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 Consultation No.:
WCRO-2019-00197
(**Previous NMFS No.: WCR-2018-9978**)

October 25, 2019

William D. Abadie
U.S. Army Corps of Engineers
Regulatory Branch, Portland District
P.O. Box 2946
Portland, Oregon 97208-2946

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Columbia River Bar Pilots 16th Street Moorage Dock Project (12th field HUC 170800060500; Baker Bay-Lower Columbia River), Clatsop County, Oregon (COE No.: NWP-2017-133)

Dear Mr. Abadie:

Thank you for your letter of June 7, 2018, 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 Columbia River Bar Pilots (CRBP) 16th Street Moorage Dock Project. The enclosed document contains a biological opinion (opinion) prepared by the NMFS pursuant to section 7(a)(2) of the Endangered Species Act (ESA) on the effects of the U.S. Army Corps of Engineers (COE) proposal to grant a permit, as authorized under sections 401 and 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act, for the CRBP to construct and operate a commercial vessel mooring facility in Clatsop County, Oregon.

In this opinion, NMFS concludes that the proposed action is not likely to jeopardize the continued existence of Lower Columbia River (LCR) Chinook salmon (*Oncorhynchus tshawytscha*), Snake River (SR) fall-run Chinook salmon, SR spring/summer run Chinook salmon, Upper Columbia River (UCR) Chinook salmon, Upper Willamette River (UWR) Chinook salmon, Columbia River (CR) chum salmon (*O. keta*), LCR coho salmon (*O. kisutch*), SR sockeye salmon (*O. nerka*), LCR steelhead (*O. mykiss*), Middle Columbia River (MCR) steelhead, UCR steelhead, Snake River Basin steelhead, UWR steelhead, southern designated population segment (DPS) of green sturgeon (*Acipenser medirostris*), southern DPS of eulachon (*Thaleichthys pacificus*) or result in the destruction or adverse modification of their designated critical habitats.

As required by section 7 of the ESA, NMFS is providing an incidental take statement with the opinion. The incidental take statement describes reasonable and prudent measures NMFS considers necessary or appropriate to minimize the impact of incidental take associated with this action. The take statement sets forth nondiscretionary terms and conditions, including reporting requirements, that the COE and the CRBP must comply with to carry out the reasonable and prudent measures. Incidental take from actions that meet these terms and conditions will be exempt from the ESA's prohibition against the take of listed species.

Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA)(16 U.S.C. 1855(b)) for this action. Therefore, we have included the results of that review in Section 3 of this document and include two 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 these recommendations.

If the response is inconsistent with the EFH conservation recommendations, the COE must explain why the recommendations will not be followed, including the scientific justification for any disagreements over the effects of the action and the recommendation. 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 request that in your statutory reply to the EFH portion of this consultation, you clearly identify if the conservation recommendations are accepted.

Please contact Scott Sebring, from the Oregon-Washington Coastal Office in Lacey, Washington at 360-753-9887 or scott.sebring@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: Danielle Erb, U.S. Army Corps of Engineers
Eric Campbell, Campbell Consulting

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

Columbia River Bar Pilots 16th Street Moorage Dock Project

NMFS Consultation Number: WCRO-2019-00197

Action Agency: U.S. Army Corps of Engineers, Portland District

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?
LCR Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	Yes	No
SR spring/summer Chinook salmon	Threatened	Yes	No	Yes	No
SR fall Chinook salmon	Threatened	Yes	No	Yes	No
UCR Chinook salmon	Endangered	Yes	No	Yes	No
UWR Chinook salmon	Threatened	Yes	No	Yes	No
CR chum salmon (*O. keta*)	Threatened	Yes	No	Yes	No
LCR coho salmon (*O. kisutch*)	Threatened	Yes	No	Yes	No
SR sockeye salmon (*O. nerka*)	Endangered	Yes	No	Yes	No
LCR steelhead (*O. mykiss*)	Threatened	Yes	No	Yes	No
Middle Columbia River steelhead	Threatened	Yes	No	Yes	No
SR basin steelhead	Threatened	Yes	No	Yes	No
UCR steelhead	Threatened	Yes	No	Yes	No
UWR steelhead	Threatened	Yes	No	Yes	No
southern designated population segment (sDPS) Pacific eulachon (*Thaleichthys pacificus*)	Threatened	Yes	No	Yes	No
sDPS green sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	Yes	No

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Yes	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: October 25, 2019

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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.), and implementing regulations at 50 CFR 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 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). A complete record of this consultation is on file at the Oregon/Washington Coastal Office in Lacey, Washington.

Updates to the regulations governing interagency consultation (50 CFR part 402) will become effective on October 28, 2019. Because this consultation was pending and will be completed prior to that time, we are applying the previous regulations to the consultation. However, as the preamble to the final rule adopting the new regulations noted, "[t]his final rule does not lower or raise the bar on section 7 consultations, and it does not alter what is required or analyzed during a consultation. Instead, it improves clarity and consistency, streamlines consultations, and codifies existing practice." Thus, the updated regulations would not be expected to alter our analysis.

