removal of over 5,800 nets has restored over 870 acres of the benthic habitat of Puget Sound and likely reduced mortality levels for each species, most new derelict gear becomes entangled in habitats less than 100 feet deep (and thus avoid most adults), and recent and ongoing programs provide outreach to fishermen to prevent net loss.

Critical habitat overlaps with large areas of Chinook and coho out-migration through Puget Sound, but fish passage through the pelagic zone will have no impact on benthic marine habitats. The quantity and availability of prey species, water quality, and the amount and structure of rugosity will not be altered to affect feeding opportunities and predator avoidance. We recently worked collaboratively to develop a Kelp Conservation and Recovery Plan (Calloway 2020), and over the next few years several groups are implementing restoration and recovery actions to improve habitats for yelloweye rockfish and bocaccio.

Thus, while the proposed action may have some small effect on the species' abundance (by killing a relatively small proportion of larvae), it is not likely to have an appreciable effect on their productivity, diversity, or structure within the Puget Sound/Georgia Basin. The structure of our analysis provides conservative population scenarios for the total population of the DPS, and likely overestimates the total mortalities of larval fish. Thus, taken together the effects of the proposed actions on ESA-listed rockfish in Puget Sound, in combination with anticipated bycatch from other fisheries and research, their current status, and the condition of the environmental baseline are not likely to reduce appreciably the likelihood of survival or recovery of yelloweye rockfish and bocaccio.

2.8. Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of yelloweye rockfish or bocaccio of the Puget Sound/Georgia Basin, or destroy or adversely modify their designated critical habitat.

2.10 Incidental Take Statement

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

2.10.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as a result of the proposed action. Larvae of yelloweye rockfish and bocaccio would be present in the action area and thus exposed to salmon predation. This exposure will harm some larvae by killing them. Based on the model described in the *effects of the action* (Section 2.5), we estimate that up to 4,462,344 larval yelloweye rockfish and 143,645 bocaccio larvae may be killed on an annual basis. Relative to high larval production, high natural mortality, and low intrinsic growth rates for the species, this could result in take of up to four yelloweye rockfish and seven bocaccio adult equivalents being killed. We consider this to be an overestimate based on a worst-case scenario of low larval abundance, and the assumption that larval consumption will occur at the same rate across all Puget Sound basins.

Although we have information indicating larvae of ESA-listed rockfish will be present and exposed to salmon predation, we have no information that enables us to precisely quantify the number of larvae harmed or killed by this action. Previous monitoring has demonstrated it would be extremely difficult to find and identify rockfish larvae in the diets of sub-yearling salmon, and annual variation in natural larval mortality makes it difficult to predict the numbers of larvae exposed to predation. Therefore, as a surrogate for actual take NMFS is using the *high* level hatchery release scenario (Table 1-3) as a worst-case estimate for incidental take of yelloweye rockfish and bocaccio in the model. This is a reasonable surrogate because should those release numbers be exceeded, that would then indicate that the expected incidental take has been exceeded, as a higher release level would logically increase the opportunities for take (although this higher level was not input into the model and therefore not analyzed in this opinion). The surrogate can be reliably monitored because NMFS SFD will provide annual reports on salmon and steelhead releases to NMFS PRD annually, and will alert NMFS PRD if the proposed release numbers are exceeded, as described in subsection 2.10.3, Reasonable and Prudent Measures.

2.10.2 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.

2.10.3 Reasonable and Prudent Measures

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

The following reasonable and prudent measures are included in this incidental take statement for Puget Sound/Georgia Basin yelloweye rockfish and bocaccio considered in this opinion.

1. NMFS SFD shall provide annual reports to NMFS PRD on anadromous salmon and steelhead hatchery program releases.
2. NMFS SFD shall submit a written report, and/or convene a discussion with NMFS PRD if the proposed release numbers are exceeded.

