UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OR 97232-1274

Refer to NMFS No:
WCRO-2021-03087

February 16, 2022

Susan Poulsom
Manager, NPDES Permitting Section
United States Environmental Protection Agency
Region 10
1200 Sixth Avenue, Suite 155
Seattle, Washington 98101-3188

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the NPDES General Permit for Tribal Enhancement and Federal Research Marine Net Pen Facilities Within Puget Sound, NPDES Permit No. WAG132000.

Dear Mrs. Poulsom:

Thank you for your letter of November 30, 2021, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for reissuance of the NPDES General Permit for Tribal Enhancement and Federal Research Marine Net Pen Facilities within Puget Sound, NPDES Permit No. WAG132000. 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) that analyzes the effects of the United States Environmental Protection Agency's (EPA's) reissuance of National Pollutant Discharge Elimination System (NPDES) general permit for tribal enhancement and federal research net pens in the Puget Sound, WA. In this opinion, we conclude that the proposed action is not likely to jeopardize the continued existence of PS Chinook salmon (*Oncorhynchus tshawytscha*), PS steelhead (*O. mykiss*), Hood Canal summer-run chum (HCSRC; *O. keta)*, PS/Georgia Basin (PS/GB) yelloweye rockfish (*Sebastes ruberrimus*) or PS/GB bocaccio (*S. paucispinis*). Further, we conclude that the proposed action is not likely to result in the destruction or adverse modification of the designated critical habitat for any of the listed species.

The opinion includes an incidental take statement that describes reasonable and prudent measures we consider necessary or appropriate to minimize incidental take associated with this action. The take statement also sets forth terms and conditions, including reporting requirements that EPA must comply with to carry out the reasonable and prudent measures. Incidental take from actions that meet these terms and conditions would be exempt from the ESA take prohibition.

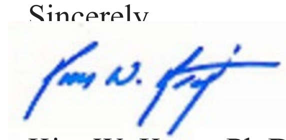
NMFS also reviewed the likely effects of the proposed action on essential fish habitat (EFH), pursuant to section 305(b) of the Magnuson–Stevens Fishery Conservation and Management Act (16 U.S.C. 1855(b)), and concluded that the action would adversely affect the EFH of Pacific Coast Salmon, Pacific Coast groundfish and coastal pelagic species. Therefore, we have included the results of that review in Section 3 of this document.

We have included conservation recommendations to avoid, minimize, or otherwise offset potential adverse effects on EFH. These conservation recommendations are a subset of the ESA take statement's terms and conditions. Section 305(b) (4) (B) of the MSA requires federal agencies to provide a detailed written response to NMFS within 30 days after receiving the final recommendations.

If the response is inconsistent with the essential fish habitat conservation recommendations, the EPA must explain why the recommendations will not be followed, including the scientific justification for any disagreements over the effects of the action and the recommendations. In response to increased oversight of overall essential fish habitat program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each essential fish habitat consultation and how many are adopted by the action agency. Therefore, we request that, in your statutory reply to the essential fish habitat portion of this consultation, you clearly identify the conservation recommendations accepted.

Please contact Dr. Jeff Vanderpham, consulting biologist in the Lacey, Washington office (360-999-8060, jeff.vanderpham@noaa.gov) if you have any questions concerning this consultation, or if you require additional information.

Sincerely,



Kim W. Kratz, Ph.D
Assistant Regional Administrator
Oregon Washington Coastal Office

cc: John Palmer, EPA Region 10
Martin Merz, EPA Region 10

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson–Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the

NPDES General Permit for Tribal Enhancement and Federal Research Marine Net Pen Facilities Within Puget Sound, NPDES Permit No. WAG132000

NMFS Consultation Number: WCRO-2021-03087

Action Agency: United States Environmental Protection Agency

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?
PS steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	No	No
PS Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	Yes	No
Hood Canal summer-run chum salmon (*O. keta*)	Threatened	Yes	No	Yes	No
PS/GB bocaccio rockfish (*Sebastes paucispinis*)	Endangered	Yes	No	Yes	No
PS/GB yelloweye rockfish (*S. ruberrimus*)	Threatened	Yes	No	Yes	No
Southern DPS green sturgeon (*Acipenser medirostris*)	Threatened	No	No	No	No
Southern DPS eulachon (*Thaleichthys pacificus*)	Threatened	No	No	No	No
Mexico DPS humpback whale (*Megaptera novaeanglia*)	Threatened	No	No	No	No
Central America DPS humpback whale (*M. novaeanglia*)	Endangered	No	No	No	No
Southern resident killer whale (*Orcinus orca*)	Endangered	No	No	No	No

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	Yes
Pacific Coast Groundfish	Yes	Yes
Coastal Pelagic Species	Yes	Yes

Consultation Conducted By: National Marine Fisheries Service
West Coast Region

Issued By:

Kim W. Kratz, Ph.D.
Assistant Regional Administrator
Oregon Washington Coastal Office

Date: February 16, 2022

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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 U.S.C. 1531 et seq.), as amended, and implementing regulations at 50 CFR part 402.

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

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

We conducted the above-referenced consultation in accordance with the 2019 revised regulations that implement section 7 of the Endangered Species Act (ESA) (50 CFR 402, 84 FR 45016).[1]

1.2. Consultation History

On December 23, 2020, NMFS received a request for informal consultation from the EPA for the proposed action. The request included a BE, concurrence request letter, a draft proposed general permit (GP) and a net pens fact sheet. We had two meetings with the EPA to discuss the proposed action and the consultation process on September 29, 2021, and November 9, 2021. Upon review of the information provided, we determined that the information provided did not demonstrate that the effects of the proposed action are either wholly beneficial, discountable, or insignificant. Therefore, NMFS could not concur with the EPA's not likely to adversely affect (NLAA) determinations for Puget Sound (PS) Chinook salmon, PS steelhead, Hood Canal summer-run chum (HCSRC), PS/Georgia Basin (PS/GB) bocaccio and PS/GB yelloweye rockfish, and their designated critical habitat. We electronically provided a non-concurrence letter to the EPA on November 18, 2021, that included a request for additional information about the proposed action should the EPA request formal consultation.

1 Pursuant to Executive Order 13990, NMFS currently is reviewing the revisions to those ESA section 7 regulations at 50 CFR part 402 adopted on August 27, 2019 (84 FR 44976) (the 2019 Rule). For purposes of this consultation, we also considered whether the substantive analysis and its conclusions regarding the effects of the proposed actions articulated in the Biological Opinion and its Incidental Take Statement would be any different under the 50 CFR part 402 regulations as they existed prior to the 2019 Rule. We have determined that they would not be any different. In making this determination, we considered the categories of effects we analyzed, as well as the prior definitions of "effects of the action," and "environmental baseline," among other prior terms and provisions.

We received EPA's request for formal consultation on November 30, 2021. A BE addendum, maps and drawings of net pen facilities, and notices of intent (NOI) for coverage of tribal enhancement marine net pen facilities were provided with the request and added to the administrative record for the consultation. Upon review, we determined that the information provided by the EPA included the necessary information to complete ESA Section 7 and EFH consultation, and formal consultation was initiated on November 30, 2021. This formal ESA Section 7 consultation is triggered by likely adverse effects to PS Chinook salmon, PS steelhead, HCSRC, PS/GB bocaccio and PS/GB yelloweye rockfish, and critical habitat for each of these species. The EFH portion of this consultation is triggered because the proposed action may adversely affect EFH for Pacific Coast groundfish, coastal pelagic species, and Pacific Coast salmon.

1.3. Proposed Federal Action

Under the ESA, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (see 50 CFR 402.02). Under the MSA, "Federal action" means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal agency (see 50 CFR 600.910).

The proposed action is a reissuance of the existing GP (NPDES Permit No. WAG132000) for marine tribal enhancement net pen facilities within PS, and expansion of the permit eligibility to include federal research net pen facilities. The reissuance of the GP as a proposed action does not include commercial facilities as they are not covered by this permit. However, those commercial facilities are analyzed under a concurrent biological opinion (WCRO-2018-00286) and are included and addressed in the Environmental Baseline section (Section 2.4) of this opinion.

1.3.1 Facility Background

The net pens permitted under the proposed GP are defined as concentrated aquatic animal production (CAAP) facilities. CAAP facilities are defined as a hatchery, fish farm, or other facility that contains, grows, or holds:

> Cold water fish species or other cold-water aquatic animals in ponds, raceways, or other similar structures that discharge at least thirty days per year, but does not include:
>
> 1. Facilities that produce less than 20,000 harvest weight pounds of aquatic animals per year, and
> 2. Facilities that feed less than 5,000 pounds of food during the calendar month of maximum feeding.

These CAAP facilities are point sources subject to the NPDES permit program per 40 CFR 122.24.

The proposed GP is expected to authorize discharges from existing tribal enhancement marine net pen facilities raising native salmonids (enhancement facilities) and one federal research marine net pen facilities raising native finfish (research facilities) within PS in Washington State. Currently there are five tribal enhancement facilities that have submitted NOI for coverage under the existing GP, all of which were approved and are currently covered (NPDES Permit No. WAG132000). One additional enhancement facility that the Lummi Tribe plans to construct in Lummi Bay, which we reasonably expect will apply for coverage under the proposed GP, is included in the proposed action. In these facilities, young fish remain in the net pens for several months in order to imprint on the location, with the expectation that after they are released they will return a year or two later for harvesting.

There is one federal research facility, the Manchester Research Facility operated by the National Oceanic and Atmospheric Administration (NOAA) that has submitted an individual permit application to EPA. This facility is not eligible for coverage under the existing GP, but would be eligible for coverage under the proposed GP, and NOAA plans to submit a NOI for coverage. The existing federal research facility grows sablefish (black cod) in order to assess the growth, survival, economics, and/or environmental impact of growing these fish in net pen systems. At the end of the initial two-year grow-out, the sablefish will be harvested. Although this is the only research facility expected to apply for coverage under this GP at this time, other federal research facilities that meet eligibility requirements may submit a Notice of Intent (NOI) for coverage under the reissued GP in the future.

1.3.2 Facility Operation

General Design - Net pen systems take advantage of an existing water body's circulation to disperse wastes and bring fresh water to the animals. Net pens are typically suspended from a floating structure and anchored to the sea bottom, while allowing some movement with tides and currents.

Authorized Discharges and Permit Conditions. The proposed GP is for five years, and identifies ten pollutants and practices of concern with the potential to impact PS waters: biodeposits; biological oxygen demand (BOD); drugs and pesticides; disease; fish escape; heavy metals; fuel, oil, and maintenance pollutants; fish carcasses; chlorine; and microplastics.

The effects of potential discharges on ESA listed species is evaluated in Section VII of the GP.

Table 1. Summary of Potential Discharges and Permit Requirements

Potential Discharge	Permit Requirements
Biodeposits	TOC below PS reference values (See PS Reference TOC Values; Table 3 in proposed GP) Anoxic sediment coverage below 25% Benthic mat coverage below 25%
BOD	Minimum DO of 7.0 mg/L; or 0.2 mg/L decrease if baseline is below 7.0 mg/L (see WAC 173-201A-210(1)(d)).
Drugs and pesticides	Part III.E.1 of the proposed GP, According to label, investigational studies or as prescribed by a veterinarian.
Disease	Salmonid Facilities: Follow Co-Manager Disease Control Policy (2006) Non-Salmonid Facilities: Required BMPs minimize disease risk (Part III.E in the proposed GP)
Fish escape (research facilities only)	Release prohibited Required BMPs (Part III.B.5, Part III.F.1, Part V.B Fish Escape Prevention and Response Plan

Potential Discharge	Permit Requirements
Heavy metals	Use of biocidal chemicals prohibited unless prescribed by veterinarian.
Fuel, oil, maintenance pollutants	Required BMPs minimize potential effects (Part III.B.7, Part III.C.4, Part III.A.3),
Fish Carcasses	Discharge prohibited Required BMPs minimize potential effects (Part III.C and Part III.F.2)
Chlorine	Discharge prohibited Required BMPs minimize potential effects (Part III.C.3)
Microplastics	Required BMPs minimize potential effects (Part III.A.2, Part III.B, Part III.D.2, Part III.F.2c).

1.3.3 Monitoring Requirements

In accordance with Section 308 of the CWA, 33 U.S.C. §1318, and 40 CFR §§122.48 and 122.44(i), monitoring requirements are included in an NPDES permit to determine compliance with effluent limitations, to gather data to evaluate the need for future effluent limitations, and/or to monitor impacts on the receiving water. All analyses required by the proposed GP must be conducted in accordance with methods and procedures established by 40 CFR Part 136.
The proposed GP requires monitoring of certain pollutants to assess the environmental effects of the net pens. Specifically, the GP requires total organic carbon sediment characterization, dissolved oxygen monitoring in the water column, and a visual assessment of both the benthos and water column. The monitoring results are evaluated against specific action thresholds as described in part IV.D of the proposed GP. When the action thresholds are triggered, the corrective action requirements in the permit are designed to bring permittees back into compliance quickly.

Sediment Characterization

The GP requires sediment characterization beneath and in proximity to the net pens. Sediment characterization at facilities that operate fewer than 6 months per year is required once—during peak biomass of the permit term. Facilities that operate 6 or more months per year must characterize the sediments twice during the 5-year permit term, once during peak biomass and once during the summer critical period between August 15 and September 30. These sediment characterization surveys must include analysis of the total organic carbon and percent silt-clay particles present in three locations beneath the net pens or within 10 meters of the perimeter of the net pens in a down-current direction. Sample analysis must be on a homogenization of the top 2 centimeters of sediment. Five TOC replicate samples must be taken at each of the 3 sampling locations. The standard sampling and analytical procedures (40 CFR §136) must be followed, and the methods used must be recorded. Unlike the sediment standards for commercial net pen operations, EPA does not permit the allowance of a sediment impact zone in the general permit.

Visual Assessments

The GP requires visual assessments of the benthos and water column at each net pen site. At peak biomass (within 30 days prior to release or harvest of the fish each season or cohort), the benthos must be assessed for sediment type and color, the presence of feed or other debris originating from the net pen facility, and the presence of *Beggiatoa spp*. or other benthic bacteria/fungal mats, with an estimate of the percent coverage of these mats beneath the net pen and within 150 feet of its perimeter in a down-current direction. A visual assessment of the water column is required once per week while fish occupy the net pen, to evaluate the water column for floating debris, other solids, discoloration, or sheens.

Surface Water Monitoring

Monitoring is also required for dissolved oxygen in the water column. Each sampling event must include six total samples at a minimum of two locations and depths, with one sample location at least 15 feet beneath the water surface, or within the bottom half of the water column if shallower than 15 feet. Monitoring frequency is described in Table 2. All samples must include the location, date and time, and water depth of the sample. The standard sampling and analytical procedures (40 CFR §136) must be followed, and the methods used must be recorded.

Table 2. Dissolved Oxygen Monitoring Frequency

Timeframe	Frequency
January 1 – August 14 (Only while fish occupy the net pens)	1/Month
August 15 – September 30 (Only while fish occupy the net pens)	1/Week

Evaluation of Monitoring Data

All monitoring data must be evaluated against the action thresholds in Table 3 below, which can also be found in part IV.D of the proposed GP.

Table 3. Sediment and Water Quality Threshold Values

Pollutant Indicator	Action Threshold
Sediment Total Organic Carbon	Exceeds relevant reference value or facility baseline level by statistically significant amount (t-test, $p \leq 0.05$)
Presence of anoxic sediments	25% or more of the area under the net

If at any time indicator pollutants exceed the associated action threshold, the Permittee must take immediate action to address the problem(s), per Part V of the GP, Corrective Action:

- The source of the problem must be immediately identified. Should net pen activities be the cause of the problem, adequate measures must be taken to abate the discharge of pollutants, including repairing or replacing equipment, modifying procedures or processes, or implementing additional measures. Implementation of corrective actions does not provide enforcement relief.
- Spills of any kind (i.e., drugs, pesticides, feed, maintenance related pollutants) resulting in a discharge to waters of the U.S., any noncompliance that may endanger health or the environment, any unanticipated bypass (See GP Part VII.J), and any upset (See GP Part VII.K) should be reported to EPA as soon as possible but within 24 hours from the time the permittee becomes aware of the circumstances.
- EPA may also request the Permittee to undertake additional monitoring to determine the cause or extent of a water quality-related problem. Permittees are required to comply with

all provisions of the GP; if there is an exceedance of an action threshold and the facility Permittee neglects to take corrective action in response, EPA's Enforcement and Compliance Assurance Division has the authority to invoke formal enforcement actions to bring the Permittee into compliance.

The GP also prohibits certain practices and discharges, and requires discharge controls to protect environmental conditions, as detailed in the Draft GP.

1.3.4 Prohibited Practices, Prohibited Discharges and Discharge Controls

General

1. Visible oil sheen, foam, discoloration, floating solids, or settleable solids that would impair the designated uses of the receiving water must not discharge to waters of the U.S.

2. Solid wastes shall be collected for transport, recycling and/or disposal at a recycling or disposal facility and must not be discharged to waters of the U.S.

3. Fuel, drugs, pesticides and other potential pollutants must be stored off-site and conveyed to the facility in daily quantities only, with the exception of feed which may be conveyed in weekly quantities (See Part III.D.3 regarding on-site storage).

4. [Research facilities only] The release of fish from the net pens to waters of the U.S. is prohibited.

Cleaning and Maintenance

1. [Research facilities only] Permittees shall maintain flow through the nets such that there is no impedance and drag on the nets that threatens the structural integrity of the net pen array. Predator exclusion nets shall be cleaned in-situ as needed but not less frequently than at 6-month intervals when nets are in the water. Fish containment nets shall be replaced with new nets as needed but not less frequently than at 6-month intervals while nets are in the water. Alternatively, fish containment nets may be cleaned in situ as needed, but not less frequently than at 4-month intervals. During the fallowing period between fish cohorts, the fish containment nets shall be removed from the water and cleaned at an upland location. Between each cohort of fish, net pens must be fallowed for at least six weeks.

2. To the maximum extent possible, when the net pens are empty, facilities should allow the nets to dry over water and then remove them for upland cleaning. If infeasible to move the net pens to an upland location prior to cleaning, in situ mechanical cleaning (e.g., brushing and power washing) of nets, frames and anchor structures to remove solids in situ is allowed under conditions that will disperse solids and prevent concentrated bottom settling (i.e., high tide, rapid current). Only biofouling solids are allowed to be dispersed. All other solid wastes must be collected and removed for land-based disposal. In-situ net cleaning of discreet portions of the net must be phased over a sufficient period of time in order to avoid a significant discharge of material during a single cleaning event.

3. The use of biocidal chemicals to disinfect nets is prohibited for all facilities unless prescribed by a veterinarian or so determined by the Northwest Indian Fisheries Commission Fish Health Specialist, as necessary to prevent the spread of disease.

4. Runoff or solids from upland cleaning of nets are prohibited from being discharged to waters of the United States.

5. [Research facilities only] Permittees are required to have inspections completed by a professional engineer every two years, when the net pen sites are fallow, to assess the structural integrity of the walkways, attachment points and pilings. The resulting report, and any previous studies related to structural integrity, are required to be kept onsite and made available to EPA and the Washington Department of Ecology (Ecology) upon request. Any changes related to escapement potential and structural integrity since the previous inspection shall be documented in the annual report for that year. Any issues identified in the inspection that could impact permit compliance should be addressed by the Permittee in a timely manner in accordance with Part V of the permit (Corrective Action).

6. Nets and anchoring structures are prohibited from impeding the current flow or tidal exchange so as to contribute to the deposition of solids that would impair water quality standards.

7. Fueling, lubrication and other general maintenance of boats and other mechanical equipment are prohibited at the net pen facility, with the exception set forth in Part III.C.4 regarding fueling during fish transport.

Fish Transport, Mortalities and Harvest

1. Fish harvesting is prohibited at enhancement facilities, other than for the purposes of removing fish to evaluate growth, health or other sub-sampling for evaluation purposes. Fish harvesting at research facilities is permitted.

2. Discharge associated with transport or harvesting of fish, including blood, viscera, carcasses, transport water containing blood, and leachate from these materials are prohibited from being discharged to waters of the U.S.

3. Water used in rearing and holding units or hauling trucks that is disinfected with chlorine or other chemicals shall be treated before it is discharged to waters of the U.S (i.e., dechlorinated).

4. Gas powered water pumps used during fish transfer to the net pens on a the transportation barge, which takes approximately 2 weeks, may be refueled on-site as long as refueling takes place within secondary containment. Spill response procedures must also be established and the necessary spill response supplies must be in place at all times.

5. Fish and other animal mortalities are required to be removed and disposed of in leak-proof containers at least once per week. Disposal shall be to an approved land-based facility/operation, e.g., composting facility, properly maintained dumpster, incineration facility. No dead animals, fish, fish tissue or fish products shall be released to the water.

Fish Feed

1. Fish feeding will occur according to protocols that ensure that excess feeding and accumulation of uneaten food below the net pens does not occur, through a combination of:
    a. Calculated feed conversion ratios based on fish size;
    b. Direct fish feeding observations designed to immediately cease feeding when the fish are not eating; and
    c. Other monitoring practices that ensure feeding rates are appropriate.

2. Used feed bags shall be collected for transport, recycling and/or disposal at a recycling or disposal facility and must not be discharged to waters of the U.S.

3. Large quantities of food are required to be stored off-site and conveyed to the facility only in weekly quantities. On-site storage must be in covered and locked facilities on the storage barge.

Drugs, Pesticides and Disease

1. All drugs and pesticides are required to be used in accordance with applicable label directions (FIFRA or FDA), except under the following conditions, both of which must be recorded and reported to EPA in accordance with Part VI.A and VI.B, below: a. Participation in Investigational New Animal Drug (INAD) studies, using established protocols; or
b. Extra-label drug use, as prescribed by a veterinarian.

2. [Salmonid facilities only] Disease surveillance, prevention, and treatment for facilities rearing salmonids shall be consistent with the requirements of *The Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State*, revised July 2006 (NWTT and WDFW 2006). Any facility that is not already party to the Policy is expected to become a formal co-operator of the Policy. See Part V.B for contact information. The Policy stipulates several requirements including:
    a. The health of each fish stock will be monitored monthly for regulated pathogens by a Fish Health Inspector;
    b. Significant fish losses suspected due to an infectious agent must be promptly investigated by the facility manager and a Fish Health Inspector, and preventative drug, pesticide or other chemical use must be implemented; and
    c. Transfer requirements must be met to prevent the spread of endemic fish pathogens.

Disease epidemic notification requirements can be found in Part V.B. of the proposed GP. Drug, pesticide and other chemical use recordkeeping and reporting requirements can be found in Parts VI.A and VI.B.

[Non-salmonid facilities only] Permittees are required to take the following steps to mitigate disease spread:
    a. Complete daily inspections of fish by net pen technicians and weekly inspections by the net pen manager to look for any irregularities in fish behavior or conditions (e.g., lesions) that would suggest health issues requiring subsequent pathogen analysis and a veterinarian;

b. Carry out a mandatory health inspection of the fish and net pen system by a fish health specialist or veterinarian every 6 months during fish net pen occupancy;
c. Ensure controlled water quality rearing conditions for broodstocks, eggs, and larvae leading to the production of juveniles for net pen stocking;
d. Ensure segregation of age classes (no co-culture of >1 generation); and
e. Employ standard biosecurity protocols (e.g., tank, net, and equipment disinfection) during rearing on land and during movement from land to net pens.

Disease epidemic notification requirements can be found in Part V.B. Drug, pesticide and other chemical use recordkeeping and reporting requirements can be found in Parts VI.A and VI.B. of the proposed GP.

Accident Prevention and Response Planning

[Research facilities only] Permittees must have a plan in place to prevent fish escape and to react in the event of escape in accordance with WAC 220-370-110 and WAC 220-370-120. The plan must be developed within 180 days of the effective date of this permit, kept onsite and made available to EPA and Ecology upon request. The plan must include the following:

a. Routine procedures to minimize escape during day to day operations;
b. Procedures to minimize escape during cleaning, repair, or other maintenance of net pens;
c. Training procedures for employees on fish escape prevention;
d. Procedures for reporting fish escape within 24 hours of knowledge of escape in accordance with Part V.B of the permit;
e. Procedures to recapture escaped fish;
f. Procedures to minimize the number of escaped fish; and
g. Procedures for monitoring fish mortality, predation, and escape.

Permittees must have an Accident Prevention and Response Plan in place. The Plan must be developed within 180 days of the effective date of this permit, kept onsite and made available to EPA upon request. The plan must include the following:

a. Spill prevention and response procedures; necessary materials for responding to spills must also be on-site and readily available for immediate action;
b. Mass mortality response procedures including plans for disposal of large quantities of fish mortalities;
c. Measures to recover any materials, structural elements or debris that may be lost in an accident, storm or other event; and
d. Relevant personnel must be trained on fish husbandry, feeding, equipment operation, spill prevention and response, and other management provisions stipulated in this permit.

1.3.4 Other Activities Caused by the Proposed Action

We considered, under the ESA, whether or not the proposed action would cause any other activities and determined that it would cause vessel traffic to and from net pen facilities for net pen operation and maintenance activities.

2. ENDANGERED SPECIES ACT BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS, and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provide an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

The EPA determined the proposed action is not likely to adversely affect Southern DPS green sturgeon (*Acipenser medirostris*) or its critical habitat, Southern DPS Pacific eulachon (*Thaleichthys pacificus*) or its critical habitat, Mexico DPS and Central America DPS humpback whale (*Megaptera novaeangliea*), and Southern Resident killer whale (*Orcinus orca*) or their critical habitat. Our concurrence is documented in the "Not Likely to Adversely Affect"" Determinations section (Section 2.12).

2.1. Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "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 also relies on the regulatory definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 CFR 402.02).

The designation(s) of critical habitat for PS Chinook salmon, PS steelhead, HCSR chum, PS/GB bocaccio and PS/GB yelloweye rockfish use(s) the term primary constituent element (PCE) or essential features. The 2016 final rule (81 FR 7414; February 11, 2016) that revised the critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The ESA Section 7 implementing regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the final rule revising the definition and adding this term (84 FR 44976, 44977; August 27, 2019), that revision does not change the scope of our analysis, and in this opinion we use the terms “effects” and “consequences” interchangeably.

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

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their critical habitat using an exposure–response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species; or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

2.2. Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that is likely to be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species’ likelihood of both survival and recovery. The species status section also helps to inform the description of the species’ “reproduction, numbers, or distribution” for the jeopardy analysis. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the PBFs that are essential for the conservation of the species.

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

During the last century, average regional air temperatures in the Pacific Northwest increased by 1-1.4°F as an annual average, and up to 2°F in some seasons (based on average linear increase per decade; Abatzoglou et al. 2014; Kunkel et al. 2013). Recent temperatures in all but two years since 1998 ranked above the 20th century average (Mote et al. 2014). Warming is likely to continue during the next century as average temperatures are projected to increase another 3 to 10°F, with the largest increases predicted to occur in the summer (Mote et al. 2014).

Decreases in summer precipitation of as much as 30 percent by the end of the century are consistently predicted across climate models (Mote et al. 2014). Precipitation is more likely to occur during October through March, less during summer months, and more winter precipitation will be rain than snow (ISAB 2007; Mote et al. 2013). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB 2007; Mote et al. 2014). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

The combined effects of increasing air temperatures and decreasing spring through fall flows are expected to cause increasing stream temperatures; in 2015 this resulted in 3.5-5.3°C increases in Columbia Basin streams and a peak temperature of 26°C in the Willamette (NWFSC 2015). Overall, about one-third of the current cold-water salmonid habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (Mantua et al. 2009).

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

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

In addition to changes in freshwater conditions, predicted changes for coastal waters in the Pacific Northwest as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al. 2014). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by 1.0-3.7°C by the end of the century (IPCC 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Tillmann and Siemann 2011; Reeder et al. 2013).

Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. A 38 percent to 109 percent increase in acidity is projected by the end of this century in all but the most stringent CO_2 mitigation scenarios, and is essentially irreversible over a time scale of centuries (IPCC 2014). Regional factors appear to be amplifying acidification in Northwest ocean waters, which is occurring earlier and more acutely than in other regions and is already impacting important local marine species (Barton et al. 2012; Feely et al. 2012). Acidification also affects sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al. 2012; Sunda and Cai 2012).

Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10-32 inches by 2081-2100 (IPCC 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Tillmann and Siemann 2011; Reeder et al. 2013). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al. 2007). Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances, and therefore these species are predicted to fare poorly in warming ocean conditions (Scheuerell and Williams 2005; Zabel et al. 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (NWFSC 2015). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these habitats, have the potential to impact a wide range of listed aquatic species (Tillmann and Siemann 2011; Reeder et al. 2013).

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

2.2.1 Status of ESA-Listed Fish Species

For Pacific salmon, steelhead, and certain other species, we commonly use the four "viable salmonid population" (VSP) criteria (McElhany et al. 2000) to assess the viability of the populations that, together, constitute the species. These four criteria (spatial structure, diversity, abundance, and productivity) encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment.

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

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

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

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

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

The summaries that follow describe the status of the five ESA-listed species, and their designated critical habitats, that occur within the geographic area of this proposed action and are considered in this opinion. More detailed information on the status and trends of these listed resources, and their biology and ecology, are in the listing regulations and critical habitat designations published in the Federal Register (Table 4).

Table 4. Listing status, status of critical habitat designations and protective regulations, and relevant Federal Register (FR) decision notices for ESA-listed species considered in this opinion. Listing status: 'T' means listed as threatened; 'E' means listed as endangered.

Species	Listing Status	Critical Habitat
PS Chinook salmon *(Oncorhynchus tshawytscha)*	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630
Hood Canal Summer Run Chum *(Oncorhynchus keta)*	T 6/28/05; 70 FR 37160	9/02/05; 70 FR 52630
PS Steelhead (*Oncorhynchus mykiss*)	T 5/11/07; 72 FR 26722	2/24/16; 81 FR 9252
PS/GB Yelloweye Rockfish *(Sebastes ruberrimus)*	T 4/28/10; 75 FR 22276	2/11/15; 79 FR 68041
PS/GB Bocaccio (*Sebastes paucispinis)*	E 4/28/10; 75 FR 22276	2/11/15; 79 FR 68041
Southern Resident Killer Whale *(Orcus orcinus)*	E 11/18/2005; 70 FR 69903	11/29/06; 79 FR 69054 08/02/21; 86 FR 41668

Status of PS Chinook Salmon

The PS Chinook salmon evolutionarily significant unit (ESU) was listed as threatened on June 28, 2005 (70 FR 37160). We adopted the recovery plan for this ESU in January 2007. The recovery plan consists of two documents: the PS salmon recovery plan (Shared Strategy for PS 2007) and a supplement by NMFS (2006). The recovery plan adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT) (Ruckelshaus et al. 2002). The PSTRT's biological recovery criteria will be met when all of the following conditions are achieved:

- The viability status of all populations in the ESU is improved from current conditions, and when considered in the aggregate, persistence of the ESU is assured;
- Two to four Chinook salmon populations in each of the five biogeographical regions of the ESU (Table 5) achieve viability, depending on the historical biological characteristics and acceptable risk levels for populations within each region;
- At least one population from each major genetic and life history group historically present within each of the five biogeographical regions is viable;
- Tributaries to PS not identified as primary freshwater habitat for any of the 22 identified populations are functioning in a manner that is sufficient to support an ESU-wide recovery scenario; Production of Chinook salmon from tributaries to PS not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery; and

- Populations that do not meet the viability criteria for all VSP parameters are sustained to provide ecological functions and preserve options for ESU recovery.

The most recent final 5-year Status Review (NMFS 2017c) concluded that benefits from the many habitat actions identified in the recovery plan will take decades to produce significant improvement in natural population viability parameters. The Northwest Fishery Science Center (NWFSC), and NMFS' West coast Regional Office (WCRO) are currently preparing the final status review documents, with anticipated completion in early 2022. In this section, we utilize some of the information in the draft 2022 status review, in order to provide the most recent information for our evaluation in this opinion.

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

Spatial Structure and Diversity. The PS Chinook salmon ESU includes all naturally spawning populations of Chinook salmon from rivers and streams flowing into PS including the Straits of Juan De Fuca from the Elwha River, eastward, including rivers and streams flowing into Hood Canal, South Sound, North Sound and the Strait of Georgia in Washington. The ESU also includes the progeny of numerous artificial propagation programs (NWFSC 2015). The PSTRT identified 22 extant populations, grouped into five major geographic regions, based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity. The PSTRT distributed the 22 populations among five major biogeographical regions, or major population groups (MPG), that are based on similarities in hydrographic, biogeographic, and geologic characteristics (Table 5).

Between 1990 and 2014, the proportion of natural-origin spawners has trended downward across the ESU, with the Whidbey Basin the only MPG with consistently high fractions of natural-origin spawner abundance. All other MPG have either variable or declining spawning populations with high proportions of hatchery-origin spawners (NWFSC 2015, NMFS 2017c). Overall, the new information on abundance, productivity, spatial structure and diversity since the 2010 status review supports no change in the biological risk category (NWFSC 2015, Ford 2022).

Table 5. Extant PS Chinook salmon populations in each biogeographic region (NWFSC 2015).

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

Abundance and Productivity. Available data on total abundance since 1980 indicate that although abundance trends have fluctuated between positive and negative for individual populations, there are widespread negative trends in natural-origin Chinook salmon spawner abundance across the ESU (NWFSC 2015, Ford 2022). Productivity remains low in most populations, and hatchery-origin spawners are present in high fractions in most populations outside of the Skagit watershed. Available data now shows that most populations have declined in abundance over the past 7 to 10 years. Further, escapement levels for all populations remain well below the TRT planning ranges for recovery, and most populations are consistently below the spawner-recruit levels identified by the TRT as consistent with recovery (NWFSC 2015, NMFS 2017c, Ford 2022).

The most recent biological viability assessment update for Pacific salmon and steelhead (Ford 2022) has not yet been finalized, but the draft document provides similar findings. It concludes that all PS Chinook salmon populations continue to remain well below the TRT planning ranges for recovery escapement levels, and that most populations remain consistently below the spawner-recruit levels identified by the TRT as necessary for recovery. However, it also finds that most populations have increased somewhat in abundance since the last status review in 2016, but still have small negative trends over the past 15 years, with productivity remaining low in most populations (Ford 2022).

Limiting Factors. Limiting factors for this species include:

- Degraded floodplain and in-river channel structure
- Degraded estuarine conditions and loss of estuarine habitat
- Riparian area degradation and loss of in-river large woody debris
- Excessive fine-grained sediment in spawning gravel
- Degraded water quality and temperature
- Degraded nearshore conditions
- Impaired passage for migrating fish
- Altered flow regime

PS Chinook Salmon Recovery Plan. Nearshore areas serve as the nursery for juvenile PS Chinook salmon. Riparian vegetation, shade and insect production, and forage fish eggs along marine shorelines and river deltas help to provide food, cover and thermoregulation in shallow water habitats. Forage fish spawn in large aggregations along shorelines with suitable habitat, which produce prey for juvenile PS Chinook salmon. Juvenile salmon commonly occupy "pocket estuaries" where freshwater inputs provide salinity gradients that make adjusting to the marine environment less physiologically demanding. Pocket estuaries also provide refugia from predators. As the juvenile salmon grow and adjust, they move out to more exposed shorelines such as eelgrass, kelp beds and rocky shorelines where they continue to grow and migrate into the ocean environment. Productive shoreline habitats of PS are necessary for the recovery of PS salmon (Shared Strategy for PS 2007).

The PS Recovery Plan (Volumes 1 and 2) includes specific recovery actions for each of the 22 extant populations of PS Chinook salmon. General protection and restoration actions summarized from the plan include:

- Aggressively protect functioning drift cells and feeder bluffs that support eelgrass bands and depositional features;
- Counties should pass strong regulations and policies limiting increased armoring of these shorelines and offering incentives for protection;
- Aggressive protect areas, especially shallow water/low gradient habitats and pocket estuaries, within 5 miles of river deltas;
- Protect the forage fish spawning areas;
- Conduct limited beach nourishment on a periodic basis to mimic the natural sediment transport processes in select sections where corridor functions may be impaired by extensive armoring;
- Maintain the functioning of shallow, fine substrate features in and near 11 natal estuaries for Chinook salmon(to support rearing of fry);
- Maintain migratory corridors along the shores of PS;
- Maintain the production of food resources for salmon;
- Maintain functioning nearshore ecosystem processes (i.e., sediment delivery and transport; tidal circulation) that create and support the above habitat features and functions;
- Increase the function and capacity of nearshore and marine habitats to support key needs of salmon;

- Protect and restore shallow, low velocity, fine substrate habitats along marine shorelines, including eelgrass beds and pocket estuaries, especially adjacent to major river deltas;
- Protect and restore riparian areas;
- Protect and restore estuarine habitats of major river mouths;
- Protect and restore spawning areas and critical rearing and migration habitats for forage fish; and
- Protect and restore drift cell processes (including sediment supply, e.g., from feeder bluffs, transport, and deposition) that create and maintain nearshore habitat features such as spits, lagoons, bays, beaches.

Status of HC Summer-run Chum Salmon

We adopted a recovery plan for HC summer-run chum salmon in May of 2007. The recovery plan consists of two documents: the Hood Canal and Eastern Strait of Juan de Fuca Summer Chum Salmon Recovery Plan (Hood Canal Coordinating Council 2005) and a supplemental plan by NMFS (2007). The recovery plan adopts ESU and population level viability criteria recommended by the PS Technical Recovery Team (PS-TRT) (Sands et al. 2007). The PSTRT's biological recovery criteria will be met when the following conditions are achieved:

- Spatial Structure: 1) Spawning aggregations are distributed across the historical range of the population. 2) Most spawning aggregations are within 20 km of adjacent aggregations. 3) Major spawning aggregations are distributed across the historical range of the population and are not more than approximately 40 km apart. Further, a viable population has spawning, rearing, and migratory habitats that function in a manner that is consistent with population persistence
- Diversity: Depending on the geographic extent and ecological context of the population, a viable population includes one or more persistent spawning aggregations from each of the two to four major ecological diversity groups historically present within the two populations (see also McElhany et al. 2000).
- Abundance and Productivity: Achievement of minimum abundance levels associated with persistence of Hood Canal Summer Chum ESU populations that are based on two assumptions about productivity and environmental response (Table 6).

Despite substantive gains towards meeting viability criteria in the Hood Canal and Strait of Juan de Fuca summer chum salmon populations, the ESU still does not meet all of the recovery criteria for population viability at this time (NWFSC 2015; NMFS 2017c; and Ford 2022).

Table 6. Hood Canal summer-run chum ESU abundance and productivity recovery goals (Sands et al. 2007).

Population	Low Productivity Planning Target for Abundance (productivity in parentheses)	High Productivity Planning Target for Abundance (productivity in parentheses)
Strait of Juan de Fuca	12,500 (1.0)	4,500 (5.0)
Hood Canal	24,700 (1.0)	18,300 (5.0)

Spatial Structure and Diversity. The ESU includes all naturally spawning populations of summer-run chum salmon in Hood Canal tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington, as well as several artificial propagation programs. The PS Technical Recovery Team identified two independent populations for Hood Canal summer chum salmon, one which includes the spawning aggregations from rivers and creeks draining into the Strait of Juan de Fuca, and one which includes spawning aggregations within Hood Canal proper (Sands et al. 2009).

Spatial structure and diversity measures for the Hood Canal summer chum salmon recovery program have included the reintroduction and sustaining of natural-origin spawning in multiple small streams where summer chum salmon spawning aggregations had been extirpated. Supplementation programs have been very successful in both increasing natural spawning abundance in 6 of 8 extant streams (Salmon, Big Quilcene, Lilliwaup, Hamma Hamma, Jimmycomelately, and Union) and increasing spatial structure due to reintroducing spawning aggregations to three streams (Big Beef, Tahuya, and Chimacum). Spawning aggregations are present and persistent within five of the six major ecological diversity groups identified by the PS TRT (Table 7). As supplementation program goals have been met in most locations, they have been terminated except in the Lilliwaup and Tahuya River programs, where supplementation is anticipated to be discontinued in the next two years (NMFS 2022). Spatial structure and diversity viability parameters for each population have increased and nearly meet the viability criteria.

Table 7. Seven ecological diversity groups as proposed by the PSTRT for the HCSRC ESU by geographic region and associated spawning aggregation.

Geographic Region(population)	**Spawning aggregations: Extant* and extinct****
Eastern Strait of Juan de Fuca	Dungeness R (unknown status)
	Jimmycomelately Cr* Salmon Cr* Snow Cr* Chimacum Cr**
Hood Canal	Unknown
	Big Quilcene R* Little Quilcene R*
	Dosewallips R* Duckabush R*
	Big Beef Cr** Seabeck Cr** Stavis Cr** Anderson Cr** Dewatto R** Tahuya R** Mission Cr** Union R*
	Hamma Hamma R* Lilliwaup Cr* Skokomish R*

Abundance and Productivity. Smoothed trends in estimated total and natural population spawning abundances for both Hood Canal and Strait of Juan de Fuca populations have generally increased over the 1980 to 2014 time period. The Hood Canal population has had a 25 percent increase in abundance of natural-origin spawners in the most recent 5-year time period over the 2005-2009 time period. The Strait of Juan de Fuca has had a 53 percent increase in abundance of natural-origin spawners in the following 5-year time period (NMFS 2017c).

Trends in population productivity, estimated as the log of the smoothed natural spawning abundance in year t minus the smoothed natural spawning abundance in year (t-4), have increasing over the past five years, and were above replacement rates in the 2012 and 2013. However, productivity rates have been varied above and below replacement rates over the entire time period up to 2014. PNPTT and WDFW (2014) provide a detailed analysis of productivity for the ESU, each population, and by individual spawning aggregation, and report that 3 of the 11 stocks exceeded the comanager's interim productivity goal of an average of 1.6 Recruit/Spawner over 8 years. They also report that natural-origin Recruit/Spawner rates have been highly variable in recent brood years, particularly in the Strait of Juan de Fuca population. Only one spawning aggregation (Chimacum) meets the comanager's interim recovery goal of 1.2 recruits per spawner in 6 of most recent 8 years. Productivity of individual spawning aggregates shows only two of eight aggregates have viable performance. (NWFSC 2015, NMFS 2017c).

The 2022 biological viability assessment (Ford 2022) reported that natural-origin spawner abundance has increased since ESA-listing and spawning abundance targets in both populations have been met in some years. However, it found that productivity has been down for the last three years for the Hood Canal population, and for the last four years for the SJDF population, following prior increased productivity reported at the time of the last review (NWFSC 2015). Based on productivity of individual spawning aggregates, Ford (2022) identified viable performance for only two of eight aggregates. However, spatial structure and diversity viability parameters, as originally determined by the TRT have improved and nearly meet the viability criteria for both populations. Ford (2022) finds that although substantive gains have been made towards meeting viability criteria, the ESU still does not meet all of the recovery criteria for population viability. Therefore, Ford (2022) concludes that the HCSRC ESU remains at moderate risk of extinction, with viability largely unchanged from the prior review.

Limiting factors. Limiting factors for this species include (Hood Canal Coordinating Council 2005):

- Reduced floodplain connectivity and function
- Poor riparian condition
- Loss of channel complexity (reduced large wood and channel condition, loss of side channels, channel instability)
- Sediment accumulation
- Altered flows and water quality

Mantua et al. (2010) suggested that the unique life history of HCSRC makes this ESU especially vulnerable to the climate change impacts because they spawn in small shallow streams in late summer, eggs incubate in the fall and early winter, and fry migrate to sea in late winter.

Sensitivity during the adult freshwater stage and the early life history was ranked moderate. Predicted climate change effects for the low-elevation Hood Canal streams historically used by summer chum salmon include multiple negative impacts stemming from warmer water temperatures and reduced streamflow in summer, and the potential for increased redd-scouring from peak flow magnitudes in fall and winter. Exposure for stream temperature and summer water deficit were both ranked high, largely due to effects on returning adults and hatched fry. Likewise, sensitivity to cumulative life-cycle effects was ranked high.

HCSRC Recovery Plan. The 2005 recovery plan for HCSR chum currently guides habitat protection and restoration activities for chum Salmon recovery (HCCC 2005; NMFS 2007). Human-caused degradation of HCSRC habitat has diminished the natural resiliency of Hood Canal/SJDF river deltas and estuarine habitats (HCCC 2005). Despite some improvement in habitat protection and restoration actions and mechanisms, concerns remain that given the pressures of population growth, existing land use management measures through local governments (i.e., shoreline management plans, critical area ordinances, and comprehensive plans) may be compromised or not enforced (Shared Strategy for PS 2007). The widespread loss of estuary and lower floodplain habitat was noted by the PSTRT as a continuing threat to ESU spatial structure and connectivity (69 FR 33134).

The HCSRC recovery plan includes specific recovery actions for each stream (HCCC 2005). General protection and restoration actions summarized from those streams include:

- Incorporate channel migration zones within the protected areas of the Shoreline Master Plans of local governments.
- Acquire high priority spawning habitat
- Set back or remove levees in the lower rivers and in river deltas
- Restore upstream ecosystem processes to facilitate delivery of natural sediment and large wood features to lower river habitats
- Remove armoring along the Hood Canal shoreline, including private bulkheads, roadways, and railroad grades
- Restore large wood to river deltas and estuarine habitats
- Restore salt marsh habitats

Status of PS Steelhead

The PS Steelhead TRT produced viability criteria, including population viability analyses (PVAs), for 20 of 32 demographically independent populations (DIPs) and three major population groups (MPGs) in the DPS (Hard et al. 2015). It also completed a report identifying historical populations of the DPS (Myers et al. 2015). The DIPs are based on genetic, environmental, and life history characteristics. Populations display winter, summer, or summer/winter run timing (Myers et al. 2015). The TRT concludes that the DPS is currently at "very low" viability, with most of the 32 DIPs and all three MPGs at "low" viability.

The designation of the DPS as "threatened" is based upon the extinction risk of the component populations. Hard et al. (2015), identify several criteria for the viability of the DPS, including that a minimum of 40 percent of summer-run and 40 percent of winter-run populations historically present within each of the MPGs must be considered viable using the VSP-based criteria. For a DIP to be considered viable, it must have at least an 85 percent probability of meeting the viability criteria, as calculated by Hard et al. (2015).

On December 27, 2019, we published a recovery plan for PS steelhead (84 FR 71379) (NMFS 2019a). The proposed plan indicates that within each of the three MPGs, at least fifty percent of the populations must achieve viability, *and* specific DIPs must also be viable:

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

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

North Cascades MPG: Of the eleven DIPs with winter or winter/summer runs, five must be viable: One from the Nooksack River Winter-Run; One from the Stillaguamish River Winter-Run; One from the Skagit River (either the Skagit River Summer-Run and Winter-Run or the Sauk River Summer-Run and Winter-Run); One from the Snohomish River watershed (Pilchuck, Snoqualmie, or Snohomish/Skykomish River Winter-Run); and One other winter or summer/winter run from the MPG at large.

Of the five summer-run DIPs in this MPG, three must be viable representing in each of the three major watersheds containing summer-run populations (Nooksack, Stillaguamish, Snohomish Rivers); South Fork Nooksack River Summer-Run; One DIP from the Stillaguamish River (Deer Creek Summer-Run or Canyon Creek Summer-Run); and One DIP from the Snohomish River (Tolt River Summer-Run or North Fork Skykomish River Summer-Run)

Spatial Structure and Diversity**.** The PS steelhead DPS is the anadromous form of *O. mykiss* that occur in rivers, below natural barriers to migration, in northwestern Washington State that drain to PS, Hood Canal, and the Strait of Juan de Fuca between the U.S./Canada border and the Elwha River, inclusive. The DPS also includes six hatchery stocks that are considered no more than moderately diverged from their associated natural-origin counterparts: Green River natural winter-run; Hamma Hamma winter-run; White River winter-run; Dewatto River winter-run; Duckabush River winter-run; and Elwha River native winter-run (USDC 2014). Steelhead are the anadromous form of *Oncorhynchus mykiss* that occur in rivers, below natural barriers to migration, in northwestern Washington State (Ford 2011). Non-anadromous ‘‘resident’’ *O. mykiss* occur within the range of PS steelhead but are not part of the DPS due to marked differences in physical, physiological, ecological, and behavioral characteristics (Hard et al. 2007).

DIPs can include summer steelhead only, winter steelhead only, or a combination of summer and winter run timing (e.g., winter run, summer run or summer/winter run). Most DIPs have low viability criteria scores for diversity and spatial structure, largely because of extensive hatchery influence, low breeding population sizes, and freshwater habitat fragmentation or loss (Hard et al. 2007). In the Central and South PS and Hood Canal and Strait of Juan de Fuca MPGs, nearly all DIPs are not viable (Hard et al. 2015). More information on PS steelhead spatial structure and diversity can be found in NMFS' technical report (Hard et al. 2015).

Abundance and Productivity. Abundance of adult steelhead returning to nearly all PS rivers has fallen substantially since estimates began for many populations in the late 1970s and early 1980s. Smoothed trends in abundance indicate modest increases since 2009 for 13 of the 22 DIPs. Between the two most recent five-year periods (2005-2009 and 2010-2014), the geometric mean of estimated abundance increased by an average of 5.4 percent. For seven populations in the Northern Cascades MPG, the increase was 3 percent; for five populations in the Central & South PS MPG, the increase was 10 percent; and for six populations in the Hood Canal & Strait of Juan de Fuca MPG, the increase was 4.5 percent. However, several of these upward trends are not statistically different from neutral, and most populations remain small. Inspection of geometric means of total spawner abundance from 2010 to 2014 indicates that 9 of 20 populations evaluated had geometric mean abundances fewer than 250 adults and 12 of 20 had fewer than 500 adults. Between the most recent two five-year periods (2005-2009 and 2010-2014), several populations showed increases in abundance between 10 and 100 percent, but about half have remained in decline. Recent viability risk assessments from the Northwest Fisheries Science Center indicate that long-term (15-year) trends in natural spawners are predominantly negative (NWFSC 2015, Ford 2022).

There are some signs of modest improvement in steelhead productivity since the 2011 and 2016 review, at least for some populations, especially in the Hood Canal & Strait of Juan de Fuca MPG. However, these modest changes must be sustained for a longer period (at least two generations) to lend sufficient confidence to any conclusion that productivity is improving over larger scales across the DPS. Moreover, several populations are still showing dismal productivity, especially those in the Central & South PS MPG (NWFSC 2015, NMFS 2017c, Ford 2022).

Very little data continue to be available on summer-run steelhead populations to evaluate extinction risk or abundance trends (Ford 2022). Because of their small population size and the complexity of monitoring fish in headwater holding areas, summer steelhead have not been broadly monitored.

The 2022 biological viability assessment (Ford 2022) identified a slight improvement in the viability of the PS steelhead DPS since the PS steelhead technical review team concluded that the DPS was at very low viability, as were all three of its constituent MPGs, and many of its 32 DIPs (Hard et al. 2015). Ford (2022) reported observed increases in spawner abundance in a number of populations over the last five years, which were disproportionately found within the South and Central PS and SJDF and Hood Canal MPGs, and primarily among smaller populations. Fifteen-year trends continue to be largely negative for PS steelhead (Ford 2022). The draft update concluded that recovery efforts in conjunction with improved ocean and climatic conditions have resulted in a slightly increasing viability trend for the PS steelhead DPS, although the extinction risk remains moderate.

Limiting factors. In our 2013 proposed rule designating critical habitat for this species (USDC 2013), we noted that the following factors for decline for PS steelhead persist as limiting factors:

- The continued destruction and modification of steelhead habitat
- Widespread declines in adult abundance (total run size), despite significant reductions in harvest in recent years
- Threats to diversity posed by use of two hatchery steelhead stocks (Chambers Creek and Skamania)
- Declining diversity in the DPS, including the uncertain but weak status of summer run fish
- A reduction in spatial structure
- Reduced habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and reduced movement of large woody debris
- In the lower reaches of many rivers and their tributaries in PS where urban development has occurred, increased flood frequency and peak flows during storms and reduced groundwater-driven summer flows, with resultant gravel scour, bank erosion, and sediment deposition
- Dikes, hardening of banks with riprap, and channelization, which have reduced river braiding and sinuosity, increasing the likelihood of gravel scour and dislocation of rearing juveniles

Table 8. Extant PS Steelhead populations in each biogeographic region (NWFSC 2015).

Biogeographic Region	Population (Watershed)
Hood Canal and SJDF	East Hood Canal Tributaries Sequim/Discovery Bay Tributaries Elwha River Dungeness River Skokomish River South Hood Canal Tributaries West Hood Canal Tributaries SJDF Tributaries
Northern Cascades	Snohomish/Skykomish River Snoqualmie River Stillaguamish River Nooksack River Skagit River Pilchuck River Sammish/Bellingham Bay Tributaries Tolt River
Central/South PS Basin	Cedar River North Lake Washington/ Sammamish River Green River Puyallup/Carbon River White River Nisqually River

PS steelhead Recovery Plan. Juvenile PS steelhead are less dependent on nearshore habitats for early marine rearing than Chinook or Chum Salmon; nevertheless, nearshore, estuarine, and shoreline habitats provide important features necessary for the recovery of steelhead. PS steelhead spend only a few days to a few weeks migrating through the large fjord, but mortality rates during this life stage are critically high (Moore et al. 2010; Moore and Berejikian 2017). Early marine mortality of PS steelhead is recognized as a primary limitation to the species' survival and recovery (NMFS 2019a). Factors in the marine environment influencing steelhead survival include predation, access to prey (primarily forage fish), contaminants (toxics), disease and parasites, migration obstructions (e.g., the Hood Canal bridge), and degraded habitat conditions which exacerbate these factors.

The PS steelhead recovery plan identifies ten ecological concerns that directly impact salmon and steelhead:

- Habitat quantity (anthropogenic barriers, natural barriers, competition);
- Injury and mortality (predation, pathogens, mechanical injury, contaminated food);
- Food (altered primary productivity, food-competition, altered prey species composition and diversity);
- Riparian condition (riparian condition, large wood recruitment);
- Peripheral and transitional habitats (side channel and wetland condition, estuary conditions, nearshore conditions);
- Channel structure and form (bed and channel form, instream structural complexity);

- Sediment conditions (decreased sediment quantity, increased sediment quantity);
- Water quality (temperature, oxygen, gas saturation, turbidity, pH, salinity, toxic contaminants);
- Water quantity (increased water quality, decreased water quality, altered flow timing); and
- Population-level effects (reduced genetic adaptiveness, small population effects, demographic changes, life history changes).

The PS steelhead recovery plan and associated appendix 3 includes specific recovery actions for the marine environment. General protection and restoration actions summarized from the plan include:

- Continue to improve the assessments of harbor seal predation rates on juvenile steelhead;
- Remove docks and floats which act as artificial haul-out sites for seals and sea lions;
- Consistent with the MMPA, test acoustic deterrents and other hazing techniques to reduce steelhead predation from harbor seals;
- Develop non-lethal actions for “problem animals and locations” to deter predation;
- Increase forage fish habitat to increase abundance of steelhead prey;
- Remove bulkheads and other shoreline armoring to increase forage fish;
- Acquire important forage fish habitat to protect high forage fish production areas;
- Add beach wrack to increase forage fish egg survival;
- Protect and restore aquatic vegetation (e.g., eelgrass and kelp);
- Remove creosote pilings to reduce mortality of herring eggs;
- Increase the assessment of migratory blockages, especially the Hood Canal bridge, where differential mortality has been documented;
- Identify and remedy sources of watershed chemical contaminants (e.g., PBDEs and PCBs).