2.10.4 Terms and Conditions

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

1. NMFS SFD shall provide an annual report to NMFS PRD on anadromous salmon and steelhead hatchery program releases
    a. A report shall be submitted by December 31
    b. The report should be sent to: Lynne.Barre@noaa.gov

        National Marine Fisheries Service, West Coast Region
        Attention: Protected Resources Division Branch Chief
        7600 Sandpoint Way NE, Building #1
        Seattle, Washington 98115

2. NMFS SFD shall submit a written report, and/or convene a discussion with NMFS PRD if the proposed release numbers are exceeded within two weeks.
   a. If hatchery release numbers exceed the *high* proposed release number organized by species (Table 1-3) used in the model above to estimate take, NMFS SFD will notify NMFS PRD within two weeks.
   b. The Seattle PRD Branch Chief (Lynne.Barre@noaa.gov) shall serve as the point of contact for this notification

2.11 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).

1. While monitoring rockfish larvae in salmon diet is difficult, there has been a recognized need in Puget Sound to increase general monitoring of ichthyoplankton across the region. NMFS should support collaborative efforts by the Salish Sea Marine Survival Project have worked to address the linkage between zooplankton availability and sub-yearling salmon survival. This partnership includes researchers from USGS, University of Washington, Long Live the Kings, tribal agencies, WDFW, King County, and more to address data and funding gaps to monitoring. The Puget Sound Partnership also recently added zooplankton monitoring as an important indicator to understanding ecosystem health.

2. The Rockfish Recovery Plan (NMFS 2017f) outlines multiple conservation measures, including monitoring for fisheries management, cooperative research to reduce the impacts of bycatch and derelict gear, education and outreach, and habitat mapping for improving spatial planning. These recommendations lead to the development of the Kelp Conservation and Recovery Plan (Calloway et al. 2020) to improve benthic habitats for juvenile and adult rockfish. The Kelp Plan also includes a range of measures to improve and expand kelp habitats in Puget Sound. NMFS should support these recovery efforts, which are key to improving suitable critical habitat for yelloweye rockfish and bocaccio.

3. NMFS should continue ongoing efforts to monitor effectiveness of increased hatchery production to support the prey base for SRKW.

2.12 Reinitiation of Consultation

This concludes formal consultation for NMFS Sustainable Fisheries Division's (SFD) determinations on salmon and steelhead hatchery programs in Puget Sound. This consultation was conducted in accordance with the 2019 revised regulations that implement section 7 of the ESA (50 CFR 402, 84 FR 45016).

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

2.13 "Not Likely to Adversely Affect" Determinations

Three ESA-listed species overlap in time and area with the proposed action: Southern Resident killer whales, Southern DPS green sturgeon, and Southern DPS Pacific eulachon. Although the action may affect these three species, we conclude in the following section that it is not likely to adversely affect them or their designated critical habitat. Although the action area is described as the inland waters of Washington State, we do note that hatchery fish are also likely to migrate into coastal waters, where they become available to SRKW as adults anywhere those adult fish overlap with the range of the whales.

2.13.1 Species Determinations

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 2016 concluded that Southern Residents should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2016). Critical habitat in inland waters of Washington was designated on November 29, 2006 (71 FR 69054). Because NMFS determined the action is not likely to adversely affect SKRWs, this document does not provide detailed discussion of environmental baseline or cumulative effects for the SRKW portion of the action area.

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 significant 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 (Bigg 1982; Ford 2000; Krahn et al. 2002; Hauser et al. 2007; 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. Data from acoustic detections, opportunistic sightings, and satellite tagging was used to propose a revision of the Southern Resident killer whale critical habitat designation to include their coastal range in 2019 (84 FR 49214). The Draft Biological Report supporting this proposed rule contains more detailed information about SRKW habitat use along the U.S. West Coast, and can be found at https://beta.regulations.gov/document/NOAA-NMFS-2014-0041-0281.

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. 2016), but salmon are identified as their primary prey. Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. Scale and tissue sampling indicate that their diet consists of a high percentage of Chinook salmon. From May through September, Chinook salmon make up greater than 90% of Southern Residents' diet (Hanson et al. 2010; Ford et al. 2016). Prey remains and fecal samples collected in coastal areas during the winter and spring months indicate that although their diet is more diverse during this time of year, Chinook salmon remain an important prey species, making up 80% of the prey remains and 69% of the fecal samples collected (Hanson et al. in review). The diet data also indicates that the whales are consuming mostly larger (i.e., older) Chinook salmon.

Recently, Ford et al. (2016) confirmed the importance of Chinook salmon to the Southern Residents in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98% of the inferred diet, of which almost 80% were Chinook salmon. Coho salmon and steelhead are also found in the diet in spring and fall months when Chinook salmon are less abundant. Specifically, coho salmon contribute to over 40% of the diet in late summer, which is evidence of prey shifting at the end of summer towards coho salmon (Ford et al. 1998; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016). Less than 3% each of chum salmon, sockeye salmon, and steelhead were observed in fecal DNA samples collected in the summer months (May through September), however chum salmon are the second highest contributor to SRKW diet in the winter months, accounting for 33% of the fecal samples and 60% of the prey samples collected (Hanson et al. in review). 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. The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al. 2013). Chinook genetic stock identification from samples collected in winter and spring in coastal waters included 14 stocks from the U.S. west coast and Alaska, and over half the Chinook salmon consumed originated in the Columbia River (Hanson et al. in review).

Southern Residents are exposed to a mixture of toxic chemicals— primarily through their diet— some of which may interact synergistically and enhance toxicity, influencing their health, and reproduction. Relatively high levels of these pollutants have been measured in blubber biopsy samples from Southern Residents compared to other resident killer whales in the North Pacific (Ross et al. 2000; Krahn et al. 2007; Krahn et al. 2009; Lawson et al. 2020), and more recently, these pollutants were measured in fecal samples collected from the whales (Lundin et al. 2016a; Lundin et al. 2016b). Chinook salmon contain higher levels of some persistent pollutants than other salmon species, but only limited information is available for pollutant levels in Chinook salmon (Krahn et al. 2007; O'Neill and West 2009; Veldhoen et al. 2010; Mongillo et al. 2016). These harmful pollutants are stored in the blubber and can later be released; when the pollutants are released, they are redistributed to other tissues when the SRKWs metabolize the blubber, for example, responses to food shortages or reduced acquisition of food energy as one possible stressor. The release of pollutants can also occur during gestation or lactation. Once the pollutants mobilize from the blubber in to circulation, they have the potential to cause a toxic response. Therefore, nutritional stress from reduced Chinook salmon populations may act synergistically with high pollutant levels in SRKWs and result in adverse health effects.

NMFS has continued to fund the Center for Whale Research to conduct an annual census of the Southern Resident population. As of December 2019, Southern Residents totaled 73 individuals (22 in J pod, 17 in K pod, and 34 in L pod). 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. 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 2-6, NMFS 2016). 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.

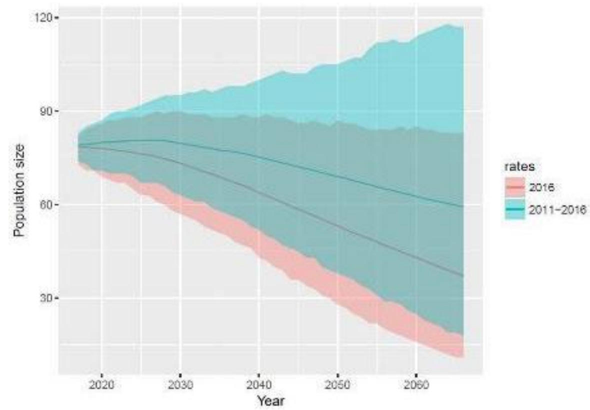

Figure 2-6. Southern Resident killer whale population size projections from 2016 to 2066 using two scenarios: (1) projections using demographic rates held at 2016 levels, and (2) projections using demographic rates from 2011 to 2016. The pink line represents the projection assuming future rates are similar to those in 2016, whereas the blue represents the scenario with future rates being similar to 2011 to 2016 (NMFS 2016).