Status of PS/GB Rockfish

Detailed assessments of yelloweye rockfish and bocaccio can be found in the recovery plan (NMFS 2017a) and the 5-year status review (NMFS 2016a), and are summarized here. We describe the status of yelloweye rockfish and bocaccio with nomenclature referring to specific areas of PS. PS is the second largest estuary in the United States, located in northwest Washington state and covering an area of about 900 square miles (2,330 square km), including 2,500 miles (4,000 km) of shoreline. PS 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 PS into five interconnected basins because of the presence of shallow areas called sills: (1) the San Juan/SJDF Basin (also referred to as “North Sound”), (2) Main Basin, (3) Whidbey Basin, (4) South Sound, and (5) Hood Canal. We use the term “PS proper” to refer to all of these basins except the San Juan/SJDF Basin.

The PS/GB 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 PS/GB 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 PS/GB 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. 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 PS, the Strait of Georgia, and the SJDF east of Victoria Sill (Figure 1 and Figure 2). Yelloweye rockfish and bocaccio are 2 of 28 species of rockfish in PS (Palsson et al. 2009).

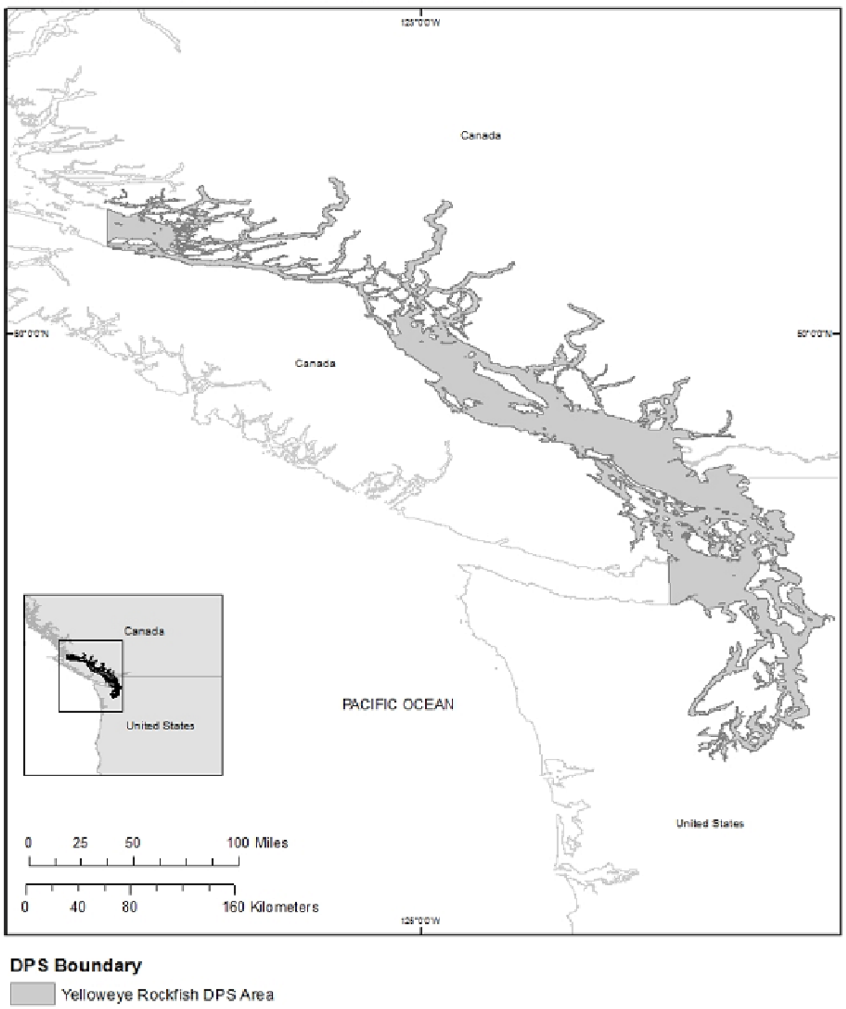

Figure 1. Yelloweye rockfish DPS area.

Figure 2. Bocaccio DPS area.

The life histories of yelloweye rockfish and bocaccio include a larval/pelagic 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; NMFS 2017a). The timing of larval release for each species varies throughout their geographic range (see NMFS 2017a). In the PS, there is some evidence that yelloweye larvae are extruded in early spring to late summer (Washington et al. 1978) and in British Columbia between April and September with a peak in May and June (Yamanaka et al. 2006). Along the coast of Washington State, bocaccio release larvae between January and April (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 PS 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).

A study of rockfish in PS found that larval rockfish appeared to occur in two peaks (early spring, late summer) that coincide with the main primary production peaks in PS. Both measures indicated that rockfish ichthyoplankton essentially disappeared from the surface waters by the beginning of November. Densities also tended to be lower in the more northerly basins (Whidbey and Rosario), compared to Central and South Sound (Greene and Godersky 2012).

When bocaccio reach sizes of 1 to 3.5 inches (3 to 9 centimeters (cm)) (approximately 3 to 6 months old), they settle onto shallow nearshore waters in rocky or cobble substrates with or without kelp (Love et al. 1991; Love et al. 2002). These habitat features offer a beneficial mix of warmer temperatures, food, and refuge from predators (Love et al. 1991). Areas with floating and submerged kelp species support the highest densities of most juvenile rockfish (Carr 1983; Halderson and Richards 1987; Matthews 1990; Hayden-Spear 2006). Unlike bocaccio, juvenile and young-of year yelloweye rockfish do not typically occupy intertidal waters (Love et al. 1991; Studebaker et al. 2009; NMFS 2017a), 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 PS 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.

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 PS/GB 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. 2010). Analysis of SCUBA surveys, recreational catch, and WDFW trawl surveys indicated total rockfish populations in the PS 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 PS 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 PS (Washington 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 PS (West et al. 2001). Although few studies have investigated the effects of toxins on rockfish ecology or physiology, other fish in the PS 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 PS 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 would likely be small.

Yelloweye Rockfish Abundance and Productivity

Yelloweye rockfish within the PS/GB (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 by fishing and the density and proximity of mature fish decreases. Adult yelloweye rockfish typically occupy relatively small ranges (Love et al. 2002) and it is unknown the extent 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, the Washington Department of Fish and Wildlife (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 (WDFW 2017). For the purposes of this analysis we use the an abundance scenario derived from the combined WDFW ROV survey in the San Juan Islands in 2010, and the 2015 ROV survey in PS 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 PS/GB 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 PS/GB (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 PS/GB. 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 PS 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 PS/GB 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 PS 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 SJDF 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 PS.

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 PS 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 PS proper is naturally low because of the generally retentive circulation patterns that occur within each of the major basins of PS 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. 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 3). Recreationally caught yelloweye rockfish in the 1970s spanned a broad range of sizes. By the 2000s, there was some evidence of fewer older fish in the population (Drake et al. 2010). No adult yelloweye rockfish have been observed within the WDFW ROV surveys and all observed fish in 2008 in the San Juan Basin were less than 8 inches long (20 centimeters (cm)) (Pacunski et al. 2013). Since these fish were observed several years ago, they are likely bigger. However, Pacunski et al. (2013) did not report a precise size for these fish; thus, we are unable to provide a precise estimate of their likely size now. As a result, the reproductive burden may be shifted to younger and smaller fish. This shift could alter the timing and condition of larval release, which may be mismatched with habitat conditions within the range of the DPS, potentially reducing the viability of offspring (Drake et al. 2010). Recent genetic information for yelloweye rockfish further confirmed the existence of fish genetically differentiated within the PS/GB compared to the outer coast (NMFS 2016a) and that yelloweye rockfish in Hood Canal are genetically divergent from the rest of the DPS. Yelloweye rockfish in Hood Canal are addressed as a separate population in the recovery plan (NMFS 2017a).

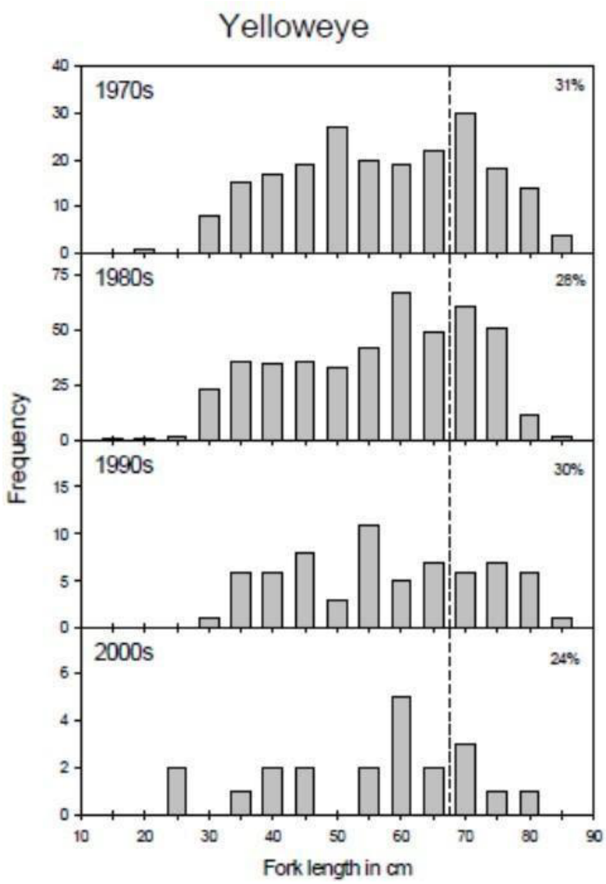

Figure 3. Yelloweye rockfish length frequency distributions (cm) binned within four decades.

Bocaccio Diversity

Size-frequency distributions for bocaccio in the 1970s indicate a wide range of sizes, with recreationally caught individuals from 9.8 to 33.5 inches (25 to 85 cm) (Figure 4). 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 PS/GB 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).

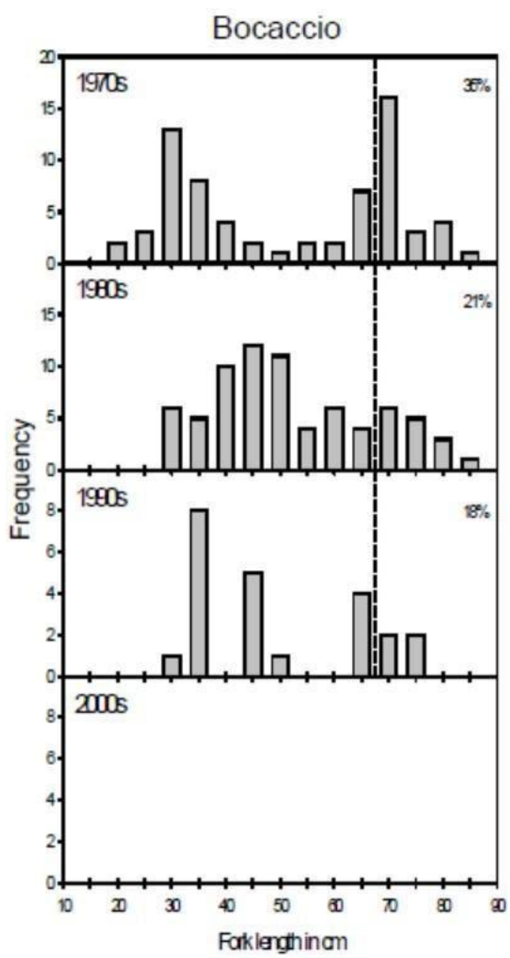

Figure 4. Bocaccio length frequency distributions (cm) within four decades. The vertical line depicts the size at which about 30 percent of the population comprised fish larger than the rest of the population in the 1970s, as a reference point for a later decade.

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 PS 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 PS, especially in Hood Canal and South Sound, that cause the water to be corrosive and hypoxic, such as restricted circulation and mixing, respiration, and strong stratification (Newton and Van Voorhis 2002; Feely et al. 2010). However, these natural conditions, typically driven by climate forcing, are exacerbated by anthropogenic sources such as OA, nutrient enrichment, and land-use changes (Feely et al. 2010). By the next century, OA will increasingly reduce pH and saturation states in PS (Feely et al. 2010). Areas in PS 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 PS. Recreational fishermen targeting bottom fish the shrimp trawl fishery in PS can incidentally catch listed rockfish. In 2012, we issued an incidental take permit (ITP) to the WDFW for listed rockfish in these fisheries (Table 9) and the WDFW is working on a new ITP application (WDFW 2017). If issued, the new permit would be in effect for up to 15 years.

Table 9. Anticipated maximum annual takes for bocaccio and yelloweye rockfish by the fisheries within the WDFW ITP (2012 – 2017) (WDFW 2012).

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

In addition, NMFS permits limited take of listed rockfish for scientific research purposes (Section 2.4.5). Listed rockfish can be caught in the recreational and commercial halibut fishery. In 2018 we estimated that these halibut fisheries would result in up to 270 lethal takes. In addition, NMFS permits limited take of listed rockfish for scientific research purposes (Section 2.4.4). Listed rockfish can be caught in the recreational and commercial halibut fishery. In 2017 we estimated that these halibut fisheries would result in up to 270 lethal takes of yelloweye rockfish, and 40 bocaccio (all lethal) (NMFS 2018a). A recent estimate by NMFS (2020b) calculated that 0.32 percent of the PS/GB yelloweye rockfish DPS and 0.32 percent of the PS/GB bocaccio DPS is killed annually as fishery bycatch (Table 10).

Table 10. Estimated (high estimate) total annual lethal take of PS/GB bocaccio and yelloweye rockfish from fisheries and research activities.

Species	Total Lethal Take in Baseline (high estimate)	DPS Abundance Estimate	Percent of DPS Killed (total lethal takes)
Bocaccio	160[a]	4,606	3.5
Yelloweye rockfish	452[b]	143,086	0.32

Source: NMFS 2020b
[a]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.
[b]This includes the following estimated yelloweye rockfish mortalities: 66 from the salmon fishery, 270 from the halibut fishery, 51 during research, and 65 in other fisheries.

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 Habitats for Fishes

This section examines the status of designated critical habitat affected by the proposed action by examining the condition and trends of essential physical and biological features throughout the designated areas. 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).

Salmon and Steelhead

For salmon and steelhead, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC_5) in terms of the conservation value they provide to each listed species they support.[2] The conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS's critical habitat analytical review teams (CHARTs) evaluated the quantity and quality of habitat features (for example, spawning gravels, wood and water condition, side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area (NOAA Fisheries 2005). Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential due to factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution of the population it served (e.g., a population at the extreme end of geographic distribution), or if it serves another important role (e.g., obligate area for migration to upstream spawning areas).

The physical or biological features of freshwater spawning and incubation sites, include water flow, quality and temperature conditions and suitable substrate for spawning and incubation, as well as migratory access for adults and juveniles (Table 11). These features are essential to conservation because without them the species cannot successfully spawn and produce offspring. The physical or biological features of freshwater migration corridors associated with spawning and incubation sites include water flow, quality and temperature conditions supporting larval and adult mobility, abundant prey items supporting larval feeding after yolk sac depletion, and free passage (no obstructions) for adults and juveniles. These features are essential to conservation because they allow adult fish to swim upstream to reach spawning areas and they allow larval fish to proceed downstream and reach the ocean.

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[2] The conservation value of a site depends upon "(1) the importance of the populations associated with a site to the ESU [or DPS] conservation, and (2) the contribution of that site to the conservation of the population through demonstrated or potential productivity of the area" (NOAA Fisheries 2005).

Table 11. Primary constituent elements (PCEs) of critical habitats designated for ESA-listed salmon and steelhead species considered in the opinion and corresponding species life history events.

Primary Constituent Elements Site Type	Primary Constituent Elements Site Attribute	Species Life History Event
Freshwater spawning	Substrate Water quality Water quantity	Adult spawning Embryo incubation Alevin growth and development
Freshwater rearing	Floodplain connectivity Forage Natural cover Water quality Water quantity	Fry emergence from gravel Fry/parr/smolt growth and development
Freshwater migration	Free of artificial obstruction Natural cover Water quality Water quantity	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Estuarine areas	Forage Free of artificial obstruction Natural cover Salinity Water quality Water quantity	Adult sexual maturation and "reverse smoltification" Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Nearshore marine areas	Forage Free of artificial obstruction Natural cover Water quantity Water quality	Adult growth and sexual maturation Adult spawning migration Nearshore juvenile rearing

CHART Salmon and Steelhead Critical Habitat Assessments

The CHART for each recovery domain assessed biological information pertaining to occupied by listed salmon and steelhead, determine whether those areas contained PCEs essential for the conservation of those species and whether unoccupied areas existed within the historical range of the listed salmon and steelhead that are also essential for conservation. The CHARTs assigned a 0 to 3 point score for the PCEs in each HUC_5 watershed for:

Factor 1. Quantity,
Factor 2. Quality – Current Condition,
Factor 3. Quality – Potential Condition,
Factor 4. Support of Rarity Importance,
Factor 5. Support of Abundant Populations, and
Factor 6. Support of Spawning/Rearing.

Thus, the quality of habitat in a given watershed was characterized by the scores for Factor 2 (quality – current condition), which considers the existing condition of the quality of PCEs in the

HUC_5 watershed; and Factor 3 (quality – potential condition), which considers the likelihood of achieving PCE potential in the HUC_5 watershed, either naturally or through active conservation/restoration, given known limiting factors, likely biophysical responses, and feasibility.

PS Recovery Domain. Critical habitat in PS has been designated for PS Chinook salmon, PS steelhead, HC summer-run chum salmon, southern green sturgeon, and for eulachon. Major tributary river basins in the PS basin include the Nooksack, Samish, Skagit, Sauk, Stillaguamish, Snohomish, Lake Washington, Cedar, Sammamish, Green, Duwamish, Puyallup, White, Carbon, Nisqually, Deschutes, Skokomish, Duckabush, Dosewallips, Big Quilcene, Elwha, and Dungeness rivers and Soos Creek.

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

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

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

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

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

Juvenile mortality occurs in unscreened or inadequately screened diversions. Water diversion ditches resemble side channels in which juvenile salmonids normally find refuge. When diversion headgates are shut, access back to the main channel is cut off and the channel goes dry. Mortality can also occur with inadequately screened diversions from impingement on the screen, or mutilation in pumps where gaps or oversized screen openings allow juveniles to get into the system (WDFW 2009). Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in many PS tributary basins (Shared Strategy for PS 2007).

The nearshore marine habitat has been extensively altered and armored by industrial and residential development near the mouths of many of PS's tributaries. A railroad runs along large portions of the eastern shoreline of PS, eliminating natural cover along the shore and natural recruitment of beach sand (Shared Strategy for PS 2007).

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

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

The PS recovery domain CHART (NOAA Fisheries 2005) determined that only a few watersheds with PCEs for Chinook salmon in the Whidbey Basin (Skagit River/Gorge Lake, Cascade River, Upper Sauk River, and the Tye and Beckler rivers) are in good-to-excellent condition with no potential for improvement. Most HUC_5 watersheds are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some or a high potential for improvement (Table 12).

PS Recovery Domain: Current and potential quality of HUC_5 watersheds identified as supporting historically independent populations of ESA-listed Chinook salmon (CK) and chum salmon (CM) (NOAA Fisheries 2005).[3] Watersheds are ranked primarily by "current quality" and secondly by their "potential for restoration." Current PCE Conditions are rated:

3 = good to excellent
2 = fair to good
1 = fair to poor
0 = poor

Potential PCE Condition are rated:

3 = highly functioning, at historical potential
2 = high potential for improvement
1 = some potential for improvement
0 = little or no potential for improvement

[3] On January 14, 2013, NMFS published a proposed rule for the designation of critical habitat for LCR coho salmon and PS steelhead (USDC 2013). A biological report, which includes a CHART assessment for PS salmon, was also completed (NMFS 2012).

Table 12. PS Recovery Domain: Current and potential quality of HUC5 watersheds identified as supporting historically independent populations of ESA-listed Chinook salmon (CK) and chum salmon (CM) (NOAA Fisheries 2005). Watersheds are ranked primarily by their "potential for restoration."

Watershed Name(s) and HUC$_5$ Code(s)	Listed Species	Current Quality	Restoration Potential
Strait of Georgia and Whidbey Basin #1711000xxx			
Skagit River/Gorge Lake (504), Cascade (506) & Upper Sauk (601) rivers, Tye & Beckler rivers (901)	CK	3	3
Skykomish River Forks (902)	CK	3	1
Skagit River/Diobsud (505), Illabot (507), & Middle Skagit/Finney Creek (701) creeks; & Sultan River (904)	CK	2	3
Skykomish River/Wallace River (903) & Skykomish River/Woods Creek (905)	CK	2	2
Upper (602) & Lower (603) Suiattle rivers, Lower Sauk (604), & South Fork Stillaguamish (802) rivers	CK	2	1
Samish River (202), Upper North (401), Middle (402), South (403), Lower North (404), Nooksack River; Nooksack River (405), Lower Skagit/Nookachamps Creek (702) & North Fork (801) & Lower (803) Stillaguamish River	CK	1	2
Bellingham (201) & Birch (204) bays & Baker River (508)	CK	1	1
Whidbey Basin and Central/South Basin #1711001xxx			
Lower Snoqualmie River (004), Snohomish (102), Upper White (401) & Carbon (403) rivers	CK	2	2
Middle Fork Snoqualmie (003) & Cedar rivers (201), Lake Sammamish (202), Middle Green River (302) & Lowland Nisqually (503)	CK	2	1
Pilchuck (101), Upper Green (301), Lower White (402), & Upper Puyallup River (404) rivers, & Mashel/Ohop(502)	CK	1	2
Lake Washington (203), Sammamish (204) & Lower Green (303) rivers	CK	1	1
Puyallup River (405)	CK	0	2
Hood Canal #1711001xxx			
Dosewallips River (805)	CK/CM	2	1/2
Kitsap – Kennedy/Goldsborough (900)	CK	2	1
Hamma Hamma River (803)	CK/CM	1/2	1/2
Lower West Hood Canal Frontal (802)	CK/CM	0/2	0/1
Skokomish River (701)	CK/CM	1/0	2/1
Duckabush River (804)	CK/CM	1	2
Upper West Hood Canal Frontal (807)	CM	1	2
Big Quilcene River (806)	CK/CM	1	1/2
Deschutes Prairie-1 (601) & Prairie-2 (602)	CK	1	1
West Kitsap (808)	CK/CM	1	1
Kitsap – Prairie-3 (902)	CK	1	1
Port Ludlow/Chimacum Creek (908)	CM	1	1
Kitsap – Puget (901)	CK	0	1
Kitsap – Puget Sound/East Passage (904)	CK	0	0
Strait of Juan de Fuca Olympic #1711002xxx			
Dungeness River (003)	CK/CM	2/1	1/2
Discovery Bay (001) & Sequim Bay (002)	CM	1	2
Elwha River (007)	CK	1	2
Port Angeles Harbor (004)	CK	1	1

Critical habitat for PS steelhead was designated on February 24, 2016 (81 FR 9252). Critical habitat includes 2,031 stream miles. Nearshore and offshore marine waters were not designated for this species.

PS Rockfish Designated Critical Habitat

NMFS designated critical habitat for PS/GB yelloweye and PS/GB bocaccio rockfish on November 13, 2014 (79 FR 68042). Critical habitat is not designated in areas outside of United States jurisdiction; therefore, although waters in Canada are part of the DPSs' ranges for both species, critical habitat was not designated in that area. The U.S. portion of the PS/Georgia Basin that is occupied by PS/GB yelloweye rockfish and PS/GB bocaccio can be divided into five areas, or Basins, based on the distribution of each species, geographic conditions, and habitat features. These five interconnected Basins are: (1) The San Juan/Strait of Juan de Fuca Basin, (2) Main Basin, (3) Whidbey Basin, (4) South PS, and (5) Hood Canal. We have determined that approximately 644.7 square miles (1,669.8 sq km) of nearshore habitat for juvenile PS/GB bocaccio and 438.5 square miles (1,135.7 sq km) of deepwater habitat for yelloweye rockfish and PS/GB bocaccio meet the definition of critical habitat.

Critical habitat for PS/GB bocaccio includes 590.4 square miles of nearshore habitat and 414.1 square miles of deep water habitat. Based on the natural history of PS/GB bocaccio and their habitat needs, NMFS identified two physical or biological features, essential for their conservation: 1) Deepwater sites (>30 meters) that support growth, survival, reproduction, and feeding opportunities; and 2) Nearshore juvenile rearing sites with sand, rock and/or cobbles to support forage and refuge. Habitat threats include degradation of rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality.

Nearshore critical habitat for PS/GB bocaccio at juvenile life stages, is defined as areas that are contiguous with the shoreline from the line of extreme high water out to a depth no greater than 98 feet (30 m) relative to mean lower low water. The PBFs of nearshore critical habitat include settlement habitats with sand, rock, and/or cobble substrates that also support kelp. Important site 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 (DO) to support growth, survival, reproduction, and feeding opportunities.

Deep water critical habitat includes marine waters and substrates of the U.S. in PS east of Green Point in the Strait of Juan de Fuca, and serves both adult PS/GB bocaccio, and both juvenile and adult yelloweye rockfish. Deepwater critical habitat is defined as areas at depths greater than 98 feet (30 m) that supports feeding opportunities and predator avoidance.

The federal register notice for the designation of rockfish critical habitat in PS notes that many forms of human activities have the potential to affect the essential features of listed rockfish species, and specifically calls out, among others, (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 (79 FR 68041; 11/13/14). Water quality throughout PS is degraded by anthropogenic sources within the Sound (e.g., pollutants from vessels) as well as upstream sources (municipal, industrial, and nonpoint sources). Nearshore habitat degradation exists throughout the PS from fill and dredge to create both fastland and navigational areas for commerce, from shore hardening to protect both residential and commercial waterfront properties, and from overwater structures that enable commercial and recreational boating (Table 13).

NMFS' 2016 status update identifies recommended future actions including Protection and restoration of nearshore habitat through removal of shoreline armoring, and protecting and increasing kelp coverage.

Table 13. Physical or Biological Features of Rockfish Critical Habitat.

PS Basin	**Nearshore sq. mi. (for juvenile bocaccio only)**	**Deepwater sq. mi. (for adult and juvenile yelloweye rockfish and adult bocaccio)**	**Physical or Biological Features**		**Activities**
San Juan/Strait of Juan de Fuca	394.4	203.6	Deepwater sites <30 meters that support growth, survival, reproduction and feeding opportunities	Nearshore juvenile rearing sites with sand, rock and/or cobbles to support forage and refuge	1,2,3,6,9,10,11
Whidbey Basin	52.2	32.2			1,2,3,4,6,9,10,11
Main Basin	147.4	129.2			1,2,3,4,6,7,9,10,11
South Puget Sound	75.3	27.1			1,2,3,6,7,9,10,11
Hood Canal	20.4	46.4			1,2,3,6,7,9,10,11

Management Considerations Codes: (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 habitats; (9) research; (10) aquaculture; and (11) activities that lead to global climate change and ocean acidification. Commercial kelp harvest does not occur presently, but would probably be concentrated in the San Juan/Georgia Basin. Artificial habitats could be proposed to be placed in each of the Basins. Non-indigenous species introduction and management could occur in each basin (79 FR 68041; 11/13/14).

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 is determined by the greatest extent of physical, chemical and biological effects stemming from the proposed action, including activities caused by the proposed action.

The greatest extent of physical, chemical or biological effects stemming from the action is associated with potential movement of sablefish (biological) that escape from net pens into the

PS. We assume that escaped sablefish would likely move throughout PS, based on their long migration tendencies (Echave et al. 2013). As described in Section 2.4 (Environmental Baseline), the hatchery programs, including the escape or release of fish, associated with the tribal enhancement net pens are part of the environmental baseline and thus movement of those fish is not considered an effect of the action nor used to delineate the action area. However, given the vast amount of available habitat for sablefish in the Pacific Ocean, and the small number of escaped fish expected to reach the ocean, we do not expect any measurable or observable physical, chemical or biological effects to be caused by the escaped fish beyond the PS. For this consultation, the action area is all of PS, which is defined as all marine waters in the PS basin, including the Georgia Basin and SJDF to the mouth of the Strait (Cape Flattery) (Figure 5).

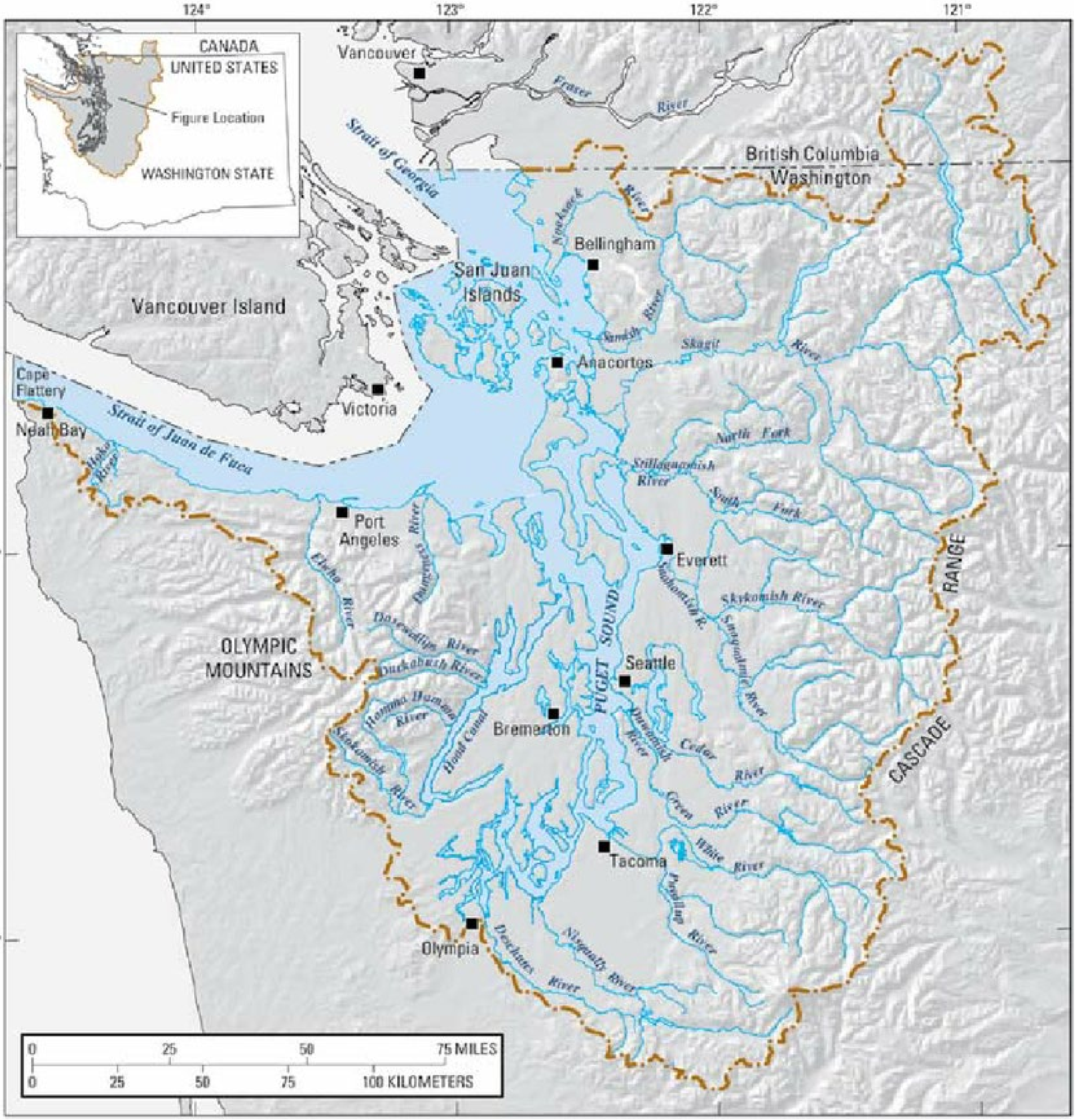

Figure 5. Action Area –Marine waters of PS (as defined to include the SJDF and Georgia Basin), to the westernmost extent of the SJDF that defines the action area. Note that the dashed line delineates the United States – Canada jurisdictional boundary, but does not define the action area. Source: Shipman 2008.

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).

Puget Sound is one of the largest estuaries in the United States, having over 2,400 miles of shoreline, more than two million acres of marine waters and estuarine environment, and a watershed of more than 8.3 million acres. In 1988, PS was given priority status in the National Estuary Program. This established it as an estuary of national significance under an amendment to the Clean Water Act. In 2006, the Center for Biological Diversity recognized the PS Basin as a biological hotspot with over 7,000 species of organisms that rely on the wide variety of habitats provided by PS (Center for Biological Diversity 2006).

The State of the Sound biannual report produced by the PS Partnership (PSP) (PSP et al. 2019) summarizes how different indicators of health of the PS ecosystem are changing.[4] The assessment identifies that PS marine and freshwater habitats continue to face impacts of accelerating population growth, development, and climate change; and that few of the 2020 improvement targets (including habitat for ESA-listed salmonids and rockfish) identified by the PSP are being reached.

Over the last 150+ years, 4.5 million people have settled in the PS region. There is a suite of impacts of human development on aquatic habitat conditions in the PS, including water quality effects of stormwater runoff, industrial pollutants and boats, in-water noise from boats and construction activities, and fishing pressure, to name a few (see SSDC 2007; Hamel et al. 2015). With the level of infrastructure development associated with population growth, the PS nearshore has been altered significantly. Major physical changes documented in the PS include the simplification of river deltas, the elimination of small coastal bays, the reduction in sediment supply to the foreshore due to beach armoring, and the loss of tidally influenced wetlands and salt marsh (Fresh et al. 2011).

The PS Nearshore Ecosystem Restoration Project (PSNERP), an investigation project between the COE and the state of Washington, reviewed the historical changes to PS's shoreline environment between 1850-1880, and 2000-2006, and found the most pervasive change to PS to be the simplification of the shoreline and reduction in natural shoreline length (Simenstad et al. 2011). Recent studies have estimated the loss of nearshore habitat in PS at close to 85 percent or more (Brophy et al. 2019). Throughout PS, the nearshore areas have been modified by human activity, disrupting the physical, biological, and chemical interactions that are vital for creating and sustaining the diverse ecosystems of PS. The shoreline modifications are usually intended for erosion control, flood protection, sediment management, or for commercial, navigational, and recreational uses. Seventy-four percent of shoreline modification in PS consists of shoreline armoring (Simenstad et al. 2011), which usually refers to bulkheads, seawalls, or groins made of

[4] The Puget Sound Partnership tracks 52 vital sign indicators to measure progress toward different PS recovery goals. Of the 6 PS recovery goals, the most relevant for this Opinion include: Thriving species and food webs, Protected and Restored Habitat, Healthy Water Quality and Quantity.

rock, concrete, or wood. Other modifications include jetties and breakwaters designed to dissipate wave energy, and structures such as tide gates, dikes, and marinas, overwater structures, including bridges for railways, roads, causeways, and artificial fill. An analyses conducted in 2011 though the PS Nearshore Ecosystem Restoration Project (Fresh et al. 2011; Simenstad et al. 2011) found that since 1850, of the approximately 2,470 miles of PS shoreline:

- Shoreline armoring has been installed on 27 percent of PS shores.
- One-third of bluff-backed beaches are armored along half their length. Roads and nearshore fill have each affected about 10 percent of the length of bluff-backed beaches.
- Forty percent of PS shorelines have some type of structure that impacts habitat quality.
- Conversion of natural shorelines to artificial shoreforms occurred in 10 percent of PS.
- There has been a 93 percent loss of freshwater tidal and brackish marshes. The Duwamish and Puyallup rivers have lost nearly all of this type of habitat.
- A net decline in shoreline length of 15 percent as the naturally convoluted and complex shorelines were straightened and simplified. This represents a loss of 1,062 km or 660 miles of overall shoreline length.
- Elimination of small coastal embayments has led to a decline of 46 percent in shoreline length in these areas.
- A 27 percent decline in shoreline length in the deltas of the 16 largest rivers and a 56 percent loss of tidal wetlands in the deltas of these rivers.

Effects of shoreline armoring on nearshore and intertidal habitat function include diminished sediment supply, diminished organic material (e.g., woody debris and beach wrack) deposition, diminished over-water (riparian) and nearshore in-water vegetation (submerged aquatic vegetation; SAV), including macroalgae, diminished prey availability, diminished aquatic habitat availability, diminished invertebrate colonization, and diminished forage fish populations (see Toft et al. 2007; Shipman et al. 2010; Sobocinski et al. 2010; Morley et al. 2012; Toft et al. 2013; Munsch et al. 2014; Dethier et al. 2016). Shoreline armoring often results in increased beach erosion waterward of the armoring, which, in turn, leads to beach lowering, coarsening of substrates, increases in sediment temperature, and reductions in invertebrate density (Fresh et al. 2011; Morley et al. 2012; Dethier et al. 2016).

The reductions to shallow water habitat, as well as reduced forage potential resulting from shoreline armoring may cause juvenile salmonids and juvenile bocaccio to temporarily utilize deeper habitat, thereby exposing them to increased piscivorous predation. Typical piscivorous juvenile salmonid and bocaccio predators, such as flatfish, sculpin, and larger juvenile salmonids, being larger than their prey, generally avoid the shallowest nearshore waters that outmigrant juvenile salmonids and juvenile bocaccio prefer. When juvenile salmonids temporarily leave the relative safety of the shallow water, their risk of being preyed upon by other fish increases. This has been shown in the marine environment where juvenile salmonid consumption by piscivorous predators increased fivefold when juvenile pink salmon were forced to leave the shallow nearshore (Willette 2001).

In addition to beach armoring, other shoreline changes including overwater structures (i.e., piers and floats), marinas, roads, and railroads reduce habitat quantity and quality, and impact nearshore salmonid migrations and juvenile bocaccio rearing. The prevalence of overwater structures (e.g., piers, ramps and floats) in the PS nearshore has also altered nearshore habitat conditions. Schlenger et al. (2011) mapped 8,972 separate overwater structures in the PS, with a total overwater coverage of 9 square kilometers. These structures, as well as turbidity from boat propeller wash typically associated with them, decrease light levels in the water column and reduce primary productivity and growth of submerged aquatic vegetation (Fresh et al. 2001; Kelty and Bliven 2003; Shafer 1999, 2002; Haas et al. 2002; Eriksson et al. 2004; Mumford 2007). This reduces forage potential and cover for juvenile fish, including ESA-listed salmonids and bocaccio. In addition to reduced cover, shading by overwater structures may also delay salmonid migration and further increase predation risk (Heiser and Finn 1970; Able et al. 1998; Simenstad 1988; Nightingale and Simenstad 2001a; Willette 2001; Southard et al. 2006; Toft et al. 2013; Ono 2010). The biological opinions completed by NMFS on Regional GP 6 (RGP6) for structures in the PS (NMFS 2016c) and on a batch of 39 projects in the nearshore environment of PS (NMFS 2020a) provide detailed summaries of the effects of overwater structures, shoreline armoring and other nearshore structures on ESA-listed species and designated critical habitat in PS.

Benthic habitats within PS, where PS rockfish primarily occur, have been influenced by a number of factors. The degradation of some rocky habitat, loss of eelgrass and kelp, introduction of non-natural-origin species that modify habitat, and degradation of water quality are threats to marine habitat in PS (Palsson et al. 2009; Drake et al. 2010). Some benthic habitats have been impacted by derelict fishing gear that include lost fishing nets, and shrimp and crab pots (Good et al. 2010). Derelict fishing gear can continue “ghost” fishing and is known to kill rockfish, salmon, and marine mammals as well as degrade rocky habitat by altering bottom composition and killing numerous species of marine fish and invertebrates that are eaten by rockfish (Good et al. 2010). Thousands of nets have been documented within PS 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 PS region. In addition, WDFW and the Lummi, Stillaguamish, Tulalip, Nisqually and Nooksack tribes and others have supported or conducted derelict gear prevention and removal efforts. Net removal has mostly concentrated in waters less than 100 feet (33 m) deep where most lost nets are found (Good et al. 2010). The removal of over 4,600 nets and over 3,000 derelict pots have restored over 650 acres of benthic habitat, 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 PS.

Over the last century, human activities have introduced a variety of toxins into the Georgia Basin at levels that can affect adult and juvenile salmonid and rockfish habitat, and/or the prey that support them. Along shorelines, human development has increased nutrient loads from failing septic systems, and from use of nitrate and phosphate fertilizers on lawns and farms (Shared Strategy for PS 2007). The combination of runoff from highways and dense residential, commercial and industrial development has further degraded chemical characteristics of the PS marine environment (HCCC 2005; Shared Strategy for PS 2007; PSEMP 2017; PSEMP 2019). Toxic pollutants in PS include oil and grease, polychlorinated biphenyls (PCBs), phthalates, polybrominated diphenyl ethers (PBDEs), and heavy metals that include zinc, copper, and lead.

In addition to degraded water quality, about 32 percent of the sediments in the PS 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).

Mackenzie et al. (2018) found that stormwater is the most important pathway to PS for most toxic contaminants, transporting more than half of the PS's total known toxic load (Ecology and King County 2011). During a robust PS monitoring study, toxic chemicals were detected more frequently and at higher concentrations during storm events compared with base flow for diverse land covers, pointing to stormwater pollution (Ecology 2011). The PS basin has over 4,500 unnatural surface water and stormwater outfalls, 2,121 of which discharge directly into the Sound (WDNR 2015).

In general, the pollutants in the existing stormwater discharge are diverse. The discharge itself comes from rainfall or snowmelt moving over and through the ground, also referred to here as "runoff." As the runoff travels along its path, it picks up and carries away natural and anthropogenic pollutants (U.S. EPA 2016b). Pollutants in stormwater discharge typically include the following (Buckler and Granato 1999; Colman *et al.* 2001; Driscoll *et al.* 1990; Kayhanian *et al.* 2003; Van Metre *et al.* 2006; Stokstad 2020; Tian et al. 2021):

- Excess fertilizers, herbicides, insecticides and sediment from landscaping areas.
- Chemicals and salts from de-icing agents applied on sidewalks, driveways, and parking areas.
- Oil, grease, PAHs, tire rubber-derived chemicals and other toxic chemicals from roads and parking areas used by motor vehicles.
- Bacteria and nutrients from pet wastes and faulty septic systems.
- Metals (arsenic, copper, chromium, lead, mercury, and nickel) and other pollutants from the pesticide use in landscaping, roof runoff (Ecology 2014), decay of building and other infrastructure, and particles from street and tire wear.
- Atmospheric deposition from surrounding land uses.
- Metals, PAHs, PBDEs, and phthalates from roof runoff.
- Erosion of sediment and attached pollutants due to hydromodification.

The environmental baseline would also include the projected effects of climate change for the time period commensurate with the effects of the proposed actions. Mauger et al. (2015) predict that circulation in PS is projected to be affected by declining summer precipitation, increasing sea surface temperatures, shifting streamflow timing, increasing heavy precipitation, and declining snowpack. While these changes are expected to affect mixing between surface and deep waters within PS, it is unknown how these changes will affect upwelling. Changes in precipitation and streamflow could shift salinity levels in PS by altering the balance between freshwater inflows and water entering from the North Pacific Ocean. In many areas of PS, variations in salinity are also the main control on mixing between surface and deep waters. Reduced mixing, due to increased freshwater input at the surface, can reduce phytoplankton growth, impede the supply of nutrients to surface waters, and limit the delivery of dissolved oxygen to deeper waters. Patterns of natural climate variability (e.g., El Niño/La Niña) can also influence PS circulation via changes in local surface winds, air temperatures, and precipitation.

All three ESA-listed PS salmonids were classified as highly vulnerable to climate change in a recent climate vulnerability assessment (Crozier et al. 2019). In estuarine environments, the two greatest concerns associated with climate change are rates of sea-level rise and temperature warming (Wainwright and Weitkamp 2013; Limburg et al. 2016). While the effects of climate change-induced ocean acidification on invertebrate species are well known, the direct exposure effects on salmon remains less certain (Crozier et al. 2019).

Physiological effects of acidification may also impair olfaction, which could hinder homing ability (Munday et al. 2009), along with other developmental effects (Ou et al. 2015). Using the criteria of Morrison et al. (2015) for scoring, PS Chinook salmon, HC Chum salmon, and PS steelhead had low-to-moderate sensitivity to ocean acidification (Crozier et al. 2019).

The same document states that "sea level rise is projected to expand the area of some tidal wetlands in PS but reduce the area of others, as water depths increase and new areas become submerged. For example, the area covered by salt marsh is projected to increase, while tidal freshwater marsh area is projected to decrease. Rising seas will also accelerate the eroding effect of waves and surge, causing unprotected beaches and bluffs to recede more rapidly. The rate of sea level rise in PS depends both on how much global sea level rises and on regionally-specific factors such as ocean currents, wind patterns, and the distribution of global and regional glacier melt. These factors can result in higher or lower amounts of regional sea level rise (or even short-term periods of decline) relative to global trends, depending on the rate and direction of change in regional factors affecting sea level" (Mauger et al. 2015).

As described in Section 2.2 (Rangewide Status of the Species and Critical Habitats), climate change is and will continue to alter environmental conditions in the PS, exasperating the impacts of human development on ESA-listed species and critical habitat. Within the PS, sea level is likely to rise by 0.4 to 0.9 feet by 2050, and by 1 to 2.8 feet by 2100 (Miller et al. 2018). This is expected to result in increased coastal bluff erosion, larger storm surge, and groundwater intrusion (Miller et al. 2018). Where shoreline armoring prevents beach formation at these higher sea level elevations, the width of intertidal zones will be reduced, diminishing habitat for intertidal beach spawners, including forage species like surf smelt and sand lance (Krueger et al. 2010). It will also reduce shallow water habitat for juvenile salmonids, including PS Chinook salmon, HCSR chum salmon and PS steelhead, and juvenile PS/GB bocaccio.

Increasing average air temperatures will raise average surface water temperatures in the PS. Coastal waters and the PS are expected to experience increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al. 2014). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by 1.0-3.7°C by the end of the century (IPCC 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Tillmann and Siemann 2011, Reeder et al. 2013).

In the PS region, river deltas will also be impacted by changes in mountain snowpack. Warming is expected to result in decreased snow pack, increased winter flows, and advanced timing of spring melt (Mote et al. 2014, Mote et al. 2016). We anticipate decreased summer precipitation, with, and more winter precipitation will be rain than snow (ISAB 2007; Mote et al. 2014). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB 2007; Mote et al. 2014). We also expect increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al. 2012).

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

These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Tillmann and Siemann 2011, Reeder et al. 2013). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al. 2007). Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances, and therefore these species are predicted to fare poorly in warming ocean conditions (Scheuerell and Williams 2005; Zabel *et al.* 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (NWFSC 2015). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these habitats, have the potential to impact a wide range of listed aquatic species (Tillmann and Siemann 2011, Reeder et al. 2013).

Historical harvest of salmon, steelhead and rockfish species has caused declines in PS populations. In the past, fisheries exploitation rates were generally too high for the conservation of many rockfish populations, and for naturally spawning salmon and steelhead populations. In response, over the past several decades, the co-managers have implemented strategies to manage fisheries to reduce harvest impacts and to implement harvest objectives that are more consistent with the underlying productivity of the natural populations. The effect of these overall reductions in harvest has been to improve the baseline condition and help to alleviate the effect of harvest as a limiting factor.

Since 2010, the state and tribal fishery co-managers have managed Chinook salmon mortality in PS salmon and tribal steelhead fisheries to meet the conservation and allocation objectives described in the jointly-developed 2010-2014 PS Chinook Harvest RMP (PSIT and WDFW 2010), and as amended in 2014 (Grayum and Anderson 2014; Redhorse 2014), 2015, 2016, and 2017, and 2018 (Grayum and Unsworth 2015; Shaw 2015; 2016; Speaks 2017). The 2010-2014 PS Chinook Harvest RMP was adopted as the harvest component of the PS Salmon Recovery Plan for the PS Chinook ESU (NMFS 2011). Exploitation rates for most of the PS Chinook salmon management units have been reduced substantially since the late 1990s compared to years prior to listing (average reduction = -33%, range = -67 to +30%) (NMFS 2020b).

Fifty percent or more of the harvest of 8 of the 14 PS Chinook salmon management units occurs in salmon fisheries outside the Action Area, primarily in Canadian waters. Salmon fisheries in Canadian waters are managed under the terms of the Pacific Salmon Treaty (PST). Ocean salmon fisheries in contiguous U.S. federal waters are managed by NMFS and the PFMC, under the MSA and are managed under the terms of the PST. For salmon fisheries off of the Southeast coast of Alaska, in federal waters, the North Pacific Fisheries Management Council (NPFMC) delegates its management authority to the State of Alaska. These fisheries are also managed under the terms of the PST. The effects of these Northern fisheries (Canada and SEAK) on PS Chinook salmon were assessed in previous biological opinions (NMFS 2004; 2008e; 2019c).

NMFS observed that previous harvest management practices likely contributed to the historical decline of PS steelhead, but concluded in the Federal Register Notice for the listing determination (72 FR 26732, May 11, 2007) that the elimination of the direct harvest of wild steelhead in the mid-1990s has largely addressed this threat. The recent NWFSC biological viability assessment concluded that current harvest rates on natural-origin steelhead continue to decline and are unlikely to substantially reduce spawner abundance of most PS steelhead populations (NWFSC 2015, Ford 2022).

To address impacts of harvest of rockfish populations, in 2010 the Washington State Fish and Wildlife Commission formally adopted regulations that ended the retention of rockfish by recreational anglers in PS and closed fishing for bottom fish in all waters deeper than 120 feet (36.6 m). On July 28, 2010, WDFW enacted a package of regulations for the closure of set net, set line, bottom and pelagic trawl, inactive pelagic trawl and inactive bottom fish pot fisheries by emergency rule for non-tribal commercial fisheries in PS in order to protect dwindling rockfish populations. 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 were enacted on a temporary basis, but were permanently closed in February 2011. The pelagic trawl fishery was closed by permanent rule on the same date.

Hatchery programs have benefitted and harmed native-origin PS Chinook salmon, HCSR chum salmon, and PS steelhead. The central challenge of operating and managing hatchery programs is finding a balance between the risks and benefits of hatchery production for harvest or conservation. Hatchery production of Chinook salmon and steelhead can be an effective tool to increase fish abundance for conservation and harvest. However, hatcheries can also pose demographic, genetic, and ecological risks to these species. Risks and benefits of hatchery production are best evaluated in the context of the purpose of the hatchery program. Conservation of native populations is one purpose. The primary goal of Chinook salmon and steelhead conservation in Puget Sound is sustainable natural production of locally adapted fish throughout the accessible watersheds (Hard et al. 2015). Thus, to effectively achieve its goals, a conservation hatchery program must increase the abundance, productivity, spatial structure, and/or diversity of a natural-origin steelhead population. In contrast, some hatchery programs have a different goal: to provide harvest opportunities. These hatchery programs may be either integrated or segregated.

Interactions of hatchery and natural-origin Chinook salmon and steelhead pose different risks to abundance, productivity, genetic diversity, and fitness of fish spawning in the natural environment depending on how hatcheries are operated. A growing body of scientific literature, stemming from improved tools to assess parentage and other close genetic relationships on relative reproductive success of hatchery and natural-origin salmonids, suggests that strong and rapid declines in fitness of natural-produced fish due to interactions with hatchery-produced fish are possible (Araki et al. 2008; Christie et al. 2014). These studies have focused primarily on steelhead, Chinook salmon, coho salmon, and Atlantic salmon. Limited but growing evidence suggests that steelhead may be more susceptible to genetic risk (i.e., domestication) posed by hatchery propagation than other species (Ford et al. 2016). Further, because selective regimes and mortality differ dramatically between natural and cultured populations, some genetic change cannot be avoided (Waples 1999). These changes are difficult to predict quantitatively because there may be considerable variation in relative reproductive success among species, populations, and habitats, as well as temporal variability owing to environmental change.

A new role for hatcheries emerged during the 1980s and 1990s after naturally produced salmon and steelhead populations declined to unprecedented low levels. Because genetic resources that represent the ecological and genetic diversity of a species can reside in fish spawned in a hatchery, as well as in fish that spawn in the wild, hatcheries began to be used for conservation purposes (e.g., HCSR chum salmon). Such hatchery programs are designed to preserve the salmonid genetic resources until the factors limiting salmon and steelhead viability are addressed. Hatchery programs can also be used to help improve viability by increasing the number and spatial distribution of naturally spawning fish with returning hatchery adults. However, hatcheries are not a proven tool for achieving sustained increases in adult production (ISAB 2003), and the long-term benefits and risks of hatchery supplementation remain untested (Christie et al. 2014).

Because most hatchery programs are ongoing, the effects of each program are reflected in the most recent status of the species (NWFSC 2015; NMFS 2017c, Ford 2022), which was summarized in Section 2.2 of this opinion. In addition, for those hatchery programs NMFS has completed section 7 consultation on, their effects are included here in the environmental baseline. The review of HGMPs by NMFS ensures that all hatchery programs are consistent with the ESA. For those listed in Table 14, NMFS has concluded that these programs do not appreciably reduce the likelihood of survival and recovery, nor do they adversely modify critical habitat. Below we provide more detail on the hatchery programs in the action area, including those associated with the tribal enhancement net pen operations covered by the proposed GP.

Table 14. Completed HGMP bundle consultations in PS and the SJDF.

HGMP Bundle	HGMP Name	Completion Date
Hood Canal Summer Chum	Quilcene NFH Supplementation Hamma Hamma FH Supplementation Lilliwaup Creek Supplementation Union/Tahuya Supplementation/Reintroduction Big Beef Creek Reintroduction Chimacum Creek Reintroduction Jimmycomelately Creek Reintroduction Salmon Creek Supplementation	July 2002
Elwha	Lower Elwha Hatchery Native Steelhead Lower Elwha Hatchery Elwha Coho Elwha Channel Hatchery Chinook Lower Elwha Hatchery Elwha Chum	December 2012; Reinitiation December 2014
	Lower Elwha Hatchery Pink	
Dungeness	Dungeness River Hatchery Spring Chinook Dungeness River Hatchery Coho Dungeness River Hatchery Fall Pink	June 2016
Snohomish	Tulalip Hatchery Chinook Sub-yearling 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	October 2017
Early Winter Steelhead #1	Kendall Creek Winter Steelhead Dungeness River Early Winter Steelhead Whitehorse Ponds Winter Steelhead	April 2016
Early Winter Steelhead #2	Snohomish/Skykomish Winter Steelhead Snohomish/Tokul Creek Winter Steelhead	April 2016
Hood Canal	Hoodsport Fall Chinook 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	October 2016
Duwamish/Green	Soos Creek Hatchery Fall Chinook 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	January 2020

HGMP Bundle	HGMP Name	Completion Date
Stillaguamish	Stillaguamish Fall Chinook Natural Restoration Stillaguamish Summer Chinook Natural Restoration Stillaguamish Late Coho Stillaguamish Fall Chum	April 2020

There are five existing enhancement net pen programs rearing native coho salmon in the PS that are operated by tribes and one additional facility that is proposed for inclusion by the Lummi Tribe. As described in Section 1.3 (Proposed Federal Action), these facilities are currently covered by the existing GP and would be covered by the proposed GP. In these operations, juvenile coho salmon are reared for a short period of time (approximately four to six months) in marine net pens before being released into the PS to supplement PS coho salmon stocks. These programs provide additional coho salmon for harvest in PS commercial and recreational fisheries, as well as tribal ceremonial harvest. These net pen rearing programs are part of broader hatchery programs. Separate freshwater hatcheries spawn, hatch and rear coho salmon for each of these six programs before they are transferred to the marine net pens.