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 effects of hatchery production on SRKW have been considered through several section 7 consultations. In a biological opinion issued on February 23, 2018 (NMFS 2018a), NMFS concluded that Chinook hatchery production in the Columbia River basin under the *US v Oregon* Management Agreement provided a benefit to SRKW by offsetting the reduction in natural-origin Chinook salmon from harvest. In fact, hatchery production currently provides a significant component of the salmon prey base returning to watersheds within the SRKW range (Barnett-Johnson et al. 2007; NMFS 2008a).

To assess the effect of the hatchery component of that action on SRKW, we considered the geographic area of overlap in the marine distribution of the Chinook salmon produced by the hatchery and the range of SRKW. We evaluated both the short-term and long-term effects from the hatchery component of that action. For the Columbia River action, hatchery production was found to offset the short-term impacts of the fishery by supplementing the prey base harvested in the fishery. Although hatchery production can pose a risk to natural-origin Chinook salmon and therefore SRKW, hatchery programs are often managing various program elements to allow operators to achieve Chinook salmon recovery program goals. These include, but are not limited to, changes in production, release sites, broodstock composition, and adult management. Therefore, as long as hatchery programs are managed in ways to minimize effects on natural-origin Chinook salmon, especially listed ESUs, the long-term effects to prey availability may also be minimized.

NMFS has identified the Northern and Southern Puget Sound Chinook salmon regions as the highest priority stocks for Southern Residents, based on their overall contribution to SRKW diet, their presence in SRKW diet during periods of reduced body condition, and spatio-temporal overlap with SRKW (NMFS 2018b). As we demonstrated in our analyses of hatchery impacts on SRKW for the *US v Oregon* Management Agreement and the Mitchell Act funded hatchery programs, hatchery production is a significant contributor to the SRKW prey base. The Puget Sound Chinook salmon hatchery programs considered in this opinion are expected to produce up to 394,307 adult equivalents spread between the Northern and Southern Puget Sound prey groups, compared to the almost 249,000 adult equivalents produced under current conditions (Table 1-3). For coho, which are also part of the diet of SRKW, the proposed hatchery programs are expected to produce up to 582,479 adult equivalents, compared to the over 426,000 produced under current conditions (Table 1-3). While other species included in the total hatchery production include steelhead, and chum, sockeye, and pink salmon (Table 1-2), and hatchery production of these other species and increases in their production could also benefit the whales, the benefits would not be to the same extent as coho and, most importantly, Chinook salmon production, which are much more prevalent in the whales' diet.

We also considered the potential for hatchery salmon and steelhead to introduce additional contaminants into the marine environment through the rearing process. Contaminants in salmon and steelhead in Puget Sound can pose problems for higher trophic levels that prey on these fish. Researchers have found that exposure to contaminants such as polychlorinated biphenyls (PCBs) occurs mostly in the marine environment (96-99% of the contaminant load), with the remainder attributed to the freshwater rearing phases (Cullon et al. 2009; O'Neill and West 2009). The 1-4% of the contaminant load attributable to the freshwater was further characterized as closer to 1% for undeveloped rivers and 4% for developed rivers. This trend still holds when comparing fish that originated in the freshwater rivers of the more developed region of Puget Sound, which also typically have higher contaminant loads, compared to fish originating on the less developed Washington Coast. Missildine et al. (2005) found that fish originating from Issaquah and Deschutes State Fish Hatcheries in Central and South Puget Sound, respectively, had higher levels of contaminants (> 45 µg/kg) than Chinook salmon originating from the Makah National Fish Hatchery and Quinalt Lake Tribal Hatchery on the Coast (< 20ug/kg; Missildine et al. 2005).

Although some PCBs in hatchery fish may be attributed to hatchery feed—up to 1% of the total contaminant load (PSEMP 2018)—, there may be some indication that hatchery feed contains lower levels of PBDEs than the diets of naturally feeding juvenile Chinook salmon (Sloan et al. 2010). As most of the exposure to contaminants takes place in the marine environment, there is insufficient data to suggest that the contaminant loads of adult hatchery-origin Chinook salmon differ significantly from natural-origin Chinook. While resident Chinook salmon in Puget Sound have higher contaminant levels, we are not able to compare residency proportions in hatchery-origin Chinook salmon to natural-origin Chinook salmon in Puget Sound. Based on the available information, an increase in hatchery production is not expected to affect the accumulation of contaminants or cause adverse health effects for SRKWs.

In the short-term over 3-5 years as the hatchery fish mature and become available as prey to the whales, this increase to high priority stocks represents a measurable increase in the prey base for SRKW, which would benefit the whales. However, healthy populations of natural-origin

Chinook salmon are also important prey for SRKW, and long-term effects on natural-origin Chinook salmon can occur from hatchery production. In our completed separate analyses of the impacts of these programs on listed salmonids (listed in Table 1-2), we concluded that the programs do meet management goals for natural-origin Chinook salmon. Although not all of the consultations have not been completed for every hatchery included in the proposed action, we expect that the bundles that have yet to be consulted on will be evaluated consistently with bundles that have already undergone consultation, using similar metrics and approaches. We also expect the remaining HGMPs that are the subject of ongoing consultations will include measures to minimize adverse effects of operating hatchery programs on viable salmonid population criteria (i.e. abundance, productivity, spatial structure and diversity) to the extent that the hatchery production will not jeopardize the listed salmonids or have significant adverse effects on the prey base of SRKW. Therefore, we expect that the continuation and proposed increases in hatchery production of Chinook and coho salmon in Puget Sound will be beneficial to the whales and not adversely affect the Southern Resident killer whale DPS.

Green Sturgeon

Green sturgeon are broadly distributed in nearshore marine areas from Mexico to the Bering Sea. Green sturgeon consist of two DPS's that co-occur throughout much of their range, but use different river systems for spawning. The Southern DPS consists of all naturally-spawned populations of green sturgeon originating from coastal watersheds south of the Eel River in California, and the Northern DPS consists of populations originating from coastal watersheds north of and including the Eel River. On April 7, 2006, NMFS listed Southern DPS green sturgeon as a threatened species and maintained the Northern DPS as a NMFS Species of Concern (71 FR 17757). Because NMFS determined the action is not likely to adversely affect green sturgeon, this document does not provide detailed discussion of environmental baseline or cumulative effects for the green sturgeon portion of the action area.

Subadults and adults of both the Southern DPS and Northern DPS migrate seasonally along the West Coast, congregating in bays and estuaries in Washington, Oregon, and California during the summer and fall months. During winter and spring months, they congregate off of northern Vancouver Island, B.C., Canada (Lindley et al. 2008).

Tagged Southern DPS green sturgeon have been detected in the Strait of Juan de Fuca, likely entering and migrating some distance into the Strait (Lindley et al. 2008; NMFS 2009). Some migrate through the Strait and into Puget Sound. Green sturgeon do not appear to use Puget Sound very extensively. Observations of green sturgeon in Puget Sound are much less common compared to the other estuaries in Washington. A few green sturgeon adults and/or subadults have been incidentally captured in Puget Sound fisheries, mostly in trawl fisheries (Adams et al. 2002). Monitoring data for tagged green sturgeon show few detections in Puget Sound (pers. comm. with Mary Moser, NMFS Northwest Fisheries Science Center, 4 April 2018).