Two individual ESA consultations (biological opinions) for Hatchery and Genetic Management Plans (HGMPs) have been completed for the Hood Canal and Green River hatchery programs, which include net pens operations (Table 15). The completed biological opinion in Hood Canal (NMFS 2016) identified take of ESA-listed species as a result of broodstock collection, genetic and ecological effects, and competition and predation. The more recently completed biological opinion for the Green River program (NMFS 2019a) identified four take pathways: 1) Genetic and ecological effects of hatchery adults on the spawning grounds, 2) handling/tagging of adults at adult collection facilities, 3) ecological effects of juveniles during emigration, and 4) ecological and genetic effects of juveniles that do not migrate. This is consistent with the general observations of hatchery programs in the PS described above. Both opinions (Hood Canal and Green River) concluded that the proposed actions (HGMPs) are not likely to jeopardize the continued existence of ESA-listed species, or destroy or adversely modify their designated critical habitat.

Table 15. Existing Net Pen Facilities Eligible for Coverage. One additional facility is proposed by the Lummi Tribe.

Waterbody	Agate Pass	Elliott Bay	Peale Passage	Port Gamble	Quilcene Bay	Clam Bay
Facility Operator	Suquamish Tribe	Suquamish Tribe (co-owned by Muckleshoot Tribe)	Squaxin Island Tribe	Port Gamble S'Klallam Tribe	Skokomish Indian Tribe	NOAA (Manchester Research Station)
Coverage Status	Covered	Covered	Covered	Covered	Covered	Applied – will seek coverage under proposed GP
EPA Permit #	WAG132001	WAG132002	WAG132003	WAG132004	WAG132005	N/A
Latitude	47.7036	47.6222	47.2029	47.8454	47.7864	47.5734
Longitude	-122.5750	-122.3676	-122.9053	-122.5740	-122.8530	-122.5456
Annual Production (lbs)	45,000	90,909	52,600	45,850	13,000	58,429
Months/ Year	March-June (4)	March-June (4)	January-June (6)	Jan – May (5)	January – May (6)	Year-round
Species	Coho	Coho	Coho	Coho	Coho	Sablefish
HGMP Bundle	East Kitsap	Green River	Deep South Sound	Hood Canal	Hood Canal	N/A
HGMP ESA Consultation Status	In Progress	Complete (2019)[a]	Not started • Coho HGMP received in 2017 in revision by co-managers • Chinook HGMP is in development	In Progress • Reinitation of 2016 Biological Opinion[b]	Complete (2016)[b]	N/A

[a]WCR-2016-00014, Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation for Ten Hatchery Programs for Salmon and Steelhead in the Duwamish/Green River Basin (NMFS 2019a); [b] WCR-2014-1688, Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation for Ten Hatchery Programs and Genetic Management Plans for Salmon and Steelhead in Hood Canal under Limit 6 of the Endangered Species Act 4(d) Rule (NMFS 2016).

Net pens are also in operation at NOAA's Manchester Research Station in Clam Bay, near Manchester, WA to study aquaculture practices for rearing of sablefish (Table 14). As described in Section 1.3 (Proposed Federal Action), we expect this facility to receive coverage under the proposed GP. An ESA consultation was completed for this facility and operations in 2019 (NMFS 2019b). The biological opinion described indirect effects on habitat and direct effects on species as generally minor and localized, but identified incidental take of ESA listed salmonids and rockfish in the form of death, injury or harassment from pile driving noise, increased predation resulting from in-water and overwater structures, and entrainment of fish within a water pump. The opinion determined that the proposed action would permanently and incrementally degrade nearshore habitat conditions. In response to these habitat changes reduced foraging success, changed migratory pathway due to the obstruction from OWS, increased energy expenditure, and larval rockfish entrainment are anticipated. The opinion finds that all of these effects, independently or in combination, are likely to lead to proportional decreases in individual fitness and survival of each of the species. However, only a small number of PS Chinook salmon, PS steelhead, PS/GB bocaccio and PS/GB yelloweye rockfish were expected to be killed by the proposed action, and the proposed action would likely not disproportionately affect any one population and thus not diminish spatial structure. The opinion found that the incremental decrease in abundance among the salmonid cohorts over time is expected to be difficult to impossible to discern among migrating cohorts, and any downward pressure on productivity from a decrease in adult spawners would not be able to be attributed to the proposed net pen operation. However, the continued limitation of larval rockfish survival associated with entrainment by water pumping included in the proposed action is expected to impede productivity improvements in Sinclair inlet and mid-PS at a rate proportional to the amount of water taken in by the pump. The opinion also identified a possible slight impairment of PS Chinook salmon diversity as a result of increased predation of fish that extensively use the nearshore (delta fry) as a result of juvenile migration disruption by overwater and in-water structures. The biological opinion concluded that the proposed action is not likely to jeopardize the continued existence of ESA-listed species, or destroy or adversely modify their designated critical habitat. The Manchester facility utilizes existing piles and a dock, which are included in the environmental baseline.

In addition to the sablefish net pen research operations and the coho salmon enhancement programs, there are currently four commercial net pen facilities in PS, all operated by Cooke Aquaculture, Inc. Cooke Aquaculture, Inc. intends to farm all-female triploid rainbow trout/steelhead at all of their net pen facilities once they have attained the required permits and leases. Cooke Aquaculture, Inc. has also expressed an intent to begin farming sablefish as a secondary crop to rainbow trout/steelhead in the near future. The effects on ESA-listed species and critical habitat, and on EFH, from maintenance and operation of existing commercial net pens in the PS has been assessed in a separate biological opinion on EPA's approval of Washington State's revisions to sediment standards pertaining to marine finfish rearing in Washington (WCRO-2018-00286), finalized on the same day as this Opinion. We consider any consequences caused by EPA's approval of Washington's sediment standards to be part of the baseline of this Opinion and as such, consider those effects, along with the rest of the environmental baseline described in this Section 2.4, in our Integration and Synthesis analysis below in Section 2.7, consistent with 50 CFR 402.14(g)(4).

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 (see 50 CFR 402.02). A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered the factors set forth in 50 CFR 402.17(a) and (b).

The purpose of EPA's action is to regulate federal and tribal net pens and related structures and their associated operations and maintenance, which are proposed to rear fish in the marine environment and release them into the PS as part of programs to supplement wild populations, or as part of aquaculture research at the Manchester federal research net pen facility. Because tribal enhancement net pens are part of hatchery programs for which the genetic and demographic effects (HGMPs) have been previously assessed under ESA Section 7 consultations (biological opinions) for those programs, and because we would expect those fish to be released from land-based facilities even if they were never raised in marine net pes, we consider the presence of hatchery-origin fish in the action area to be part of the baseline, as discussed above. In summary, the consequences of fish released from the tribal enhancement net pens have already been assessed as effects in past ESA Section 7 consultations. Moreover, we would not consider any genetic or demographic effects from the release of hatchery fish to be consequences of the proposed action here because the hatcheries from which the net pen fish are reared have received ESA Section 7 consultation and were planned for release under these consultations; they are, in fact, the same fish. Based on these baseline conditions, we expect that if the NPDES permits were not issued for these proposed net pens, the fish otherwise reared in net pens would instead be reared in and released from land-based hatchery facilities.

However, the presence, operation, and maintenance of the net pens would not continue without the issuance of the NPDES permits as part of the proposed GP. Therefore, we consider tribal enhancement and federal research net pen facilities and their operation and maintenance a consequence of the proposed action.

There are no documented large-scale structural failure and escape events at the Manchester facility net pens. However, based on evidence at commercial net pen facilities (e.g. see Skilbrei et al. 2015), small-scale escape events, sometimes unobserved (i.e. 'fish leakage events'), may occur as a result of spill of fish during transfer to or from the pens, or fish swimming out as a result of tears in containment nets or the top edges of containment nets being submerged below the water surface, for example. Therefore, although likely to be rare and small in scale, we consider escape of fish from the Manchester research facility to be reasonably likely. We consider the potential effects of any escapes from the Manchester research facility (i.e., sablefish) as a consequence of this action since those fish are not permitted to be released and otherwise could not have the potential to escape, but for this proposed GP.

Effects of the proposed action evaluated here are the effects of discharges allowed by the proposed GP from tribal enhancement and federal research net pens in the PS. Our effects analysis is based on the discharges allowed by, and the operational and monitoring requirements specified by the proposed GP. We have based our assumptions about net pen facility structures and operations on these regulatory parameters and the operations currently carried out at the five existing tribal net pen facilities, one proposed tribal net pen facility, and the single Manchester federal research facility (see Table 15). We use these as the basis for our assumptions concerning effects of facilities and operations in our analyses of effects. We expect any effects to be consistent with past effects associated with these facilities and operations.

Much of the existing literature about marine net pen effects come from studies of commercial net pen operations. Supplementing available information specific to the GP and tribal enhancement and the federal enhancement facilities, the scientific literature provides the best available science for our analyses of effects. We expect similar, and generally a smaller scale of effects associated with the facilities covered by the GP compared to commercial net pens in the PS. Fish in the commercial pens typically have longer in-pen marine rearing periods, a greater biomass of fish and shorter fallowing periods. For example, the existing PS commercial net pens have rearing periods of 12-15 months, fallow periods of approximately 42 days and total annual fish biomass at each facility of between 2.8 million and 5 million pounds of fish (Cooke 2019a, b, c, d, and Cooke 2020a, b, c, d). The existing enhancement facilities to be covered by the GP typically have rearing periods of 3-6 months, fallow periods of at least 6 months and total annual fish biomass at each facility of between 13,000 and 90,909 pounds (Table 15). The Manchester research facility raises fish in net pens for periods longer than a year, but has fallow periods that are a minimum of 6 weeks long, and total annual biomass of only 58,429 pounds.

However, unlike commercial net pen structures, there are no known large structural failure events (e.g., mooring system failures and collapse of net pens) of tribal enhancement net pens or the Manchester research net pens. Commercial net pen operations in PS have collapsed as a result of net biofouling (Clark et al. 2018). However, recent advances in marine finfish rearing science, technology, and policy have reduced the risk associated with fouled nets. To reduce the accumulation of net biofouling, current NPDES permits require that facilities prevent the excessive accumulation of marine growth. Additionally, nets are removed from the water and cleaned off-site after each production cycle. Regular cleaning of the nets, as needed, limit bio-fouling loads, and avoid large volumes of bio-deposition. Failure of tribal enhancement or federal research facilities has not been reported; however, net pen failures have occurred in commercial operations of net pens in PS. Thus, although commercial net pen failures have occurred infrequently in PS, we consider it unlikely that such events would occur at tribal enhancement or federal research facilities. As a result of improved science, technology, and monitoring we do not consider large scale failure events reasonably likely to occur at tribal enhancement or federal research facilities as a consequence of the proposed action.

2.5.1 Effects on Habitat in the Action Area

Effects of the proposed action evaluated here are those of activities caused by EPA's issuance of the NPDES GP for tribal enhancement and federal research marine net pen facilities within PS. The consequence of EPA's action is the use of net pens to rear fish in PS at net pen sites for the foreseeable future. In addition to site-specific effects at the net pen locations associated with ongoing operations, broader effects would also result from the transport of fish to and from the tribal enhancement and federal research net pens, and from potential escapes at the Manchester research facility.

In Section 1.3 (Proposed Federal Action) we identified that the proposed action would cause vessel traffic to and from the net pen facilities for net pen operation and maintenance activities. With the contaminant control measures required by the proposed GP for vessels, as described in Section 1.3, we do not expect effects of contaminants (e.g., oil and fuel) from vessels on aquatic habitat conditions. Adequate water depth at the net pen sites is anticipated to avoid habitat alterations from prop wash or scour by boats. The shallowest net pen site of the 6 facilities to be covered by the proposed GP is 22 feet (mean lower low water; MLLW).

The long-term habitat effects that are reasonably likely at all times of operation would be changes to: (1) benthic conditions and sediment quality; and (2) water quality. We detail these expected effects below.

Effects on Benthic Conditions and Sediment Quality

Benthic Conditions—Net pen anchors, anchor chains, and mooring lines may disturb the seafloor and alter benthic conditions when they make contact with the seafloor during maintenance and replacement activities. This has the potential to affect prey species (invertebrates and the small fish that eat those invertebrates) that provide forage for salmonids and rockfish. However, the anchors, would be left in place, even when nets are removed from the water, and we expect repair and replacement to be infrequent. Therefore, any disturbance to the seafloor would be minor and infrequent, and any alteration of benthic condition would be highly localized.

The proposed GP prohibits nets and anchoring structures from impeding current flow or tidal exchange so as to contribute to deposition of solids that would impair water quality. This prohibition would also minimize benthic disturbance, or alteration of baseline conditions that could otherwise arise from changes to water movement around the net pens.

The net pens at the Manchester Research Station are secured by attachment to existing piles; there are no anchors or mooring lines. At tribal enhancement net pens, mooring lines and anchor chains are maintained in an upright position to minimize lateral movement, so that prolonged disturbance to the benthic environment around anchors is minimal. However, a small portion of the chain length may lift vertically off the seafloor when the tension of the mooring point increases during flood tidal currents (high tide), and then when the tidal current slacks during the ebb (low) tide, the chain comes back to rest on the seafloor. Generation of suspended sediment and benthic disturbance is expected to be minor and localized in the area immediately adjacent to the anchors during general presence and operation of net pen facilities. We anticipate colonization of exposed anchor structures by invertebrates and algae (Rensel and Forster 2007).

The footprint of the anchors and chains on the seafloor is the only area where benthic conditions would be affected over the long-term, and to the degree that these become covered with sediment and benthic organisms, we expect disturbance from removal of an anchor and installation of a new anchor would be small, localized and intermittent. Anchors are left in place to secure net pen frames at all times we anticipate only short-term effects associated with infrequent replacement of anchors and anchor chains.

Sediment Quality—Sediment under and near the net pens would be affected by feeding, fish waste and cleaning of net pen structures. Fish waste and excess feed (organics) would fall through the net pens and onto the sea floor. Periodic cleaning of accumulated microorganisms, plants and animals on the nets (biofouling) would also result in biodeposition on the seafloor, and may alter chemical benthic conditions.

Organic carbon compounds are the main nutrient discharge from salmon net pens (e.g., Wang et al. 2013). Organic enrichment from uneaten food, fecal material from net pen fish and biofouling from accumulated material falling off nets may cause changes in sediment chemistry, and benthic physical properties. Nutrient enrichment of sediment beneath net pens can result from carbon, nitrogen and phosphorus deposition as a component of fish feces and excess feed. Nitrogen and phosphorus deposited from net pens may be reduced to their inorganic form through microbial decomposition and be utilized by organisms within the sediment, increasing total organic carbon. Benthic macrofauna also feed on particulate matter that descends to the seafloor, and thus abundance and diversity may increase as a result of increased food availability. This may lead to an increase in the productivity of macro-algae, invertebrates and fish (see Rust et al. 2014; Keeley et al. 2019). As a result, benthic community composition, including invertebrate and small fish species that may become prey of salmonids, may be altered. Forage is a PBF of estuarine and nearshore marine critical habitat for PS Chinook salmon and HCSRC. Benthic community composition may also be altered by nutrient enrichment by attracting predators and scavengers, and also by providing substrate (i.e., shell material) for sessile organisms (Keeley 2013). The attraction of organisms to the area under the net pens and the biomass accumulation from biofouling drop-off may exacerbate enrichment effects. The proposed GP requires fallow periods between the time fish are released/removed from net pens and new fish are stocked. This acts as a recovery period for benthic conditions.

In some cases, organic enrichment may result in an increase in the total invertebrate abundance in the sediment beneath a net pen, but also typically reduces species diversity (Obee 2009), which may reduce the abundance of appropriate salmonid prey species (forage). Elevated levels of total organic carbon is often only detectable directly beneath net pens, or in close proximity (e.g., within 100 meters), and at highly dispersive sites (greater water movement/exchange) organic accumulation is reduced and may be undetectable (Keeley 2013; Price et al. 2015). Studies and data reviewed by Nash (2001; 2003) indicated that levels of carbon in sediment was elevated to about 30 meters beyond Atlantic salmon net pens in the Pacific Northwest. As we mentioned above, the range of the affected area is 30 meters to 100 meters, and so we have made a conservative estimate within that range, at 100 meters.

During decomposition of organic matter, oxygen is depleted by microbial respiration. If the amount of organic deposition beneath a net pen exceeds the assimilative capacity of the benthic community, layers may accumulate, essentially smothering the substrate. This may cause hypoxic (low oxygen levels) or anoxic (extreme hypoxia) conditions. Therefore, with excessive organic enrichment, hypoxic conditions may arise, leading to an increase in nutrient tolerant organisms and a decrease in species diversity. In anoxic conditions, sulfate reduction takes place, resulting in sulfide compounds that are toxic to benthic organisms, but may create conditions ideal for the mat-forming bacteria, *Beggiatoa* (Hargrave et al. 2008). In such an environment only species tolerant of suboxic conditions can survive, resulting in altered community structure (Rosenberg 2001; Hargrave 2010; Keeley 2013).

Nutrient enrichment also has the potential to lead to eutrophication when a body of water becomes overly enriched with nutrients results in excessive plant and algae growth. Nitrogen (dissolved inorganic nitrogen) in particular is considered a limiting nutrient in the PS, typical of marine systems (Newton and Van Voorhis 2002; Hawkins et al. 2019), and thus deposition of phosphorus and nitrogen may increase primary productivity and has the potential to lead to eutrophication. However, causal linkages between fish farming and eutrophication or phytoplankton blooms have not been identified (see Rust et al. 2014).

As described in Section 1.3 (Proposed Federal Action) and in the Draft GP, the GP authorizes discharge of biodeposits associated with feed, feces and net cleaning, and also sets limits on these discharges. The GP also requires conservation and minimization measures, including BMPs and prohibition of certain practices and discharges. The GP imposes monitoring requirements for TOC, an indicator of whether the benthos is being affected by the net pens, as well as visual assessments of the benthos for sediment type and color, the presence of feed or other net pen debris and the presence of benthic bacteria/fungal mats. GP reporting and response requirements ensures that any poor benthic sediment conditions resulting from net pen biodeposition are addressed in a timely manner (e.g., sediment monitoring approximately every 6 months or less; visual assessments at peak biomass).

A review by Noakes (2014) found that the field of benthic and waste discharge impacts is typically contained within 100 meters from the outer boundary of a net pen farm. Price et al. (2015) supports this finding, concluding that nutrient enrichment in the near-field water column is usually not detectable beyond 100 meters of net pen sites when feed waste is minimized and net pen farms are properly cited in deep waters with flushing currents. Thus, with the regiment of monitoring required by the proposed GP, we expect that any effects that could rise to a level that negatively affects forage to occur within the immediate vicinity of net pens. If there was an exceedance, response measures would ensure any effect is short-term. However, we conservatively estimate that TOC could be slightly elevated within about 100 meters from net pens.

Accumulation of antifoulants, antibiotics and heavy metals in sediment in close proximity to commercial net pen facilities is also well documented (Nash 2003). Antibiotics are administered to fish in net pens through medicated feed. Any medicated feed that is not consumed by the net pen fish may be consumed by wild organisms, or may accumulate in sediment. Some medication may also pass through fish if not completely metabolized. Once in the sediment, antibiotics could alter bacterial communities, which could lead to an altered composition of plankton communities, and in turn, changes to the diversity and abundance of larger organisms, like salmonids, that feed on them (see Burridge et al. 2010). Friars and Armstrong (2002) identified antibiotic resistant bacteria up to 100 meters away from concentrated salmon farms. In the PS, studies have shown an exponential decline in antibiotic-resistant bacteria with distance from commercial net pens (see Hargrave 2003). Through use of vaccines in PS hatchery programs, diseases and the need for administration of antibiotics to net pen fish is reduced.

Under the National Environmental Policy Act (NEPA), the U.S. Food and Drug Administration (FDA) must consider environmental effects of properly administered drugs (see FDA 2021). For approval of a drug to be used in aquaculture, the FDA must first determine that it will not significantly impact the environment. The use of all therapeutants for the treatment of specific pathogens are regulated by both federal (e.g., FDA) and Washington state rules. The Center for Veterinary Medicine (CVM) regulates the manufacture, distribution and use of animal drugs. Approved drugs are those that are considered safe for the target fish when applied at labeled doses. The use of unapproved drugs or approved drugs in a manner that differs from that specified on the label are prohibited unless the user has an Investigational New Animal Drug exemption (INAD) or an extra-label prescription from a veterinarian (AFS 2019). Antibiotics available to aquaculture use should have little to no toxic effects on non-target organisms when applied as directed. When potential toxicity is indicated, the FDA suggests conditions that operators or regulatory bodies can follow to avoid toxic conditions, and have little harm on the environment. However, there is evidence that some antibiotics could persist in the sediment and induce localized antibiotic resistance.

Anesthetics may also be periodically used at net pen facilities when the fish are sampled for weight and condition factors. MS 222 is used to anesthetize fish so that they can be safely handled, inspected, weighed and then returned unharmed back to the fish pen. We expect that with the proper use of, and disposal of anesthetics, there would be no measurable effects to environmental conditions in the action area.

Surface disinfectants, such as chlorine bleach, may be used at the net pen sites as a bio-security measure (e.g., in footbaths) and to sterilize equipment (e.g., fish transport tanks) used between sites. Under the GP, the discharge of chlorine to surface waters is prohibited. Treatment (i.e., dechlorination) is required before discharge of water that contains chlorine. Proper dechlorination should eliminate any discharge of chlorine into the action area. For all facilities, the use of biocidal chemicals to disinfect nets is prohibited, unless prescribed by a veterinarian or so determined by the Northwest Indian Fisheries as necessary to prevent the spread of disease. We anticipate infrequent use since no biocidal chemical use was reported by existing net pen facilities during the previous permit cycle (5 years).

The accumulation of copper in sediment can result from the use of antifoulants on nets (Nash 2003; Price and Morris 2013). However, we do not expect antifoulant paint to be used on nets at enhancement or research net pen facilities since they do not currently use antifoulant paints. Therefore, we do not anticipate any deposition of copper, or other antifoulant by-products.

Zinc is another common contaminant in aquatic systems and may accumulate below net pens through deposition of fish feces and excess feed (e.g., Brooks and Mahnken 2003). Levels of zinc added to sediments have been reduced through the use of feeds with reduced levels of zinc or more bioavailable forms of zinc (Nash 2001). Studies have demonstrated that zinc concentrations return to background levels during fallowing, and there is no evidence of long-term buildup or cumulative effects under salmon farms (Brooks et al. 2003; Sutherland et al. 2007). Given the generally larger size, and longer in-pen marine rearing periods of commercial salmon farms, we expect enhancement pens and research facilities in the PS to have less biodeposition, including excess feed, than commercial salmon farms.

Although Noakes (2014) found that the field of impacts from net pen waste discharge is typically contained within 100 meters of the outer boundary of the farm, the author also noted that depending on oceanographic conditions suspended and dissolved waste materials may spread beyond this area and result in potential cumulative and far-field effects. This cumulative effect would be more likely to occur in areas with a high number of farms, for example as is found in some parts of Chile and Norway, and particularly in areas with poor flushing (see Nash et al. 2005; Price and Morris 2013). Because many nutrients and other net pen wastes are flushed away from immediate net pen areas and dispersed into the surrounding waters, it is difficult to assess far-field effects from the net pens versus other sources (see Hargrave 2003; Price and Morris 2013).

In regions like the PS where there are many anthropogenically derived nutrients entering coastal waters from numerous sources (see Ecology 2020), it is especially difficult to attribute nitrification to any one source, including net pens. However, monitoring and modeling studies of effluent dispersion has demonstrated that the vast majority of particulate organic waste and nutrients are dispersed in the near field (e.g., Costa-Pierce 2008; Costa-Pierce, et al. 2010; Price et al. 2015; Bannister et al. 2016). In the PS there is no available literature demonstrating the accumulation or sequestration of net pen wastes in far-field (distant) areas affecting benthic conditions. Although it is difficult to make a correlation between a particular source of nutrient loading in a highly developed region, like the PS basin, based on existing information, as well as benthic monitoring and citing requirements for net pens, we consider it unlikely that any net pen effects on benthic conditions that would have a measurable effect on forage would extend more than about 100 meters. Potential near-field and far-field effects in the water column, including nutrient loading, are assessed below in our evaluation on water quality.

Changes to chemical and benthic physical properties resulting from bioaccumulation and other net pen operation by-products described above (i.e., components of feed) are likely to change the benthic community abundance and composition. Both may cause changes in benthic community composition as less tolerant species are excluded, and may ultimately reduce faunal abundance as high concentrations of contaminants become toxic. A review by Hargrave (2003) identified that most studies find that the local extent of altered benthic community structure and biomass extends no further than 50 meters, but in some cases diversity of infauna may be reduced up to 500 meters away, depending on site depth and water currents.

Net pens also have the potential to discharge microplastics through the degradation of nets, materials lost to marine waters, and discharge of solid waste. Microplastics can accumulate within the marine environment and marine life, and there is a growing body of literature indicating an association between uptake of microplastics and changes in the physiological or biochemical responses in some species. The discharge of microplastics into the environment is reduced by provisions in the proposed GP, which prohibits the discharge of solids into the PS. Net pen cleaning requirements reduce the exposure of the nets to organisms that could cause them to break down. Additionally, the required accident prevention and response plan for each facility includes measures to recover lost materials.

The proposed GP also requires reporting of other debris originating from the net pen found beneath the net pen site during visual assessment of the benthos. As reported in the BE, few items have been found during surveys and responsive modifications to operations and BMPs have minimized debris on the seafloor beneath net pens. Based on past performance and the control measures required in the proposed GP, microplastics discharged from net pens are not expected to affect ESA-listed species.

With the measures implemented by the net pen operators to minimize effects on sediment quality and benthic conditions, as required by the proposed GP, we anticipate measurable changes to sediment quality to be localized to the areas directly beneath and immediately adjacent to net pens. Within this area, there may be changes to sediment quality that alter primary productivity, and benthic communities that result in decreased prey abundance for salmonids. Although prey species may move out of this area, any change to forage outside of this area is expected to be immeasurable.

Effects on Water Quality

Water quality impacts of marine finfish net pens are well documented (see Price and Morris 2013; Rust et al. 2014; Price et al. 2015), and water quality would be affected by a variety of contaminants over the long-term. Effects on water quality below and surrounding net pens are likely to vary over time, with fluctuations associated with environmental changes (e.g., temperature, land-based contaminants, etc.), changes in net pen fish biomass (i.e., smolt to adult ratio), and during fallow periods. Although water quality conditions are expected to fluctuate, we assume that effects on water quality would occur indefinitely, for the length of time the net pens are operating.

As described above in our assessment of effects on benthic habitat conditions, the generation of suspended sediment, and resulting turbid conditions, may also arise from the movement of net pen structures on the seafloor stirring up sediment during repair and replacement of anchors and mooring lines. With the small footprint of anchors we expect the area disturbed to be small and repair and replacement activities to be infrequent. The proposed GP prohibits nets and anchoring structures from impeding the current flow or tidal exchange so as to contribute to deposition of solids that would impair water quality standards. Therefore, we expect any disturbance of sediment from regular maintenance and repair to be infrequent and result in very minor, localized, short-term elevated turbidity.

Similar to sediment impacts described above**,** effects to water quality may stem from nutrient loading by fish waste products (feces and urea) and excess (uneaten) feed, and contaminants from feed additives (e.g., medicated feed) or other disease control (e.g., bath or dip treatment). Nitrogen and phosphorus at net pens may be released into the water column in fish feces, or bound in uneaten food (see Price et al. 2015). The primary concern from a water quality perspective regarding elevated nitrogen and phosphorus levels arise from their nutrient enrichment effects. These may result in increases to phytoplankton and macroalgae production. Nitrogen in particular can have a nutrient enrichment effect that causes eutrophication and harmful algal blooms, potentially resulting in oxygen depletion (see Price et al. 2015). In the PS, and most marine waters, nitrogen is limited, so supplemental nitrogen can increase primary productivity and cause algal blooms (Price et al. 2015).

A synthesis by Price and Morris (2013) of global aquaculture scientific literature reported nitrogen ranges from none to significant differences from background concentrations, but found that measurable differences were rarely seen beyond 100 meters from net pens. Studies of PS net pen salmon farms have documented slightly increased nitrogen levels in the center of net pens, but no measurable difference 30 meters away (Brooks et al. 2003). Rensel and Forster (2007) determined that nitrogen released from properly sited net pen facilities in the PS are unlikely to have an adverse effect on water quality or cause algal blooms.

Studies in the PS have not identified dissolved phosphorus production at salmon farms as a concern (see Price et al. 2015). The amount of phosphorus in net pen effluent has decreased over time through decreases in levels of phosphorus in feed (Hardy and Gatlin III 2002). Improvements in feed formulation and management have led to significant reductions in nitrogen and phosphorus loading (Price et al. 2015).

DO levels can be reduced by increased microbial respiration or algal blooms associated with organic/nutrient enrichment from net pens. Nitrogen (dissolved inorganic nitrogen) in particular is considered a limiting nutrient in the PS, typical of marine systems (Newton and Van Voorhis 2002; Hawkins et al. 2019), and thus deposition material from net pens, including nitrogen, but also phosphorus, may increase primary productivity and has the potential to lead to eutrophication. Sufficient DO levels are essential to the health of organisms in the water column, including fish within net pens (see Solstorm et al. 2018). Salmonids are particularly sensitive to reduced DO levels at all life stages (Carter 2005). Low DO levels have been shown to also cause shifts in community structure in the water column, and reduced density and species richness of benthic infauna (Long 2007).

Historically, widespread low DO levels occur seasonally in certain geographical portions of the action area (see Encyclopedia of the PS 2022a). This has been most pronounced in southern portions of Hood Canal, but also in parts of the PS south of the Tacoma Narrows. Hypoxic conditions have resulted that are harmful to fish. Several hypoxic events have been documented in southern Hood Canal that have resulted in fish kills (see Encyclopedia of the PS 2022a; Palsson et al. 2008; Cope and Roberts 2013).

A meta-analysis by Sarà (2007) found that aquaculture operations do not generally affect DO. Seasonal and diurnal fluxes in the environment have been shown to often cause greater changes in DO than fish farms (see Price and Morris 2013). Monitoring in the PS have shown dissolved oxygen depression to be minimal in distance, usually no more than 0.1 to 0.2 mg/L depressed just five meters downstream of commercial net pens, and generally never measurable more than 30 meters downstream (Nash 2001).

A potential accumulation of nutrients from net pens could have far-field (beyond the immediate vicinity of net pens) effects on water quality. A review by Noakes (2014) found that the field of impacts from net pen waste discharge is typically contained within 100 meters of the outer boundary of the farm, consistent with other studies, but noted that depending on oceanographic conditions, suspended and dissolved waste materials may spread beyond this area, and result in potential cumulative and far-field effects. In the PS, where nitrogen is limited for algal and microbial productivity, nitrogen loading of the water column by net pens provides a potential pathway to eutrophication and decreased DO.

The proposed GP requires that responsive action be taken to address DO levels that fall below a threshold of 7.0 mg/L or less anywhere in the water column. If the baseline DO at a site is 7.0 mg/L then the action threshold is a decrease greater than or equal to 0.2 mg/L from baseline. The DO limit of 7.0 mg/L is protective of "extraordinary" water quality within PS, as defined by WAC 173-201A-210(1)(d). As described in Section 1.3 (Proposed Federal Action), DO monitoring (six samples at a minimum of two locations and depths) is required once per month between January 1 to August 14 and once per week between August 15 and September 30 when net pens contain fish. The proposed GP (Part V) requires the permittee to take immediate corrective action to address DO levels that fall below the threshold. EPA may also request the permittee to undertake additional monitoring to determine the cause or extent of a water quality-related problem. For the three covered facilities for which data was submitted during the previous permit cycle (since 2017), DO never dipped below the proposed action threshold of 7.0 mg/L.

Fallow periods, the time in which no fish are present in the net pens between removal/release and stocking, also help to reduce water quality effects. Under the proposed GP, these periods would typically be more than 6 months for the tribal enhancement net pens and a minimum of 6 weeks for the federal research facility. Flushing (water exchange) by currents during this time is expected to return water quality to background.

Water quality effects could also temporarily arise intermittently during net pen operations from the routine dislodging of biofouling from nets, fines from broken fish food and fish waste, and from turbidity from benthic disturbance during replacement or maintenance of anchors and mooring lines. Potential water quality effects include increases in nitrogen and phosphorus, decreases in dissolved oxygen (DO), the presence of disease control chemicals, turbidity and algal blooms.

Through careful management, modern marine aquaculture operating conditions have minimized impacts of aquaculture net pens on water quality, including mostly eliminating effects on dissolved oxygen and turbidity, and localizing any detectable nutrient-enrichment (Price et al. 2015). Sediment and water quality monitoring, including visual monitoring of the benthos included in the proposed GP would help minimize excess feed and fish waste. Given the small number and size of net pens in the PS, relative to the action area, we do not expect additive or compounding effects of net pens on nutrient loading.

Other chemicals used at the facilities, such as fuel, oil and other maintenance pollutants could also potentially leak into the water column at the net pen facilities or from vessels in transit to/from the net pens. The proposed GP prohibits the discharge of fuel, oil, and maintenance pollutants. As described in Section 1.3 (Proposed Federal Action), permittees must have an Accident Prevention and Response Plan to minimize potential spill of contaminants. Required BMPs include prohibition of fueling, lubrication and general maintenance of boats and mechanical equipment at the net pen facilities (with the exception of fueling during fish transport); refueling of gas powered water pumps used during fish transfer only within secondary containment; spill response procedures and supplies in place at all times; and storage of fuels, drugs, pesticides and other potential pollutants and conveyance to the facility in daily quantities only, with the exception of feed, which may be conveyed in weekly quantities. With implementation of these BMPs we do not anticipate these contaminants entering the water column and affecting water quality. Additionally, no antifoulants are used on nets so this avoids potential associated contaminants in the water column.

We expect these combined effects on water quality to be chronic and acute within the marine areas close to the net pens, but to dissipate to low levels a short distance (estimated to 100 feet) away as flushing distributes and dilutes the contaminants.

2.5.2 Effects on Physical and Biological Features of Critical Habitat

The effects to habitat features in the action area must also be evaluated for their influence on PBFs of critical habitat. For example, changes in benthic conditions, whether physical or chemical, result in changes to the invertebrate communities that reside in the benthic layer, and as these species serve as prey, the effects translate to a change in forage, a PBF of designated critical habitat. Water quality, cover and migration are also PBFs, and therefore must be evaluated for changes in effects to critical habitat and the conservation role they provide in the designated area.

Because the net pen structures do not connect to shorelines, shading or other overwater impacts that interfere with the migration of nearshore-oriented PS Chinook salmon and HCSRC, well documented with piers, docks and floats as artificial cover that extend out from the shoreline (e.g., Nightingale and Simenstad 2001) are not likely. The vast majority of the net pen facilities' surface areas are nets that allow light penetration, and much of the other structure is grated (walkways) to allow partial light penetration, so the presence of the net pens themselves are unlikely to inhibit macroalgal growth. Therefore, an effect on cover as a PBF of critical habitat is also unlikely.

Effects on Forage

We consider there to be a moderate likelihood of exposure to benthic bio-deposits and contaminants to affect forage quality and availability under and within approximately a 100-meter perimeter of net pens with the required benthic and sediment monitoring and response measures under the proposed GP. The forage PBF for nearshore PS Chinook salmon and HCSRC includes "aquatic invertebrates and fishes, supporting growth and maturation." The forage PBF for both deepwater and shallow water critical habitat of PS/GB yelloweye rockfish and bocaccio includes "quantity, quality and availability of prey species to support individual growth, survival, reproduction and feeding opportunities."

Effects on forage below net pens are likely to vary over time, with fluctuations associated with environmental changes (e.g., water temperature), changes in net pen fish biomass (i.e., smolt to adult ratio), and during fallow periods. However, taking a conservative approach, we assume that effects on forage would occur indefinitely, for the length of time the net pens are operating.

All of the net pens to be covered under the proposed GP are within or in close proximity to nearshore critical habitat for juvenile PS/GB bocaccio, and are in close proximity to deepwater juvenile and adult PS/GB yelloweye rockfish critical habitat and adult bocaccio critical habitat. Therefore, we consider it reasonably likely that effects of benthic disturbance by net pen structures and operations would extend to designated nearshore and deepwater rockfish critical habitat at all facilities.

The forage PBF for both deepwater and shallow critical habitat of PS/GB yelloweye rockfish and bocaccio includes "quantity, quality and availability of prey species to support individual growth, survival, reproduction and feeding opportunities." The effects on forage as a PBF of PS Chinook salmon and HCSRC are also a long-term diminishment of available prey in the affected footprint. However, when evaluating the influence of this diminishment on the conservation role for which this PBF was identified, we must note that forage is not a limiting factor for any of these species in the marine environment, therefore the PBF for these four species, while diminished, is so constrained spatially that this diminishment would likely not impair the conservation role of providing adequate prey for the listed species.

We also anticipate effects to forage from competition for resources with escaped fish from the research facility. The effects to the forage PBF of marine critical habitat for PS Chinook salmon, HCSRC, and PS/GB bocaccio and PS/GB yelloweye rockfish resulting from competition for prey items with escaped fish are assessed in the 'Competition and Predation' portion of Section 2.5.3. We expect minimal overlap in habitat use between any escaped sablefish and ESA-listed salmonids and rockfish. Because the hatchery programs that the salmon enhancement net pens are part of are in the baseline and we do not expect any increased competition associated with release of fish from net pens versus other land-based hatchery facilities, we do not expect the release of those fish as part of the proposed action to have any effect on forage availability.

Effects on Water Quality

Section 2.5.1 includes a detailed description of water quality effects in the environment, which we characterized as moderate in the areas around net pens. Because water quality is a PBF for PS Chinook, HCSRC, PS/GB yelloweye rockfish and bocaccio, we evaluate whether the water quality changes described above would impair the conservation role that water quality serves for these species.

Regarding salmonids, the net pens are located in critical habitat only for PS Chinook salmon and HCSRC, and thus we expect effects to be limited to the water quality PBF of nearshore PS Chinook salmon and HCSRC critical habitat—water quality is identified as a PBF because it supports growth and maturation. For rockfish, the conservation role of the water quality PBF of juvenile and adult PS/GB yelloweye rockfish and bocaccio critical habitat is to support growth, survival, reproduction, and feeding opportunities.

The aggregate effects of nutrient loading from all land and water-based sources in the PS basin (e.g., nitrogen inputs from human activities), contribute to seasonal low DO (see Encyclopedia of the PS 2022). With the required measures to minimize excess feed, waste and other biofouling under the proposed GP, as well as the intermittent nature of discharge from net pens (fallow periods), we anticipate nutrient loading to be highly localized and minor.

As described in Section 2.5.1, is difficult to assess far-field effects from the net pens versus other anthropogenic sources. However, studies around larger commercial net pens in the PS have measured only minimal reductions in DO and generally never more than 30 meters downstream (Nash 2001). Within the PS, low DO levels are most pronounced in the southern portions of Hood Canal and the southern PS (Encyclopedia of the PS 2022a). Only one of the net pen facilities (Squaxin Island) that would be covered by the proposed GB occurs in these areas, and therefore, we do not anticipate broad effects to DO levels. Additionally, throughout most of the PS, background levels of ocean-upwelling sourced nitrogen are high, and are not limiting for plankton grown, and thus the discharge of dissolved nutrients has little to no effect on the rate of phytoplankton production (see WDFW 1990; Rensel Associates and PTI Environmental Services

1991). Because of the combination of high background levels of nitrogen, and natural and anthropogenic nitrogen inputs (see Ecology 2020), we do not expect any dissolved nitrogen inputs from existing net pens to have a measurable effect on algal blooms.

As described in Section 2.5.1, we expect any disturbance of sediment from regular maintenance and repair to be infrequent and result in very minor, localized, short-term elevated turbidity. Therefore, we expect that this effect on the condition of water quality as a PBF of PS Chinook salmon and HCSRC critical habitat would not diminish the action area's conservation value for the species, because acute water quality changes would occur in a limited footprint and the dispersal of the contaminants would be at low enough concentrations, that exposure of individuals at any lifestage would not impair the role for which this habitat was designated as critical—supporting survival, growth, maturation, reproduction or feeding opportunities of these species within their critical habitat.

Rockfish display site fidelity, so are likely to have more prolonged exposure to areas with higher water quality diminishment. This is particularly true for yelloweye rockfish, with bocaccio tending to move around more. With the measures implemented to minimize impacts to water quality, and ongoing monitoring of DO, we anticipate that any input of bio-deposits and contaminants from the net pens to the water column would have a minor, localized effect on water quality, and only infrequently (periodic, but short-term on each occasion) at a level that diminishes the suitability of habitat to support yelloweye rockfish and bocaccio growth, or that would be harmful to fish health (i.e., reduced DO levels, or presence of mercury).

2.5.3 Effects on Listed Species

2.5.3.1 Exposure and Response to Habitat Changes

Effects on listed species may occur when individuals are exposed to changes in environmental conditions in the action area, and also from activities that directly affect individuals. We present the exposure and response of species to habitat changes first, and then present the consequences of the proposed action that directly affect listed fish.

Modified Benthic Conditions/Reduced Forage

Effects on forage below net pens are likely to vary over time, with fluctuations associated with environmental changes (e.g., water temperature), changes in net pen fish biomass (i.e., smolt to adult ratio), and during fallow periods. Taking a conservative approach, we assume that effects on forage would occur indefinitely, for the length of time the net pens are operating.

It is likely that some individual PS Chinook Salmon, PS steelhead and HCSRC would experience the periodic slight diminishment of prey availability caused by net pen operations. This exposure is expected to be small and very brief because the mobility of these species is high and the likelihood that they would linger to forage in depleted areas is low.

As described above, the effects on benthic conditions and forage in the marine environment, are small due to limited footprint of diminished prey, and widely available prey throughout the remainder of the action area. We expect juvenile and adult PS/GB yelloweye rockfish and bocaccio to occasionally occur in and forage in the benthic environments with sediment quality potentially impacted by bio-deposits. Invertebrate displacement and potentially reduced primary productivity would temporarily reduce the forage potential of the habitat for rockfish.

However, we expect exposure to reduced forage to remain low at any given time. The habitat area with reduced forage would be very small relative to forage available in the immediately adjacent areas, and wider action area, and only rockfish are likely to have a longer duration of exposure based on their habitat preferences. Salmonids are generally more mobile and any exposure to areas of reduced forage abundance would be extremely brief as they move through the small areas affected.

The number of rockfish feeding in the area with potentially degraded forage would be few, but we expect juvenile bocaccio rearing in nearshore waters close to where the net pens are located the most likely to be exposed to any forage effects. The number of adult PS/GB yelloweye rockfish and bocaccio even over multiple years would be low, due to depth preferences of adults. Although deepwater critical habitat is designated in waters over 98 feet, adults of both species are most commonly found between 131 to 820 feet (Orr et al. 2000; Love et al. 2002), deeper than where the net pens are located. Given the limited amount of adult habitat in close proximity to net pens, the small footprint of affected habitat and the short-term nature of benthic disturbance during mooring system movement on the seafloor, replacement and maintenance, we consider there to be a low likelihood of adult rockfish exposure to a reduction in forage in any given year.

Larval and juvenile rockfish feed on small organisms, such as zooplankton, copepods, phytoplankton, small crustaceans, invertebrate eggs, krill and other invertebrates (see NMFS 2017a). Rockfish larvae, including PS/GB yelloweye rockfish and bocaccio, are typically found in the pelagic zone, often occupying the upper layers of open waters, where they may encounter net pens. Rockfish larvae are thought to be initially distributed passively by currents (Love et al. 2002), until they are big enough to progress toward preferred habitats. Encounters with net pens would be a result of passive dispersal of larvae by prevailing currents through areas with net pens. Because larvae are carried by currents, any exposure would be very brief.

Larval juvenile rockfish may experience longer exposure to habitat effects of net pens because they are weaker swimmers, but even in this circumstance we any effect to reduced forage (invertebrate displacement in the footprint of net pen, via benthic disturbance, sediment quality degradation to water quality), to be very small due to availability of prey items drifting into the area from other undisturbed sites. The magnitude of effects on forage for larvae stemming from change in benthic conditions, would be diluted by availability of prey items drifting into the pelagic area, where larvae occur, from other undisturbed sites. Additionally, the diverse diet of larval rockfish limits any effect on overall forage from reduced prey abundance.

When bocaccio reach sizes of 1 to 3.5 inches (3 to 9 centimeters (cm)) (approximately 3 to 6 months old), they settle in shallow nearshore waters in rocky or cobble substrates with or without kelp (Love et al. 1991; Love et al. 2002). Juvenile yelloweye rockfish typically settle in water 98 to 131 feet, typically in habitats with moderate to extreme steepness, complex bathymetry, and rock and boulder-cobble substrate (Yamanaka and Lacko 2001; Love et al. 2002). None of the net pen facilities covered by the proposed GP are in deeper areas where juvenile yelloweye rockfish are typically found (over 98 feet depth) but minor effects to forage could intermittently extend to these deeper areas.

Although it is likely that some juvenile and adult salmon and steelhead migrating through the action area would encounter net pens and the areas of diminished prey associated with them, given the small area of benthic impacts and areas with diminished prey we expect very few fish to be exposed to reduced forage, and such exposure infrequent and brief.

Given the highly mobile nature of salmonids, and the small, localized areas of diminished forage, we expect that juvenile and adult salmonids would spend little time in such areas and move to areas with greater forage potential. Similarly, juvenile and adult rockfish (both bocaccio and yelloweye rockfish) are able to swim to areas of higher prey abundance. Of the few individuals of the listed species that are exposed to areas of reduced forage, we expect only the behavioral response of moving to areas where prey is more abundant. We anticipate no response that would reduce growth, maturation, fitness, or survival of exposed individuals of any of these listed salmonid or rockfish species despite their exposure to areas of low forage, because of the sufficiently abundant prey in adjacent areas.

Reduced Water Quality

Listed species are likely to be exposed to reduced water quality in the marine environment. We expect measurable effects on water quality to be limited to the area directly beneath and in close proximity to net pens (e.g., within 100 meters down current), diminishing with distance from the net pens. Overall, we anticipate that during operations of net pens, water quality, particularly DO, may be diminished to sub-optimal levels for salmonid health. With proposed monitoring and waste product minimization measures, we anticipate such conditions to occur infrequently and only persist for the short-term.

Because the more acute water quality diminishments are expected to be localized, and minor, and infrequently at a level harmful to fish, and because PS Chinook salmon, PS steelhead and HCSRC can detect and avoid areas of low DO, we anticipate few fish being exposed to or affected by poor water quality, and the primary response would be avoidance behavior.

Elevated levels of turbidity can also occur at net pen sites from fines being released to the water column as dust from broken feed pellets, and from fish waste, as well as from the scraping of biofouling (see Price et al. 2015; Floerl et al. 2016). High levels of turbidity can create conditions harmful to fish (Cooke-Tabor 1995; Bash et al. 2001), as well as reduce primary productivity in the water column and on the seafloor by limiting light penetration (see Price et al. 2015). Price et al. (2015) summarized that increased turbidity may be detected in both the near-field (immediate net pen area) and far-field (distant from net pen) area around net pens, but no detection of cumulative impacts of multiple farms. As with DO, salmonids can easily detect and, if space is available, avoid areas where water quality is impaired by turbid conditions/suspended sediment. Exposure is likely among a few individuals of both salmonid species, but response is expected to be avoidance, and not sufficient to create any injury among the exposed individuals or diminish growth, feeding or fitness.

We expect minor reductions to water quality in the immediate vicinity of net pens. This may result in short-term exposure to reduced water quality as PS Chinook and PS steelhead migrate through the affected area. Furthermore, because salmonids are highly mobile, exposure to potentially harmful conditions (e.g., low DO) would be for a very short duration of time. Therefore, we do not expect exposure to result in adverse effects on individual health.

Exposure to water quality reductions could be of greater consequence for PS/GB yelloweye rockfish and PS/GB bocaccio. In addition to the water quality effects described above and in this section, elevated levels of mercury in rockfish have also been linked to proximity to net pens in some parts of the world. Because of their site fidelity and benthic habitat use, as well as their long life-span, they may be particularly susceptible to accumulation of mercury. Elevated levels of mercury could lead to reduced growth rates and impaired reproduction in rockfish (Drake et al. 2010).

A study by deBruyn et al. (2006) identified elevated levels of mercury in rockfish near commercial net pens in BC. This was attributed to fish feed and feces incorporated through the food web (invertebrate and small fish) to rockfish, and the mobilization of naturally occurring mercury in the sediment under and near the pens because of farm-induced anoxia. Although a potential contributor of mercury, it is difficult to determine the role net pens play in mercury levels in rockfish in the PS. Elevated mercury levels in rockfish are well documented in fish in urban areas (see NMFS 2017a). We expect that current practices at the tribal enhancement and Manchester research net pens to reduce contaminants, including monitoring of sediment and water quality, greatly reduced the risk of mercury contamination. These net pen operations are also much smaller than the commercial operations linked to elevated levels of mercury in the scientific literature. However, taking a conservative approach, we assume that effects on water quality would occur indefinitely, for the length of time the net pens are operating, and, because rockfish are particularly long lived, and exhibiting site fidelity, that some individuals would be exposed for long periods.

Larval rockfish exposure is expected to be less acute. They are pelagic so may be exposed to portions of the water column near net pens with diminished water quality. As a result of passive dispersal of larvae through areas with net pens. Because larval rockfish generally move passively, they would not be able to swim away from and avoid areas of degraded water quality, currents are likely to convey most larvae out of the area of acute exposure within a short (hours to days) timeframe.

Response to reductions to water quality near net pens for salmonids is expected to be behavioral only, as avoidance of areas of high turbidity or low DO is a common and instinctive response. Salmonids are highly mobile and their likelihood of encountering these areas of diminished water quality is low when they are migrating either out to the ocean or back to spawning areas, so short-term exposure would be so brief that no negative health effects are likely. A significant portion of Chinook salmon, known as 'resident' fish, spend a significant portion, or potentially all of their marine rearing phase within the Salish Sea (PS, the Strait of Georgia and associated water bodies), instead of beyond the mouth of the SJDF in the northern Pacific Ocean (see Chamberlin and Quinn 2014; Kagley et al. 2017). These 'resident' fish thus spend most, if not all, of their life within the action area. Despite this inherent increased potential for exposure to habitat effects of net pens, we expect any exposure to be very brief, and unlikely to have negative effects on health, given the ability of juvenile and adult PS Chinook salmon to avoid these areas.

Because exposure to reduced water quality may be longer among rockfish at all lifestages, response could be more significant. Larval PS/GB yelloweye rockfish and bocaccio are carried by currents through the affected area and cannot engage in avoidance behavior. Exposure to potentially harmful conditions (e.g., low DO) may persist for a relatively short duration of time as larvae drift through the area, but currents are expected to carry them out of the area with the most acute water quality diminishment within hours to days.

For juvenile (non-larval) and adult rockfish, the habitat area with reduced water quality would be very small relative to suitable habitat available in the immediately adjacent and broader nearshore habitat of the action area where PS/GB yelloweye rockfish and bocaccio occur. We anticipate response to impaired water quality would only infrequently be at a level severe enough to affect fish health (exposure to potentially harmful conditions would be limited). Because adult PS/GB yelloweye rockfish and bocaccio prefer habitat deeper than where net pens are located, most individuals would not be exposed at acute levels, making chronic response to low level impairment indistinguishable from background health and fitness. Juvenile bocaccio could have slightly higher exposure because of their life history behaviors that include settling in shallower water and migrating over time to deeper areas. This could expose them to more load and more bioaccumulation. However, since contaminants, such as mercury are present in mature adult fish, this may not be a detriment to their long-term individual fitness or survival.

2.5.3.2. Exposure and Response to Direct Effects

In this section the effects of non-habitat related impacts (i.e., direct effects) on ESA-listed species are analyzed. These include: increased predation within net pens, entrainment by pumps, pathogens, competition for resources with escaped/released fish, and predation by escaped/released fish.

Predation by Fish in Net Pens

Juvenile PS Chinook salmon, PS steelhead and HCSRC, larval PS/GB bocaccio and yelloweye rockfish and juvenile bocaccio could be preyed upon if they enter net pens. Adults are too large to enter net pens and therefore we consider there to be no risk of predation by fish within net pens. Juvenile or larval fish that enter net pens are at risk of being consumed by larger salmonids (coho salmon) or sablefish in the pens. The risk of predation of ESA-listed fish by escaped net pen fish is assessed separately in our assessment of direct effects from competition and predation, below.

It is reasonably likely that juvenile salmonids encounter net pens during their out-migrations to the ocean. The risk of predation increases with the size of the fish within the net pens. Some juvenile wild salmonids may be attracted to net pen feed in the water, but we also expect that upon encountering or sensing larger fish in the nets, juvenile salmonids would avoid the area (e.g., see Berejikian 1995). Observations of the contents of gastrointestinal tracts of fish both within and escaped from commercial net pens shows a very low rate of predation on wild fish. An early study in the Pacific Northwest on the stomach contents of maturing escaped Atlantic salmon by McKinnel et al. (1997) found that of the 813 stomachs examined (63 from freshwater catches and 750 from ocean catches), 61.9% of the freshwater samples and 78.7 of the ocean samples were empty. A review paper by Amos and Appleby (1999) documented that all analyzed stomachs of recaptured Atlantic salmon in Washington were empty and in BC and Alaska, approximately 2-4% had herring in their stomachs, 2-4% had commercial fish food pellets and 1-5% had wood chips, kelp or other material not recognized as food. Similarly, analysis of 138 recaptured Atlantic salmon from the 2017 Cypress Island net pen failure showed no evidence of eating (Clark et al. 2017). Only one fish caught in the Skagit River had wood chips about the size of pelleted fish food.

Researchers in Tasmania investigating the ability of escaped farmed rainbow trout and Atlantic salmon ranging in size from 0.5 to 3 kg to feed on native marine fauna demonstrated differences between these two non-native species (Abrantes et al. 2011). About 63% of rainbow trout stomachs were empty, 21% contained commercial feed pellets, and about 24% contained native animals. For Atlantic salmon, none of the fish collected fed on nutritious material; 79% had empty stomachs, and the stomachs of the remainder contained leaves. Both Atlantic salmon and rainbow trout escapees had lower condition factors compared to fish of each species caged at the farm sites. Thus, although escaped rainbow trout appeared to adapt better to feeding on natural prey than Atlantic salmon, this only occurred for a quarter of those that escaped.