Salmon and steelhead hatchery programs in Puget Sound are not likely to have measurable effects on Southern DPS green sturgeon or their habitat in Puget Sound and the Strait of Juan de Fuca. We are not aware of disease transmission between salmonids and sturgeon, and do not expect competition for food resources. Within Puget Sound, there is limited overlap in prey species, and green sturgeon only use the Puget Sound to a very limited degree. The primary prey consumed by salmon and steelhead in tidal fresh, brackish, and estuarine waters include aquatic and terrestrial insects, amphipods, mysids, copepods, krill, freshwater crustaceans, and larval and juvenile fish (Weitkamp et al. 2014). The primary prey consumed by green sturgeon in freshwater, bays, and estuaries include benthic invertebrates and fishes, such as crangonid shrimp, burrowing shrimp, amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies (Moyle et al. 1995; Erickson et al. 2002; Moser and Lindley 2007; Dumbauld et al. 2008).

In the Strait of Juan de Fuca, green sturgeon are primarily migrating, but may also be feeding. We do not expect the release of hatchery salmon and steelhead to affect the ability of green sturgeon to migrate through these areas. Green sturgeon are bottom-oriented, whereas salmon and steelhead typically occupy the water column. We also expect limited, if any, competition for prey resources, given the limited overlap in prey species. Salmon in coastal marine waters primarily feed on adult krill, juvenile fish (sand lance, rockfish, greenling, sculpins), amphipods, and larval crab (Brodeur et al. 2011), whereas green sturgeon likely feed on benthic invertebrates and fish similar to those fed upon in bays and estuaries (e.g., shrimp, clams, crabs, anchovies, sand lances, as described above).

Overall, the proposed hatchery programs would not affect Southern DPS green sturgeon and their habitat in a measurable way, and any potential effects would therefore be insignificant. We conclude that the proposed hatchery programs may affect, but are not likely to adversely affect, Southern DPS green sturgeon.

Pacific Eulachon

On March 18, 2010, NMFS listed the Southern DPS of Pacific eulachon (*Thaleichthys pacificus*) as a threatened species (75 FR 13012). Eulachon are endemic to the northeastern Pacific Ocean ranging from northern California to southwest and south-central Alaska and into the southeastern Bering Sea (Gustafson et al. 2010). Eulachon are anadromous, spawning in the lower reaches of rivers, followed by a movement to the ocean as small pelagic larvae. Although they spawn in fresh water rivers and streams, eulachon are mainly a marine fish, spending 95% of their lives in marine waters (Hay and McCarter 2000). Eulachon are a short-lived smelt (3-5 years), that averages 40g in weight and 10-30cm in length (Gustafson et al. 2010). Puget Sound lies between two of the larger eulachon spawning rivers (the Columbia and Fraser rivers) but lacks a large eulachon run of its own (Gustafson et al. 2010).

The Southern DPS of eulachon includes all naturally-spawned populations that occur in rivers south of the Nass River in British Columbia to the Mad River in California. Sub populations for this species include the Fraser River, Columbia River, British Columbia and the Klamath River. In the early 1990s, there was an abrupt decline in the abundance of eulachon returning to the Columbia River. Despite a brief period of improved returns in 2001-2003, the returns and associated commercial landings eventually declined to the low levels observed in the mid-1990s. Although eulachon abundance in monitored rivers has generally improved, especially in the 2013-2015 return years, recent poor ocean conditions and the likelihood that these conditions will persist into the near future suggest that population declines may be widespread in the upcoming return years.

The following limiting factors were outlined in the "Endangered Species Act Recovery Plan for the Southern Distinct Population Segment of Eulachon (*Thaleichthys pacificus*)" (NMFS 2017):

- Changes in ocean conditions due to climate change, particularly in the southern portion of the species' range where ocean warming trends may be the most pronounced and may alter prey, spawning, and rearing success.
- Climate-induced change to freshwater habitats
- Bycatch of eulachon in commercial fisheries
- Adverse effects related to dams and water diversions
- Water quality
- Shoreline construction
- Over harvest
- Predation

For most S eulachon DPS spawning runs, abundance is unknown with the exception of the Columbia and Fraser River spawning runs. From 2015 through 2019, the eulachon spawner population estimate for the Fraser River is 2,877,962 adults and for the Columbia River 29,151,081 adults. The combined spawner estimate from the Columbia and Fraser rivers is 32.03 million eulachon. Since 2011, salmonid researchers have captured eulachon in small numbers throughout Puget Sound and in several watersheds including the Deschutes River, Dungeness River, Elwha River, Goldsborough Creek (Mason County), Nisqually River, and Salmon Creek (Jefferson County) (NMFS APPS database). The Elwha River is the only river system within the action area that (1) has critical habitat designated and (2) has an established eulachon run.

The Elwha River has historically and currently supports a small eulachon run. Since 2005, the Lower Elwha Klallam tribe has run a screw trap in the lower Elwha River to estimate outmigrating salmonids. Although these surveys are targeted at outmigrating salmonids, they do incidentally catch other species including eulachon. However, a screw trap is not an optimal capture method for eulachon due to orientation (screw traps are oriented downstream to catch outmigrants and eulachon are migrating upstream) and timing (eulachon runs begin as early as December and this trap is not operating until early-February to mid-March); therefore, neither eulachon abundance nor absence can be determined through these surveys. What can be determined is presence, and eulachon have been present in the Elwha River in 12 of the past 15 years (Table 2-12).

Table 2-12. Screw trap operation schedule and eulachon capture timing and abundance for the Lower Elwha River (pers. comm. M. McHenry, Lower Elwha Klallam Tribe, 9 May 2020).

	Screw Trap		Eulachon captures		
Year	Start Date	End Date	Start Date	End Date	Total Captures
2005	15-Mar-05	30-Jun-05	9-Apr-05	30-Jun-05	20
2006	11-Mar-06	25-Jun-06	31-Mar-06	20-Jun-06	20
2007	21-Feb-07	13-Jun-07	14-May-07	14-May-07	1
2008	7-Feb-08	14-May-08	12-Mar-08	12-Mar-08	1
2009	17-Feb-09	26-May-09	28-Feb-09	23-Mar-09	3
2010	8-Feb-10	28-May-10	14-Feb-10	7-May-10	45

2011	11-Feb-11	19-Jun-11	-	-	0
2012	17-Feb-12	1-Jul-12	17-Feb-12	12-Jun-12	187
2013	19-Feb-13	10-Apr-13	21-Feb-13	8-Mar-13	3
2014	5-Feb-14	22-Jul-14	-	-	0
2015	24-Feb-15	9-Jul-15	24-Feb-15	2-Jun-15	24
2016	26-Feb-16	10-Jul-16	3-Apr-16	2-Jun-16	3
2017	2-Feb-17	2-Aug-17	24-Feb-17	8-May-17	7
2018	16-Feb-18	15-Aug-18	20-Feb-18	18-Jun-18	23
2019	22-Feb-19	30-Jul-19	-	-	0

Beginning in 2020, the Lower Elwha Klallam tribe began surveys on the Elwha River and the adjacent Dungeness and Lyre rivers to collect eulachon eggs, ichthyoplankton, and adult fin clips to help determine eulachon abundances and genetics for those northern Olympic Peninsula rivers (pers. comm. R. Paradis, Lower Elwha Klallam Tribe, 9 May 2020).

Eulachon may be impacted by hatchery fish through competition for space, and possibly predation on eulachon by salmon and steelhead juveniles. Predation by hatchery salmon and steelhead juveniles on newly hatched juvenile eulachon is assumed to occur if hatchery salmonid juveniles overlap with juvenile eulachon emigrating from tributary basins. The actual level of predation and the effects of that predation on eulachon are unknown and were not considered substantive compared to other factors identified as limiting the recovery of eulachon (Gustafson et al. 2010). Therefore, we conclude that the potential effects of proposed hatchery programs would be insignificant and that the programs may affect, but are not likely to adversely affect, the Southern DPS of Pacific eulachon.