Studies on fish within net pens has also shown low rates of predation on wild food items. Hay et al. (2004) examined the stomachs of 734 farmed salmon (Atlantic, coho and Chinook salmon) in BC net pens, and found very few contained wild prey items. Most common were small crustaceans called caprellids that likely were a component of the net-fouling organism community. Only one fish was found, a sand lance. No fish larvae were found, but very small, fragile items, like larval fish tissue, may have gone undetected if they were unrecognizable. However, the authors conclude that if large numbers of larvae had been consumed, some would have been detected. A more recent, yet unpublished, 2-year study by the Canadian Department of Fisheries and Oceans (DFO) analyzed stomach contents of 14,100 adult Atlantic salmon from 47 farms (K. Shaw, personal communication, April 14, 2020). They found only 11 wild fish, 10 confirmed or likely to be herring, and one possibly a sand lance.

Within net pens, fish are habituated on pellet food, which is readily available. They therefore may have poor hunting ability, being cued in to food coming from the water surface as small pellets. Because they are well fed to maximize growth rate, they are also less likely to seek out other sources of nutrition. Therefore, although we cannot completely eliminate the possibility of opportunistic feeding on a juvenile salmonid that swims into a net pen with larger fish, we consider the occurrence of predation to be very low. However, all predation is considered fatal, whether injured by attempted predation or completely consumed.

Predation on PS/GB yelloweye rockfish and bocaccio could also occur during net pen operations. Again, exposure to this is limited to juvenile lifestages, particularly larvae, as adults and most non-larval juveniles have settled to the sea floor. Exposure at the larval lifestage is much more likely for rockfish than for juvenile salmonids. Larval rockfish of both species may be passively carried by currents through net pens. Co-occurrence of larval rockfish and net pens is a consequence of individual larvae being carried by currents to a net pen. Because this distribution is passive, and net pens occupy a very small portion of the total habitat area of larval PS/GB rockfish and yelloweye rockfish habitat (i.e., the PS), we consider co-occurrence of a larvae and a net pen to be only moderately likely.

Juvenile yelloweye rockfish and bocaccio may potentially swim through net pens, but because juveniles of both species are benthic, they would typically swim under net pens rather than through them. As described above for salmonid species, fish in net pens are well fed and habituated on pellet food, and based on available studies of stomach contents of farmed net pen fish, we expect very few rockfish to be preyed upon. However, all episodes would be fatal.

Entrainment by Pumps

Water pumps may be used at some of the net pen facilities covered by the proposed GP. When the pumps pull water from the PS there is potential for larval and juvenile salmonids and rockfish to be entrained and injured or killed. Adult fish would be too large to become entrained and juvenile yelloweye rockfish do not occur in the immediate vicinity of the net pens. We are aware of pump use associated with net pen operations at only two of the facilities covered by the proposed GP. For the Elliot Bay and Agate Pass net pen operations, during transport of fish in a small barge from the shore to the net pen, water from the PS is pumped and circulated through the container holding the fish. The intake pump is located about 2 feet below the water surface. The water drains back into the PS. For Elliot Bay the transport to the net pens is only about 15 minutes, and for Agate Pass about 40 minutes.

Given that juvenile salmonids and rockfish are highly mobile, we expect that very few would come in close proximity to intake pumps as they would avoid the disturbance (i.e., noise and movement in the water, and the presence of a boat). However, taking a conservative approach, we expect that a very small number of juvenile Chinook salmon, PS steelhead, HCSRC swimming near the surface of the water would be entrained and harmed or killed. Non-larval juvenile PS/GB bocaccio and PS/GB yelloweye rockfish are considered extremely unlikely of being entrained by the pumping near the water's surface because they are benthic, settling onto the substrate at three to six months of age and moving progressively deeper waters as they grow (Love et al. 1991; Yamanaka and Lacko 2001; Love et al. 2002; Palsson et al. 2009; NMFS 2017a).

Exposure of larval PS/GB bocaccio and PS/GB yelloweye rockfish is more likely due to their size and behavior at this life stage. Larval rockfish are pelagic and are passively distributed by prevailing currents (Love et al. 2002). Their mostly passive movement, and generally very weak swimming ability, make larval PS/GB bocaccio and yelloweye rockfish particularly susceptible to entrainment in the intake hose, unable to swim away and small enough to be entrained in high numbers. Entrainment of larval rockfish has been observed at power plant cooling water intakes, for example (Steinbeck et al. 2007).

Entrainment within the intake hoses and pumps is likely to harm or kill some larval PS/GB bocaccio and yelloweye rockfish. However, because of their small size (less than about 20mm length; Palsson et al. 2009) we expect that some larvae may pass through the hoses and pump and be returned to PS water unharmed. We conservatively assume that all entrained rockfish would be harmed as they have been observed to be injured by strong water flow in laboratory-rearing environments (Canino and Francis 1989).

Pathogens Transmission

All listed fish species considered in this opinion could be exposed to pathogens from the penned fish. Although no instances of disease or parasite transmission were reported during the last permit cycle, high concentrations of fish in net pen facilities does create the potential for disease or parasite transmission to natural fish populations (Nash 2001). As explained above, because the hatchery programs associated with the enhancement net pens are part of the baseline, and we do not consider the release of hatchery fish to be caused by this action, here we limit our analysis to the effects of the fish within the net pens themselves on pathogen risk to ESA-listed species.

As described in the BE, The *Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State* (NWTT and WDFW 2006) outlines the treatment, surveillance and reporting policies and procedures to be followed in order to protect free-ranging and cultured fish populations from management activities that could cause the importation, dissemination, and amplification of pathogens known to adversely affect salmonids. Required measures include stringent viral pathogen testing and fish health monitoring to protect free-ranging and cultured fish populations from pathogens known to adversely affect salmonids. The Policy stipulates several requirements including:

a. The health of each fish stock will be monitored monthly for regulated pathogens by a fish health inspector;
b. Significant fish losses suspected due to an infectious agent must be promptly investigated by the facility manager and a Fish Health Inspector, and preventative drug, pesticide or other chemical use must be implemented; and
c. Transfer requirements must be met to prevent the spread of endemic fish pathogens.

The biological opinions for the hatchery program HGMPs associated with the tribal enhancement net pens provide a thorough analysis of disease risk, and we incorporate by reference that analysis, as applicable. Both the 2016 Hood Canal HGMP Biological Opinion (NMFS 2016), which includes the Quilcene Bay and Port Gamble net pen facilities, and the Green HGMP Biological Opinion, which includes the Elliot Bay net pen facility, identify that coho salmon in the net pen programs historically suffered from endemic *Vibrio spp.*, but vaccination for the pathogen prior to moving fish to the net pens has controlled for it. The biological opinion for the Green River HGMP reports that neither the Elliot Bay nor the Des Moines (not part of the proposed GP) net pens have a history of vibriosis. As stated in the biological opinion for the Hood Canal HGMP, for these reasons, fish pathogen transmission and amplification risks associated with HGMP implementation for all programs would occur at low levels, if at all. The Green River HGMP and Hood Canal HGMP biological opinions conclude that the HGMPs are not likely to jeopardize the continued existence of the PS Chinook salmon ESU, the PS steelhead DPS or the HCSRC ESU, or to destroy or adversely modify designated critical habitat.

Under the proposed GP, we expect the required pathogen control measures to minimize the potential for pathogen outbreaks and the required monitoring and response measures would ensure an outbreak is addressed quickly and minimizes the potential for effects on wild fish in the proximity. Permittees of the GP must report fish disease epidemics, mass mortalities, and fish escape of any magnitude (from research facilities) to EPA, the Northwest Indian Fisheries Commission (NWIFC), WDFW, the Washington Department of Agriculture (WSDA) and the Washington Department of Health (WSDOH) within 24 hours from the time they become aware of the circumstances. Disease surveillance, prevention, and treatment for facilities rearing salmonids are required to be consistent with the requirements of *The Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State*, revised July 2006. Any facility that is not already party to the Policy is expected to become a formal co-operator of the Policy. The Policy stipulates several requirements including:

a. The health of each fish stock will be monitored monthly for regulated pathogens by a Fish Health Inspector;
b. Significant fish losses suspected due to an infectious agent must be promptly investigated by the facility manager and a Fish Health Inspector, and preventative drug, pesticide or other chemical use must be implemented;
c. Transfer requirements must be met to prevent the spread of endemic fish pathogens.

Additionally, pathogen and disease risk of released fish will be fully assessed in the HGPM biological opinions yet to be completed/reinitiated for hatchery programs associated with the Agate Pass, Peale Passage and Port Gamble net pen programs (see Table 14). Based on net pen operations and required control measures, we anticipate that the effects identified in these HGMP biological opinions will be consistent with those identified in the completed Green River and Hood Canal HGMP biological opinions, with similar low level risks from pathogens.

As detailed in the BE, facilities raising non-salmonids, like the Manchester research net pen facility are required to comply with protocols that are similar to those in the disease control policy described above, as outlined in the proposed GP Part III.E.3. These protocols were informed by current procedures used at Manchester Research Station and were refined in coordination with WDFW. Steps required by the proposed GP to mitigate disease spread at non-salmonid facilities include:

a. Complete daily inspections of fish by net pen technicians and weekly inspections by the net pen manager to look for any irregularities in fish behavior or conditions (e.g., lesions) that would suggest health issues requiring subsequent pathogen analysis and a veterinarian;
b. Carry out a mandatory health inspection of the fish and net pen system by a fish health specialist or veterinarian every 6 months during fish net pen occupancy;
c. Ensure controlled water quality rearing conditions for broodstocks, eggs, and larvae leading to the production of juveniles for net pen stocking;
d. Ensure segregation of age classes (no co-culture of >1 generation); and
e. Employ standard biosecurity protocols (e.g., tank, net, and equipment disinfection) during rearing on land and during movement from land to net pens.

We expect these disease control measures to minimize the risk of a disease outbreak in the sablefish net pens. We also consider there to be an extremely low risk of cross-species disease transfer between sablefish and ESA-listed salmonids and rockfish. There is evidence (Arkoosh et al., 2018) to show that sablefish can be infected by *Aeromonas salmonicida* (furunculosis) but this is "atypical" of *A. salmonicida* and not the same as the *A. salmonicida* that causes furunculosis in salmon. Therefore, we expect sablefish net pens to pose an extremely low risk of disease exposure and response for ESA-listed salmonids and rockfish.

Genetic Effects

For research net pens with non-salmonids (i.e., sablefish at Manchester research net pens), because they are not ESA-listed species, and do not interbreed with ESA-listed species under NMFS jurisdiction, we determined there would be no genetic effects of escaped sablefish on ESA-listed species. Because release of fish from the tribal enhancement net pens is not considered a consequence of this action, we do not expect this action to otherwise cause genetic effects to ESA-listed species.

Competition and Predation

Predation, either direct or indirect (increases in predation by other predator species due to enhanced attraction), can result from net pen fish being released (salmonids) or escaping (sablefish) into the wild. In general, the threat from predation is greatest when natural populations of salmon and steelhead are at low abundance, when spatial structure is already reduced, when habitat, particularly refuge habitat, is limited, and when environmental conditions favor high visibility.

Competition and predation effects associated with the hatchery programs (for which the enhancement net pens are a part of) are assessed in the HGMP biological opinions for those programs and considered part of the environmental baseline. Furthermore, because we expect competition and predation effects of net-pen reared salmonids in these programs on wild salmonids to be the same regardless of whether the net pen fish are released directly from upland hatchery facilities or from net pens after a period of marine rearing, we do not expect this proposed action to cause competition or predation effects to ESA-listed species.

For research net pens, the proposed GP prohibits the release of fish (i.e., sablefish). However, through structural failures, or other 'leaks' of fish, such as from spill during stocking or removal, or by tears in nets, some fish could escape. BMPs required by the proposed GP, including regular structural inspections by professional engineers and regular net cleaning and/or replacement, as well as a fish escape prevention and response plan reduce the risk of escapes. With these control measures we consider there to be a very low risk of escape events, and anticipate a very small number of sablefish escaping from net pens facilities into the PS.

Sablefish are opportunistic predators and thus have a very diverse diet including crustaceans, cephalopods, salps, and fish. In the 13-41 cm size range, sablefish diet was made up largely of euphasiids (krill), but also included salps (tunicates), cnidarians, and fish off the coast of Washington State. As sablefish grow into the 40-80 cm size range, their diet shifts to become predominantly composed of fish, especially Pacific herring (Buckley et al. 1999). In the surveys conducted North of Cape Blanco, OR, Buckley et al. found that of the identifiable fish species consumed in summer of 1989, Pacific herring were most common, with less than 1% of either rockfish or salmon. In the fall of 1992, sablefish diets shifted to consume predominantly longspine thornyhead and Pacific Hake; no *Oncoryhnchus spp.* were identified in sablefish gut contents. However, other rockfish species, excluding longspine thornyhead, accounted for about 3% of sablefish diet.

However, diet can vary widely based on geography, with diet reflecting the species available in a particular location. Diet may also change with the season, but limited information is available to support this idea. Some studies cited in Buckley et al. (1999) show that diet shifts from predominantly fish in the spring to shrimp, ctenophores, and some benthic organisms in the summer, and back to fish in the fall. There has also been documented cases of diet shifts inter-annually. For example, Sturdevant et al. (2009), demonstrated that in one year of their annual survey, conducted since 1997, sablefish did have a high proportion of pink, chum, and sockeye salmon in their diets within the northern region of Southeast Alaska. The authors state that interactions between sablefish and salmon are uncommon, and speculate that an unusually high sablefish abundance may have led to large proportions of salmon in sablefish diets.

Sablefish are a marine species that inhabit deeper water as they grow larger. In the wild, juvenile sablefish inhabit pelagic waters and grow rapidly. By about a year and a half typically 38 cm, they become demersal on the continental shelf in waters < 200 m. Adult sablefish inhabit the outer shelf and continental slope in waters ranging in depth from 200–1,500 m, although they move into shallower waters in the summer and inhabit deeper waters in the fall through spring where they spawn. Adults can grow up to 50 cm and live for over 50 years (Buckley et al. 1999).

There is a very low likelihood of exposure to competition and predation in the marine environment of ESA-listed salmon and steelhead from escaped sablefish for three reasons. One, the large-scale escapes are expected to be very rare as described in Section 2.5. Two, we anticipate that larger escaped sablefish would generally not overlap in habitat use with salmon and steelhead. In the event of an escape, which habitat we expect sablefish to occupy is likely to depend in part on their size; sablefish less than 38 cm are typically pelagic and occupy water depths of < 200 m. When sablefish exceed 38 cm they become demersal and occupy water depths below 200 m. Because Smith et al. (2015) found that Chinook salmon occupied marine waters at depths 50 m and above, we expect that escaped sablefish would be most likely to overlap with salmon and steelhead if escape events occurred when sablefish are in the pelagic size range. Third, Buckley et al. (1999) found less than 1% of sablefish guts contained salmon or steelhead. Thus, any interaction between escaped sablefish and ESA-listed salmon or steelhead would most likely be competition for food, especially with Chinook salmon who also eat euphasiids as juveniles and Pacific herring when piscivorous.

Few ESA-listed rockfish are expected to be exposed to competition and predation of escaped sablefish. This is because we expect large-scale escape events to be rare, and even though they occupy similar depths, rockfish are commonly associated with rocky structures (NMFS, 2017). Because Buckley et al. (1999) found that sablefish diets had less than 3% rockfish, with the exception of the non-listed longspine thorneyhead, we anticipate the most likely interactions to be over prey resources. However, even though rockfish and sablefish prey on similar fish species (e.g., herring), they are likely to encounter their prey in different habitats.

2.5.4 Effects on Population Viability

We assess the importance of effects in the action area to the Evolutionarily Significant Units (ESUs)/Distinct Population Segments (DPS) by examining the relevance of the effects among individuals to the populations they comprise, through evaluating influence on the viability parameters of abundance, population growth rate (productivity), spatial structure, and diversity. While these characteristics are described as unique components of population dynamics, each characteristic exerts significant influence on the others. For example, declining abundance can reduce spatial structure and diversity of a population. For example, if effects were concentrated on individuals from a single population, the abundance in that population could decline sufficiently to reduce productivity, spatial structure, or diversity. When effects are likely to occur at lower levels across multiple populations, then the robustness or weakness of particular populations at a baseline level may yield different level of significance of those effects at the population scale.

We anticipate that net pen discharges permitted by the proposed GP, and net pen facility structures and operations as a consequence of the action, would have a small and localized, but persistent negative effect on the habitat and individual fitness of PS Chinook salmon, PS steelhead and HCSRC. Because exposure is low for almost all of the effects described in this analysis, even where response is high, only minor changes in abundance are expected.

Among PS/GB bocaccio and PS/GB yelloweye rockfish we lack population structure and review at the species scale. However, with the low frequency of exposure to harmful effects of net pens anticipated, even where response is moderate or high, we expect only small numbers of fish to be harmed.

Abundance

Although numbers cannot be ascertained, we expect very few PS Chinook salmon, PS steelhead and HCSRC to be killed as a result net pens structures and operations, including net pen discharges covered by the proposed GP (proposed action). Juvenile salmonids are considered the most likely life-stage to be harmed with great exposure to effects in the nearshore, as well as greater risk of predation. Juvenile fish killed would represent a decrease in abundance of an even smaller number of adults, based on typical low juvenile to adult survival of Chinook salmon (Duffy and Beauchamp 2011), steelhead (Moore et al. 2015) and HCSRC (see Duffy and Beauchamp 2011) in the PS. For example, Gamble et. al (2018) estimated marine survival of subyearling Chinook salmon in the PS to be between 0.18% and 11.7%. Moore et al. (2015) estimated that in the PS, only about 16% of wild and 11% of hatchery steelhead smolts survive the migration from the mouths of their natal rivers to the Pacific Ocean. Once in the ocean, many more would die before reaching adulthood and returning to natal streams to spawn.

A small number of juvenile PS Chinook salmon, PS steelhead and HCSRC are expected to be killed by predation in net pens or by escaped sablefish. A very small number of adult PS Chinook salmon, PS steelhead and HCSRC are expected to be harmed or killed as a result of pathogens transmission and competition for resources with escaped sablefish. Therefore, we do not anticipate any discernible effect on abundance of salmonids at the population level.

Similarly, while we cannot ascertain numbers, we anticipate a small number larval and juvenile of PS/GB yelloweye rockfish and bocaccio to be killed as a result of tribal enhancement or Manchester research net pens. An extremely small number are expected to be killed as a result of changes to forage, cover or water quality, or as a result of predation by net pen fish or competition with escaped fish. The most likely effect to result in harm or death is the entrainment of larval and juvenile rockfish by pumping.

We expect a small number of larval PS/GB bocaccio and yelloweye rockfish to be entrained and harmed or killed by pumping relative to the total population, and total volume of water in the PS that may contain larvae. Depending on size and age, a female yelloweye rockfish produces up to 2,700,000 larvae and bocaccio up to 2,298,000 larvae annually (Love et al. 2002; NMFS 2017a). Mortalities from entrainment would have a proportionally small effect on the overall DPS population abundance and productivity, with generally poor larval survival in the PS, and thus only a small number of larvae becoming reproductive adults (see NMFS 2017a). For example, a study by Canino and Francis (1989) showed that rockfish larvae experienced 70 percent mortality seven to 12 days after birth in a laboratory setting, without the risk of predation. The mean natural mortality rate for rockfish varies by species and environmental conditions. The mean natural mortality rate is approximately three percent per year for yelloweye rockfish and eight percent per year for bocaccio (see NMFS 2017a). Therefore, we do not anticipate any discernible effect of the proposed action on abundance of rockfish at the population level.

Productivity

As described above, we anticipate a small number of juvenile salmonids, and larval and juvenile rockfish to be harmed or killed as a result of the effects of net pens structures and operations, including net pen discharges covered by the proposed GP. Given the low larval/juvenile to adult rate of survival for these species (Duffy and Beauchamp 2011; Moore et al. 2015; NMFS 2017a; Gamble et. al 2018), we do not anticipate any measurable effect on adult populations. We expect that an extremely small number of adult PS Chinook salmon, PS steelhead and HCSRC would be harmed or killed. Therefore, we do not anticipate any discernible effect of the proposed action on adult spawning and productivity of populations for the period of the GP, even when accounting for these chronic effects through time and climate change effects.

Spatial Structure and Diversity

With no overall declines in population abundance and productivity anticipated, we do not expect any decline in the spatial extent of habitat utilized for spawning, rearing or migration by PS Chinook salmon, PS steelhead, HCSRC, PS/GB yelloweye rockfish or PS/GB bocaccio. Salmonid populations spread across the nearshore and mix when they enter PS (Fresh 2006). Since the net pens are not located throughout the action area (i.e., central and northern PS and the SJDF) and not immediately at the mouths of natal rivers, juvenile fish from multiple different populations may be exposed to localized net pen effects as they migrate through the PS to the Pacific Ocean. Therefore, we expect any effect on populations to be indiscriminate, with no effect on population spatial structure or diversity.

Although larval rockfish are widely dispersed by currents, unique oceanographic conditions within the PS likely result in most larvae staying within the basin where they are released (Drake et al. 2010). Unlike ESA-listed salmonids, we have not identified biological populations of each species below the DPS level, instead we use the term "populations" to refer to groups within each of the five identified basins of the action area (See Section 2.2.1 Status of the Species). Given the relatively small number of larvae and juveniles expected to be harmed or killed, we do not anticipate a measurable effect on population spatial structure or diversity.

2.6. Cumulative Effects

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

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

The action area is influenced by actions within PS marine waters, along the shoreline, and in tributary watersheds. Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PBFs, many of which are activities that have occurred in the recent past and had an effect on the environmental baseline. These can be considered reasonably certain to occur in the future because they occurred frequently in the recent past, especially if authorizations or permits have not yet expired. 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 PS.

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.

Based on current trends, there will continue to be a net reduction in the total amount of shoreline armoring in PS (PSP 2019). Changes in tributary watersheds that are likely to affect the action area include reductions in water quality, water quantity, and sediment transport. Future actions in the tributary watersheds whose effects are likely to extend into the action area include operation of hydropower facilities, flow regulations, timber harvest, land conversions, disconnection of floodplain by maintaining flood-protection levees, effects of transportation infrastructure, and growth-related commercial and residential development. Some of these developments will occur without a federal nexus, however, activities that occur waterward of the OHWM require a COE permit and therefore involve federal activities, which are not considered in this section.

All such future non-federal actions, in the nearshore as well as in tributary watersheds, will cause long-lasting environmental changes and will continue to harm ESA-listed species and their critical habitats. Especially relevant effects include the loss or degradation of nearshore habitats, pocket estuaries, estuarine rearing habitats, wetlands, floodplains, riparian areas, and water quality. We consider human population growth to be the main driver for most of the future negative effects on salmon and steelhead and their habitat.

The human population in the PS region is experiencing a high rate of growth. The central PS region (Snohomish, King, Pierce and Kitsap counties) has increased from about 1.29 million people in 1950 to over 4.2 million in 2020, and projected to reach nearly 6 million by 2050 (PS Regional Council 2020). Thus, future private and public development actions are very likely to continue in and around PS. As the human population continues to grow, demand for agricultural, commercial, and residential development and supporting public infrastructure is also likely to grow. We believe the majority of environmental effects related to future growth will be linked to these activities, in particular land clearing, associated land-use changes (i.e., from forest to impervious, lawn or pasture), increased impervious surface, and related contributions of contaminants to area waters. Land use changes and development of the built environment that are detrimental to salmonid habitats are likely to continue under existing regulations. Though the existing regulations minimize future potential adverse effects on salmon habitat, as currently constructed and implemented, they still allow systemic, incremental, additive degradation to occur.

Several not for profit organizations and state agencies are also implementing recovery actions identified in the recovery plans for PS Chinook salmon, HCSRC, PS steelhead, and PS/GB yelloweye rockfish and bocaccio. The state passed House Bill 1579 that addresses habitat protection of shorelines and waterways (Chapter 290, Laws of 2019 (2SHB 1579)), and funding was included for salmon habitat restoration programs and to increase technical assistance and enforcement of state water quality, water quantity, and habitat protection laws. Other actions included providing funding to the Washington State Department of Transportation to complete fish barrier corrections. Although these measures won't improve prey availability in 2020/2021, they are designed to improve conditions in the long-term.

Notwithstanding the beneficial effects of ongoing habitat restoration actions, the cumulative effects associated with continued development are likely to have ongoing adverse effects on all the listed salmonid and rockfish species addressed in this opinion, and abundance and productivity that outpace the effects of restoration activities. Only improved low-impact development actions together with increased numbers of restoration actions, watershed planning, and recovery plan implementation would be able to address growth related impacts into the future. To the extent that non-federal recovery actions are implemented and offset ongoing development actions, adverse cumulative effects may be minimized, but will probably not be completely avoided.

2.7. Integration and Synthesis

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

2.7.1 Critical Habitat

Critical Habitat is designated for PS Chinook and HCSRC in the marine environment. Throughout the designated area, multiple features of habitat are degraded, but despite such degradation, many accessible areas remain ranked with high conservation value because of the important life history roles they play. Limiting factors (impaired or insufficient PBFs) include; riparian areas and LWD, fine sediment in spawning gravel, water quality, fish passage and estuary conditions. Loss of nearshore critical habitat quality is a limiting factor for both species. Current state and local regulations do not prevent much of the development that degrades the quality of nearshore critical habitats. There is no indication these regulations are reasonably certain to change in the foreseeable future.

Critical habitat for PS/GB bocaccio and yelloweye rockfish in the PS includes hundreds of square miles of deep-water and nearshore areas. Habitat has been degraded by, and continues to be threatened by, water pollution and runoff, nearshore development and in-water construction, dredging and disposal of dredged material, climate-induced changes to habitat and population dynamics, degradation of rocky habitat, loss of eelgrass and kelp, and the introduction of non-native species that modify habitat.

Given the rate of expected human population growth in the PS area, cumulative effects are expected to result in mostly negative impacts on critical habitat quality for PS Chinook salmon, HCSRC, PS/GB yelloweye rockfish and PS/GB bocaccio. While habitat restoration and advances in best management practices for activities that affect critical habitat could lead to some improvement of PBFs, adverse impacts created by the intense demand for future development is likely to outpace any improvements.

To this degraded baseline, including the sediment standards biological opinion (WCRO-2018-00286) and anticipated cumulative effects, we add the habitat effects we expect to result from the consequences of the action (tribal enhancement and federal research net pen structures and operations). Because net pen sites are within and/or in close proximity to critical habitat for PS Chinook salmon, HCSRC, PS/GB yelloweye rockfish and PS/GB bocaccio, we anticipate net pen facilities and operations would directly degrade quality of critical habitat for these species. Effects to critical habitat for these four species includes reduced forage resulting from benthic disturbance by structures, sediment quality degradation by bio-deposits and contaminants; increased predation associated with fish in net pens and escaped sablefish, and degraded water quality, contaminants and turbidity. Alone, the scale of these adverse effects would be spatially isolated and infrequent, so that the overall consequence on critical habitat would be low. However, the degraded baseline, anticipated cumulative effects added to the effects of the proposed action result in continued degradation of critical habitat and a prolonged period of recovery of listed species. Nevertheless, the conservation value of the critical habitat for PS Chinook salmon, HCSRC, PS/GB yelloweye rockfish and PS/GB bocaccio is largely retained.

The isolated effects the net pens covered by the proposed GP on habitat conditions (i.e., water quality, forage and cover) are expected to be minor, and intermittent. Effects would be highly localized relative to the broader action area, and expanse of critical habitat within the action area. Therefore, despite a degraded baseline and anticipated cumulative effects primarily associated with population growth and development, we do not expect the habitat effects the net pens to appreciably diminish the conservation value of critical habitat for PS Chinook, HCSRC, PS/GB yelloweye rockfish or PS/GB bocaccio.