2.13.2 Critical Habitat Determinations

Southern Resident Killer Whales

SRKW critical habitat was designated in the inland waters of Washington State on November 29, 2006 (71 FR 69054). Three physical or biological features of SRKW habitat were identified as essential to conservation: (1) Water quality to support growth and development; (2) Prey species of sufficient quantity and quality to support growth and development; and (3) Passage conditions to allow for migration, resting, and foraging. The hatchery fish produced in the Puget Sound HGMPs overlap with critical habitat for SRKW. There are no anticipated impacts to water quality or passage conditions for SRKW, and as described above, the action is expected to result in a measurable increase to the prey base for SRKW. Therefore, we conclude that the potential effects of the hatchery programs are wholly beneficial to SRKW critical habitat, and that there will be no adverse modification of SRKW critical habitat as a result of the proposed action.

Green Sturgeon

NMFS designated critical habitat for Southern DPS green sturgeon on October 9, 2009 (74 FR 52300). Designated critical habitat for Southern DPS green sturgeon does not include Puget Sound, but does include U.S. coastal marine waters in the Strait of Juan de Fuca, Washington.

The designated critical habitat within the Strait of Juan de Fuca contains all three essential habitat features for green sturgeon: water quality, food resources, and a migratory corridor. However, we do not expect the proposed production and release of salmon and steelhead from the hatchery programs to have a measurable effect on these essential features. There are no anticipated impacts to water quality parameters significant to green sturgeon, such as dissolved oxygen and contaminant levels. Because there is limited overlap between the prey species for salmonids and green sturgeon, we also do not expect the increase in salmon and steelhead within the Strait to measurably reduce food resources for green sturgeon. Finally, given their separation in space, we do not expect the increase in salmon and steelhead within the Strait to impede migration of green sturgeon.

Overall, the proposed hatchery programs would not affect designated critical habitat for Southern DPS green sturgeon in a measurable way, and any potential effects would therefore be insignificant. We conclude that the proposed hatchery programs may affect, but are not likely to adversely affect, designated critical habitat for Southern DPS green sturgeon.

Pacific Eulachon

In 2011, NMFS designated critical habitat for eulachon in portions of 16 rivers and streams in California, Oregon, and Washington (76 FR 65324). All of these areas are designated as migration and spawning habitat for this species. In Oregon, NMFS designated 24.2 miles of the lower Umpqua River, 12.4 miles of the lower Sandy River, and 0.2 miles of Tenmile Creek. NMFS also designated the mainstem Columbia River from the mouth to the base of Bonneville Dam, a distance of 143.2 miles. Dams and water diversions are moderate threats to eulachon in the Columbia and Klamath rivers where hydropower generation and flood control are major activities. Degraded water quality is common in some areas occupied by southern DPS eulachon. In the Columbia and Klamath river basins, large-scale impoundment of water has increased winter water temperatures, potentially altering the water temperature during eulachon spawning periods. Numerous chemical contaminants are also present in spawning rivers, but the exact effect these compounds have on spawning and egg development is unknown. Dredging is a low to moderate threat to eulachon in the Columbia River. Dredging during eulachon spawning would be particularly detrimental. For this action, only one critical habitat location lies within the action area – the Elwha River. We do not expect the hatchery actions described in this Opinion to have any appreciable effect on the Southern DPS of Pacific eulachon's critical habitat.

3. Data Quality Act Documentation and Pre-Dissemination Review

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

2.9. Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion is the

National Marine Fisheries Service. Individual copies of this opinion were provided to the NMFS Sustainable Fisheries Division in Portland, OR. The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adheres to conventional standards for style.

2.10. 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.

2.11. Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

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