2.7.2 ESA Listed Species

PS Chinook salmon are currently listed as threatened with generally negative recent trends in status. Widespread negative trends in natural-origin spawner abundance across the ESU have been observed since 1980. Productivity remains low in most populations, and hatchery-origin spawners are present in high fractions in most populations outside of the Skagit watershed. Although most populations have increased somewhat in abundance since the last status review in 2016, they still have small negative trends over the past 15 years, with productivity remaining low in most populations (Ford 2022). All PS Chinook salmon populations continue to remain well below the TRT planning ranges for recovery escapement levels, and that most populations remain consistently below the spawner-recruit levels identified by the TRT as necessary for recovery.

The most recently completed 5-year review (NWFSC 2015; NMFS 2017c) for Pacific salmon and steelhead noted some signs of modest improvement in PS steelhead productivity since the previous review in 2011, at least for some populations, especially in the Hood Canal and SJDF MPG. However, several populations were still showing dismal productivity, especially those in the Central and South PS MPG. The 2022 biological viability assessment (Ford 2022) identified a slight improvement in the viability of the PS steelhead DPS since the PS steelhead technical review team concluded that the DPS was at very low viability in 2015, as were all three of its constituent MPGs, and many of its 32 DIPs (Hard *et al.* 2015). Ford (2022) reported increases in spawner abundance in a number of populations over the last five years, which were disproportionately found within the South and Central PS, SJDF and Hood Canal MPGs, and primarily among smaller populations. The assessment concluded that recovery efforts in conjunction with improved ocean and climatic conditions have resulted in an increasing viability trend for the PS steelhead DPS, although the extinction risk remains moderate (Ford 2022).

HCSRC have made substantive gains towards meeting this species' recovery plan viability criteria. The most recently completed 5-year review (NWFSC 2015; NMFS 2017c) for this ESU notes improvements in abundance and productivity for both populations that make up the ESU.

The 2022 biological viability assessment reported that natural-origin spawner abundance has increased since ESA-listing and spawning abundance targets in both populations have been met in some years (Ford 2022). Implementation of recovery plan actions for HCSRC, including development of an in-lieu fee program for projects that impact critical habitat for this species, represent positive steps toward addressing habitat limiting factors for this species.

However, Ford (2022) found that productivity has been down for the last three years for the Hood Canal population of HCSRC, and for the last four years for the SJDF population, following prior increased productivity reported at the time of the last review (NWFSC 2015). Based on productivity of individual spawning aggregates, Ford (2022) identified viable performance for only two of eight aggregates. However, spatial structure and diversity viability parameters, as originally determined by the TRT have improved and nearly meet the viability criteria for both populations. Ford (2022) finds that although substantive gains have been made towards meeting viability criteria, the ESU still does not meet all of the recovery criteria for population viability. Therefore, Ford (2022) proposes to conclude that the HCSRC ESU remains at moderate risk of extinction, with viability largely unchanged from the prior review.

PS/GB bocaccio are listed as endangered and abundance of this species likely remains low. PS/GB yelloweye rockfish are listed as threatened but likely persist at abundance levels somewhat higher than bocaccio. Lack of specific information on rockfish abundance in PS makes it difficult to generate accurate abundance estimates and productivity trends for these two DPSs. Available data does suggest that total rockfish declined at a rate of 3.1 to 3.8 percent per year from 1977 to 2014 or a 69 to 76 percent total decline over that period. The two listed DPSs declined over-proportional compared to the total rockfish assemblage. Habitat degradation has limited the carrying capacity of habitat for these species and continued threats inhibit recovery. Other factors, such as overfishing, are more significant threats to PS/GB yelloweye rockfish and bocaccio. While ongoing habitat restoration and advances in best management practices may slow further habitat degradation and reduce direct take, a trajectory for recovery of populations remains uncertain, particularly given anticipated impacts of climate change.

When we evaluate the cumulative effects on these species over the time period of anticipated ongoing net pen operations and their impacts, we anticipate additional stress added to existing stressors in the baseline in both fresh and marine environments from anthropogenic changes in habitat (increased recreational use in fresh and marine waters, increased stormwater inputs in fresh and marine waters), and increasingly modified conditions related to climate change (warmer temperatures, and more variable volume and velocities in freshwater, changing temperature, pH, and salinity in marine waters). All of these are likely to exert negative pressure on population abundance and productivity.

In this context we add the effects of the proposed action. Even considered over multiple years with highly variable ocean conditions and climate change stressors, only a small number of fish relative to the affected populations would be killed or injured by the effects that result from net pen structures and operations, so that the reductions in abundance would not rise to create effects on productivity, diversity and spatial structure at discernible levels. Therefore, the proposed action is unlikely to alter the current or future trends for PS Chinook salmon, PS steelhead, HCSRC, PS/GB yelloweye rockfish or PS/GB bocaccio population viability even when cumulative effects and baseline conditions are added to the proposed action.

In other words, we expect that for the term of the GP (5 years), the total effects of the action on individual fish identified in this opinion would be indiscernible at the population level because although these species are currently well below historic levels, they are distributed widely enough and are presently at high enough abundance levels that the loss of individual fish resulting from the action would not alter their spatial structure, productivity, or diversity. Therefore, when considered in light of species status and existing risk, baseline effects, as described above in Section 2.7.1 (Effects to Critical Habitat) and cumulative effects, the action (and consequences of the action) itself does not increase risk to the affected populations to a level that would reduce appreciably the likelihood for survival or recovery of PS Chinook salmon, PS steelhead, HCSRC, PS/GB yelloweye rockfish and PS/GB bocaccio.

2.8. Conclusion

When analyzed over the period of the GP (5 years) and evaluated with variable ocean conditions and climate change stressors, only a small number of fish relative to the affected populations would be killed or injured by the effects that result from net pen structures and operations. Further, despite a degraded baseline and anticipated cumulative effects primarily associated with population growth and development, we do not expect the habitat effects of the net pens to appreciably diminish the conservation value of critical habitat for PS Chinook, HCSRC, PS/GB yelloweye rockfish or PS/GB bocaccio.

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 PS Chinook salmon, PS steelhead, HCSRC, PS/GB yelloweye rockfish or PS/GB bocaccio, or adversely modify designated critical habitat of PS Chinook salmon, HCSRC, PS/GB yelloweye rockfish or PS/GB bocaccio.

2.9. Incidental Take Statement

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

This ITS provides a take exemption to the EPA and the recipients of the GP for any incidental take caused by consequences of EPA's approval of the NPDES General Permit (see Section 1.3 Proposed Federal Action).

2.9.1 Amount or Extent of Take

When take is in the form of harm from habitat degradation, it is often impossible to enumerate the take that would occur because the number of fish likely to be exposed to harmful habitat conditions is highly variable over time, influenced by environmental conditions that do not have a reliably predictable pattern, and the individuals exposed may not all respond in the same manner or degree. Where NMFS cannot quantify take in terms of numbers of affected fish, we instead consider the likely extent of changes in habitat quantity and quality to indicate the extent of take as surrogates. The best available indicators for the extent of take, proposed actions are as follows.

As described in our effects analysis, NMFS has determined that take is reasonably certain to occur as harm of juvenile PS Chinook salmon, HCSRC, PS steelhead, and juvenile and larval PS/GB bocaccio and yelloweye rockfish resulting from habitat effects and direct effects on species from tribal enhancement and federal research net pen operations.

Specifically, we expect that the following amounts and types of take would occur:

- Harm (reduced fitness and survival) from reductions in forage production for juvenile and adult PS Chinook salmon, PS steelhead, PS/GB yelloweye rockfish and PS/GB bocaccio from sediment quality degradation occurring as a result of bio-deposits and contaminants;
- Harm to juvenile and adult PS Chinook salmon and PS steelhead, and larval, juvenile and adult PS/GB yelloweye rockfish and PS/GB bocaccio as a result of degraded water quality from bio-deposits, contaminants and reduced forage;
- Injury and death from predation on juvenile PS Chinook salmon, HCSRC, and larval PS/GB yelloweye rockfish and PS/GB bocaccio by fish within the net pen facilities;
- Injury and death from predation on, and harm from competition with, juvenile PS Chinook salmon, HCSRC and PS steelhead, and larval and juvenile PS/GB yelloweye rockfish and PS/GB bocaccio by escaped net pen sablefish;
- Injury or death from entrainment of juvenile PS Chinook salmon, HCSRC, and larval PS/GB bocaccio and PS/GB yelloweye rockfish during pumping of seawater during transfer of fish to net pens;
- Harm (reduced fitness and survival) from the transmission of pathogens to juvenile and adult PS Chinook salmon, HCSRC, PS steelhead, PS/GB bocaccio and PS/GB yelloweye rockfish from net pen fish.

For all of the above take pathways associated with net pen facilities and operations we use two surrogate take indicators:

- The maximum number of salmonid enhancement net pen facilities (six, including the anticipated Lummi Tribe facility) and the sablefish research net pen facility (one) covered by the proposed GP;
- The maximum biomass of 100,000 lbs. per year for production periods longer than 4 months, or 200,000 lbs. for production periods less than 4 months, at each tribal enhancement facility; and a maximum biomass of 75,000 lbs. at the Manchester research facility.

The number of net pen facilities of each type (salmonids and sablefish) and the maximum biomass of reared fish is causal and proportional to take we identified in this opinion resulting from effects of net pen facilities and operations, including discharge permitted by the proposed GP.

This ITS exempts take expected from six tribal enhancement net pens and one federal research net pen operation. Take would be exceeded if at any time more than six salmonid enhancement net pen facilities or more than one federal research sablefish net pen facility are covered by the GP. Additionally, this ITS exempts take expected from the total biomass reared at each facility. Take would be exceeded if at any time fish biomass was greater than the maximum biomass of 100,000 lbs. for facilities rearing fish longer than 4 months, or 200,000 lbs. for production periods less than 4 months, at each tribal enhancement facility; and 75,000 lbs. at the Manchester research facility. Exceeding these expected thresholds would trigger a need for reinitiation of this ESA Section 7 consultation.

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to PS Chinook salmon, PS steelhead, HCSRC, PS/GB yelloweye rockfish or PS/GB bocaccio, or destruction or adverse modification of PS Chinook salmon, HCSRC, PS/GB yelloweye rockfish or PS/GB bocaccio critical habitat.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" (RPMs) are 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 necessary and appropriate to minimize the likelihood of incidental take of ESA-listed species:

1. Provide NMFS with monitoring reports to confirm that the incidental take surrogate is not exceeded; and
2. Ensure the effectiveness of conservation measures, controls and regulations to minimize effects of fish escapes (at Manchester) and discharge on habitat conditions.

2.9.4 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. The EPA or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following term and condition implements reasonable and prudent measure 1:

   The EPA shall provide annually to NMFS a report that provides the number of tribal enhancement net pens and federal research net pen facilities and the annual fish biomass at each facility;

2. The following term and condition implements reasonable and prudent measure 2:

   a. The EPA shall provide annually to NMFS a report that provides the following information for each net pen facility:
      i. Monitoring results for water quality, sediment quality and benthic condition; and
      ii. Observed or estimated escapes based on fish counts and biomass; and
      iii. Any response/corrective actions to address exceedances of values permitted by the GP for the above monitored variables.

2.10. Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, "conservation recommendations" are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. Limit future net pen facilities to areas outside of a 5-mile radius of major river systems.

2.11. Reinitiation of Consultation

This concludes formal consultation for the reinitiation of consultation for the Environmental Protection Agency's Approval of Washington state Department of Ecology's Sediment Management Standards (WAC 173-204-412) regarding marine finfish rearing facilities.

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

2.12. "Not Likely to Adversely Affect" Determinations

When evaluating whether the proposed action is not likely to adversely affect listed species or critical habitat, NMFS considers whether the effects are expected to be completely beneficial, insignificant, or discountable. Completely beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Effects are considered discountable if they are extremely unlikely to occur. When effects are beneficial, insignificant and/or discountable, these species are not likely to be adversely affected by the proposed action and we present our justification for that determination separately from the biological opinion since no take, jeopardy, or adverse modification of critical habitat would reasonably be expected to occur. We concur with the EPA's NLAA determinations for Southern Resident killer whale (SRKW) and their designated critical habitat, the Central America DPS and Mexico DPS of humpback whale, the southern DPS of green sturgeon and their critical habitat, and the southern DPS of eulachon and their critical habitat. All of these species and designated critical habitat occur within the action area. We describe here those listed resources and critical habitat that we consider not likely to be adversely affected by the proposed action in this case.

2.12.1 Southern Resident Killer Whale and their Designated Critical Habitat

Southern Resident killer whale was listed as endangered on November 18, 2005 (70 FR69903) and critical habitat was designated on November 29, 2006 (71 FR 69054) and expanded on August 2, 2021 (86 FR 41668). Five-year reviews under the ESA completed in 2016 and 2021 concluded that SRKWs should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2016d; NMFS 2021). As of the summer of 2020, there were 72 SRKW, and during fall 2020 two more calves were born (L. Barre, personal communication, October 2, 2020).

Critical habitat is designated throughout the action area, excluding Hood Canal. PBFs for SRKW are:

- Water quality to support growth and development;
- Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and
- Passage conditions to allow for migration, resting, and foraging.

For the reasons outlined above in Section 2.5.3, any changes to water quality are expected to be localized and minor, with no implications on the health of SRKW. We do not anticipate water quality conditions to be degraded to such a degree that SRKW are harmed, particularly given the mobility of SRKW and limited time spent in one localized area. We do not expect any accumulation of toxic chemicals as a result of net pen operations that could harm SRKW. Water quality effects are insignificant to both SRKW and their critical habitat.

Potential benthic disturbance (Section 2.5.1) is also expected to be minor and localized, and the proposed action is expected to have an insignificant effect on the quantity and quality of salmonids and other potential prey species (e.g., squid, halibut) (see Section 2.5). Adult Chinook salmon have been identified as the preferred prey of SRKW (Hilborn et al. 2012; PFMC. 2020;

Hanson et al. 2021) and thus a decrease in the abundance of PS Chinook salmon could reduce available forage. While take of individual PS Chinook salmon is likely to occur as described in the analysis, most effects are likely to occur at sublethal levels. As described in Section 2.5.4 (Effects on Population Viability) juvenile PS Chinook salmon killed would represent a decrease in abundance of an even smaller number of adults (i.e., preferred SRKW prey), based on typical low juvenile to adult survival (Duffy and Beauchamp 2011). A very small number of adults are expected to be harmed or killed as a result of pathogens and competition for resources with escaped sablefish. Therefore, we do not anticipate a reduction in abundance or quality of Chinook salmon as a prey item to occur at levels or frequency to cause any discernible effect to the forage PBF of SR killer whale critical habitat.

Steelhead are known to make up only a very small portion of their SRKW diet, even during winter months when preferred prey (Chinook salmon) are less prevalent (see Hanson et al. 2021). Therefore, in light of similar effects on steelhead as Chinook salmon as discussed above, and because steelhead are not a preferred prey for SRKW, we do not anticipate effects of net pens on PS steelhead to have a measurable effect on SRKW diet composition, or forage availability. Reduction in prey abundance is insignificant to both SRKW and their critical habitat.

We expect vessels servicing the net pens to travel between the shore and the pens on a daily basis. State and federal regulations for marine vessels would reduce the risk of encounters with whales. Within the inland waters of Washington State, it is unlawful under federal regulations for any person to cause a vessel to approach, in any manner, within 200 meters of any killer whale, or to position a vessel to be in the path of any killer whale at any point located within 400 meters of the whale. State regulations also mandate protections for SRKWs (see RCW 77.15.740, mandating 300-400 yard approach limits, 7 knots or less speed within ½ nautical mile of the whales). Additionally, NMFS and other partners have outreach programs in place to educate vessel operators, including the fishing community, on how to avoid impacts to whales. Thus we anticipate interactions between vessels moving to and from net pens to not interfere with SRKW movement or behavior. The presence and movement of vessels associated with net pens is insignificant to both SRKW and their CH.

The location of the net pens covered by the proposed GP would not inhibit or interfere with passage of SRKW for migration, resting or foraging because of the small scale of the structures relative to the action area, and because they are not located within any constricted migration corridors. We are not aware of any SRKW interactions with net pens in the PS, and given the small footprint of structures relative to surrounding waters, we do not anticipate a detectable effect on passage conditions. Disruption of migration is insignificant to both SRKW and their CH.

Because all potential effects on PBFs of SRKW critical habitat are expected to be insignificant or discountable, the proposed action is not likely to adversely affect critical habitat for SRKW. With no significant indirect habitat effects to SRKW, nor measurable direct effects to SRKW, any potential effects to SRKW are expected to be insignificant

2.12.2 Central America DPS and Mexico DPS Humpback Whale and their Designated Critical Habitat

The humpback whale was listed as endangered in 1973 when the ESA was enacted. On September 8, 2016, we revised the ESA listing for humpback whale to identify 14 DPSs, which included the listing of the Central America DPS as endangered and the Mexico DPS as threatened (81 FR 62259). Both DPSs occur within the action area. Critical habitat was designated for the Central America and Mexico DPSs on April 21, 2021 (86 FR 21082). Only prey was identified as an essential feature (i.e., PBF) of humpback whale habitat in the critical habitat designation.

The only portion of the action area to include designated critical habitat for humpback whales is the SJDF, and thus there is no critical habitat near net pens covered by the proposed action. Sediment and water quality effects would be localized to net pen sites and would therefore not extend into humpback critical habitat. As described in effects analysis (Section 2.5), we anticipate that any impact to benthic conditions or water quality from net pen waste products or other contaminants would be minor and localized, with no measurable effect on forage potential (e.g., krill and small schooling fish) for humpback whale. We do not anticipate effects of net pens on humpback prey species abundance or quality within their designated critical habitat. Effects on prey of both DPSs of humpback whales and their critical habitat are discountable.

Humpback whales may occasionally venture beyond the Strait of Juan de Fuca further into the action area where they may encounter net pen structures. We do not expect individual whales to interact with the net pens because while humpbacks do prey on schools of fish, the fish inside these are generally larger than the preferred prey fishes of humpback (e.g., herring, anchovies, etc.). We are unaware of direct humpback whale interactions with PS net pens. As described above for SRKW, we do not anticipate any detectable effect on migration, and consider the risk of entanglement to be discountable. Therefore, we consider it unlikely that the net pen facilities or operations covered by the proposed GP would adversely affect humpback whales or their migration areas. Effects on humpbacks of entanglement with net pens are discountable.

2.12.3 Southern DPS Green Sturgeon and their Designated Critical Habitat

The southern DPS of green sturgeon was listed as threatened on April 7, 2006 (50 CFR 223) and critical habitat was designated in 2009 (74 FR 52299; 10/09/09). Within the action area, critical habitat is designated in coastal areas (within 60 fathom depth) along parts of the southern side of the SJDF and northern PS. None of the net pens covered by the proposed GP are located within designated critical habitat. In the designation documents, the PS is called out as an occupied area possessing PBFs, however most of the PS (south of Port Townsend and east of Whidbey Island) is excluded from the designation for economic reasons. The ESA designation (50 CFR 223) states the following:

> *Observations of green sturgeon in PS are much less common compared to the other estuaries in Washington. Although two confirmed Southern DPS fish were detected there in 2006, the extent to which Southern DPS green sturgeon use PS remains uncertain. PS has a long history of commercial and recreational fishing and fishery-independent monitoring of other species that use habitats similar to*

those of green sturgeon, but very few green sturgeon have been observed there. In addition, PS does not appear to be part of the coastal migratory corridor that Southern DPS fish use to reach overwintering grounds north of Vancouver Island (internal citation omitted), thus corroborating the assertion that Southern DPS do not use PS extensively.

As described in the effects analysis (Section 2.5), we expect habitat effects of net pen operations to be localized to the immediate vicinity of net pens. Therefore, only anticipated effects of net pens that would potentially occur within designated critical habitat are associated with the movement of escaped sablefish into these areas, which although possible, is anticipated to be very unlikely. The PBFs for green sturgeon critical habitat (see 50 CFR 226.219) include:

- Coastal marine waters with adequate dissolved oxygen levels and acceptably low levels of contaminants (e.g., pesticides, PAHs, heavy metals that may disrupt the normal behavior, growth, and viability of sub-adult and adult green sturgeon).
- Abundant prey items for sub-adults and adults, which may include benthic invertebrates and fish.
- A migratory pathway necessary for the safe and timely passage of Southern DPS fish within estuarine habitats and between estuarine and riverine or marine habitats.

The PS region is not a spawning area for green sturgeon, but the species spends significant time in coastal regions of Washington and may use the action area for feeding and migration (Erickson and Hightower 2007; Lindley et al. 2008; Lindley et al. 2012; NMFS 2018c). However, it appears that only a small number migrate through the SJDF, with few documented within the Strait or PS (Erickson and Hightower 2007; Lindley et al. 2008; Lindley et al. 2012). Observations of green sturgeon in PS are much less common compared to the other estuaries in Washington, and monitoring data for tagged green sturgeon show few detections in PS (NMFS 2009). During over 1,700 bottom trawls conducted by WDFW between 1987 and 2011 in the PS and SJDF, including several sites within a mile of the Port Angeles site, only one green sturgeon was caught (WDFW 2012; P. Doukakis, personal communication, April 4, 2017).

As described in Section 2.5.3, we expect any measurable changes to water quality to be minor, localized, infrequent and of short duration. Any potential diminishment of water quality at the net pen sites (e.g., low DO) would not extend to green sturgeon designated critical habitat. We do not anticipate water quality conditions to be degraded to such a degree that Southern DPS green sturgeon that encounter net pens are harmed, particularly given their mobility and limited time spent in one localized area within the action area.

Effects on benthic conditions from benthic disturbance by net pens structures or by bio-deposits and other contaminants are expected to be highly localized and minor, and would not extend to Southern DPS green sturgeon critical habitat (see Section 2.5). We also do not expect any accumulation of toxic chemicals as a result of net pen operations that could harm Southern DPS green sturgeon. Effects of modified benthic conditions and toxics on this species critical habitat are discountable. Effects on the species would be insignificant if they are exposed due to the brevity of any such exposure.

Green sturgeon prey includes benthic invertebrates and fish, such as shrimp, clams, crabs, anchovies and sand lances (Moyle et al. 1995; Erickson et al. 2002; Moser and Lindley 2007; Dumbauld et al. 2008). Given the relatively small number of escaped fish likely to co-occur with and compete for forage with green sturgeon in the SJDF we expect no measurable effect on the abundance of these prey items (see Section 2.5). Thus we do not expect any measurable effect on the forage PBF of Southern DPS green sturgeon, nor effects on the species related to any change in prey abundance or quality. Therefore, we do not expect any measurable effects on habitat quality for Southern DPS green sturgeon, nor adverse effects on the species. Effects of prey reduction are discountable to this species' critical habitat, and insignificant if any individual is exposed, due to the brevity of any such exposure.

2.12.4 Southern DPS Eulachon and their Designated Critical Habitat

The southern DPS of eulachon was listed as threatened on March 18, 2010 (75 FR 13012) and critical habitat was designated on October 20, 2011 (76 FR 65323). Southern DPS eulachon migrate through the SJDF on their migrations to and from spawning grounds in the Fraser River in British Columbia, and the Elwha River in Washington (NMFS 2017b). The Elwha River is the only known spawning site in the action area, and also the only designated critical habitat within the action area. The river is approximately many miles from the nearest net pen sites. Eulachon occupy nearshore waters to approximately 1,000 feet in depth. Dealy and Hodes (2019) did extensive eulachon sampling on the Canadian side of the SJDF and found that Strait likely provides important year-round habitat for feeding and growth, as well as being a migration corridor.

Over the continental shelf, it is generally believed that eulachon stay at depth (approximately 100 to 200 meters deep) and rarely come to the surface. In the SJDF, Dealy and Hodes (2019) caught eulachon at depths of 81 to 227 meters, with the highest catch per unit effort at bottom depths of between 117 and 170 meters. However, as demonstrated during night-time surface trawls in the Columbia River plume, they may occur near the surface at natal river mouths and estuaries (Litz et al. 2014). Larval eulachon may also be distributed by prevailing currents in the action area, but would be most concentrated near natal river mouths and estuaries.

The PBFs for southern DPS eulachon critical habitat that may occur within the action area include:

- Freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation.
- Freshwater and estuarine migration corridors free of obstruction with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted.

Within the action area, critical habitat for southern DPS eulachon is only designated within the Elwha River. Because of the distance of the Elwha River from the net pen facilities, we anticipate that any potential effects would be a result of escaped rainbow trout/steelhead entering the Elwha River. We do not expect any water or sediment quality effects of commercial net pen operations in the Elwha River or near the river mouth in the SJDF. Because of the distance from net pen facilities, we do not expect any measurable effect on habitat conditions. All effects of the proposed action are discountable for eulachon critical habitat.

Because there are no natal streams in close proximity to the net pens, the occurrence of eulachon, either adult or juvenile, near the net pens is unlikely. Given their depth preference in marine waters, and the distance of their closest natal stream (Elwha River) from net pen sites, we do not expect any measurable effect of net pen facilities or operations on forage availability. Likewise, because of the distance of the Elwha River from net pens and eulachon preference for waters deeper than where the net pens are located, we consider exposure to localized degraded sediment or water quality conditions to be unlikely. We also do not expect water quality to be degraded to such a degree that any eulachon that do encounter net pens would be harmed. This is particularly true given their mobility and likely brief exposure to net pens that are located in shallower waters than where they typically occur. Therefore, we do not anticipate any adverse effects to the southern DPS of eulachon or their designated critical habitat. Any exposure among eulachon is expected to be so brief that responses are insignificant.

3. MAGNUSON–STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH (CFR 600.905(b)).

This analysis is based, in part, on the EFH assessment provided by the EPA and descriptions of EFH for Pacific Coast groundfish (Pacific Fishery Management Council [PFMC] 2005), coastal pelagic species (CPS) (PFMC 1998), and Pacific Coast salmon (PFMC 2014) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1. Essential Fish Habitat Affected by the Project

The environmental effects of the proposed action may adversely affect EFH for Pacific Coast salmon, Pacific Coast groundfish and coastal pelagic species EFH, all of which are present in the action area. The action area also contains Habitat Areas of Particular Concern (HAPC) for

Pacific Coast salmon and for Pacific Coast groundfish in marine areas. Impacts to EFH include benthic disturbance by structures, sediment quality degradation by bio-deposits and contaminants, and water quality degradation by bio-deposits, contamination and turbidity.

3.2. Adverse Effects on Essential Fish Habitat

The features of EFH of Pacific Coast salmon, Pacific Coast groundfish and coastal pelagic species would include diminishments in water quality, sediment quality, forage, and kelp which is a vegetation that serves as cover. These effects would occur within localized areas of PS to varying degrees.

As a result of tribal enhancement and federal research net pen operations, we anticipate the following habitat effects:

- Reductions in forage production from sediment quality degradation occurring as a result of bio-deposits and contaminants;
- Degraded water quality from bio-deposits, and contaminants;

3.3. Essential Fish Habitat Conservation Recommendations

NMFS determined that the following conservation recommendation is necessary to avoid, minimize, mitigate, or otherwise offset the impact of the proposed action on EFH.

1) Based on water quality, sediment quality and benthic condition monitoring results Modify operations as necessary to minimize habitat degradation.

Fully implementing this EFH conservation recommendation would protect, by avoiding or minimizing the adverse effects described in section 3.2, above, for Pacific Coast salmon, Pacific Coast groundfish and coastal pelagic species.

3.4. Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the EPA must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of the measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects [50 CFR 600.920(k)(1)].

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5. Supplemental Consultation

The EPA must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations [50 CFR 600.920(l)].

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion is the EPA. Other interested users could include permit applicants, citizens of affected areas, and others interested in the conservation of the affected ESUs/DPSs. Individual copies of this opinion were provided to the EPA. The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

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