1.2 Consultation History

On May 8, 2018 the COE contacted NMFS requesting consultation prior to granting a permit under its authorities as described in sections 401 and 404 of the Clean Water Act and section 10 of the Rivers and Harbors Act and requested consultation with NMFS to consult under section 7 of the ESA.

The COE proposed to have the action certified as compliant with the Standard Local Operating Procedures for Endangered Species (SLOPES) biological opinion (2011/05585). The COE proposed consultation for adverse effects to Lower Columbia River (LCR) Chinook salmon (*Oncorhynchus tshawytscha*), Snake River (SR) fall-run Chinook salmon, SR spring/summer run Chinook salmon, Upper Columbia River (UCR) spring-run Chinook salmon, Upper Willamette River (UWR) Chinook salmon, Columbia River (CR) chum salmon (*O. keta*), LCR coho salmon (*O. kisutch*), SR sockeye salmon (*O. nerka*), LCR steelhead (*O. mykiss*), Middle Columbia River (MCR) steelhead, UCR steelhead, Snake River Basin steelhead, UWR steelhead, southern designated population segment (DPS) of green sturgeon (*Acipenser medirostris*), southern DPS of eulachon (*Thaleichthys pacificus*) and their designated critical habitats:

- NMFS reviewed the action according to proposed design criteria as stipulated in SLOPES (2011/05585) and on May 21, 2018 suggested the applicant to offset adverse effects of the action by removing additional timber piles.
- On May 25, 2018 NMFS requested the applicant remove a total of 31 timber piles to offset adverse effects to designated critical habitat for 15 ESA-listed species.
- On May 29, 2018 the applicant declined to remove a total of 31 timber piles to offset adverse effects to designated critical habitat for 15 ESA-listed species.
- On June 6, 2018 NMFS wrote a letter to the COE stating that the proposed action was ineligible for certification under the SLOPES biological opinion (2011/05585) because it did not comply with mandatory offsets to adverse effects to designated critical habitat.
- On June 7, 2018 the COE sent a letter to NMFS requesting individual consultation under section 7 of the ESA for the installation of a marine berthing facility on the Columbia River in Astoria, Oregon.
- On June 8, 2018 the NMFS reviewed the information and initiated consultation.
- On September 19, 2018 the applicant requested a status update on completion of the biological opinion. The NMFS responded to the requested status update on September 28, 2018.
- On February 15, 2019 the COE sent a message to NMFS after a 35-day federal furlough requesting an estimated time for completion of the biological opinion.
- On February 20, 2019 the NMFS responded to the inquiry and estimated the priority, project status, and estimate for completing a draft biological opinion.
- On September 28, 2018 NMFS responded to the request.
- On May 28, 2019 the COE received a status request. The NMFS responded the following day.

1.3 Proposed Federal Action

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

The COE seeks to issue a permit under its authorities in section 404 of the Clean Water Act and section 10 of the Rivers and Harbors Act, for the Columbia River Bar Pilots (CRBP) to build a vessel mooring facility in the city of Astoria, Clatsop County, Oregon. The CRBP currently operates two 72-foot all-weather, high-speed vessels with full rollover and self-righting capability based out of moorage facilities in Astoria and Warrenton, Oregon. A biological assessment submitted by the CRBP's agent (Campbell Environmental) lists the following activities necessary to build a new facility to moor one of these vessels:

- Remove approximately 100 timber piles.
- Dredge a maximum of 200 cubic yards of sediment from the Columbia River to establish vessel access.

- Dredge up to 400 cubic yards of sediment for the following four years to maintain vessel access at a depth of -10 feet.
- Dispose of dredged sediments in the flow lane of the Columbia River in a location approximately 0.25 miles northwest of the construction location.
- Install 18 steel piles measuring between 16 and 18 inches in diameter.
- Install a 5-foot by 80-foot (400 square feet) aluminum walkway.

The CRBP proposes to install the vessel mooring facility as the sole owner and operator providing navigational assistance to large commercial oceangoing cargo vessels in and out of the Columbia River mouth. The proposed facility is located on the south bank of the Columbia River in the city of Astoria, Oregon at river mile (RM) 13 (Figure 1).

Figure 1. Photo of project area and areal extent of dredge prism at Columbia River, mile 13.

The CRBP proposes to dredge about 0.13 acres in the space where the vessel will be moored and maintain the edges of the prism at a 2:1 slope (Figure 2). The CRBP anticipates dredging approximately 200 cubic yards during the initial project construction (year one), and up to 400 additional cubic yards of sediment may be dredged over the course of the next four years (100 yards per year) in order to maintain a birth depth of -10 feet (MLLW). The CRBP proposes to remove sediment using a hydraulic or a mechanical dredge, and deposit the material into the deep water flow lane Columbia River at a location approximately 700 feet northwest of the construction site. Contractors are likely to complete dredging operations with days to several weeks, depending on the equipment available and unforeseen necessity of completing mechanical repairs or unfavorable weather conditions. Given the relatively small volume, it is likely that contractors will be able to complete sediment disposal operations within 30 minutes. The dredge material contains no chemical contaminants and was approved for in-water disposal by the Portland Sediment Evaluation Team (PSET).

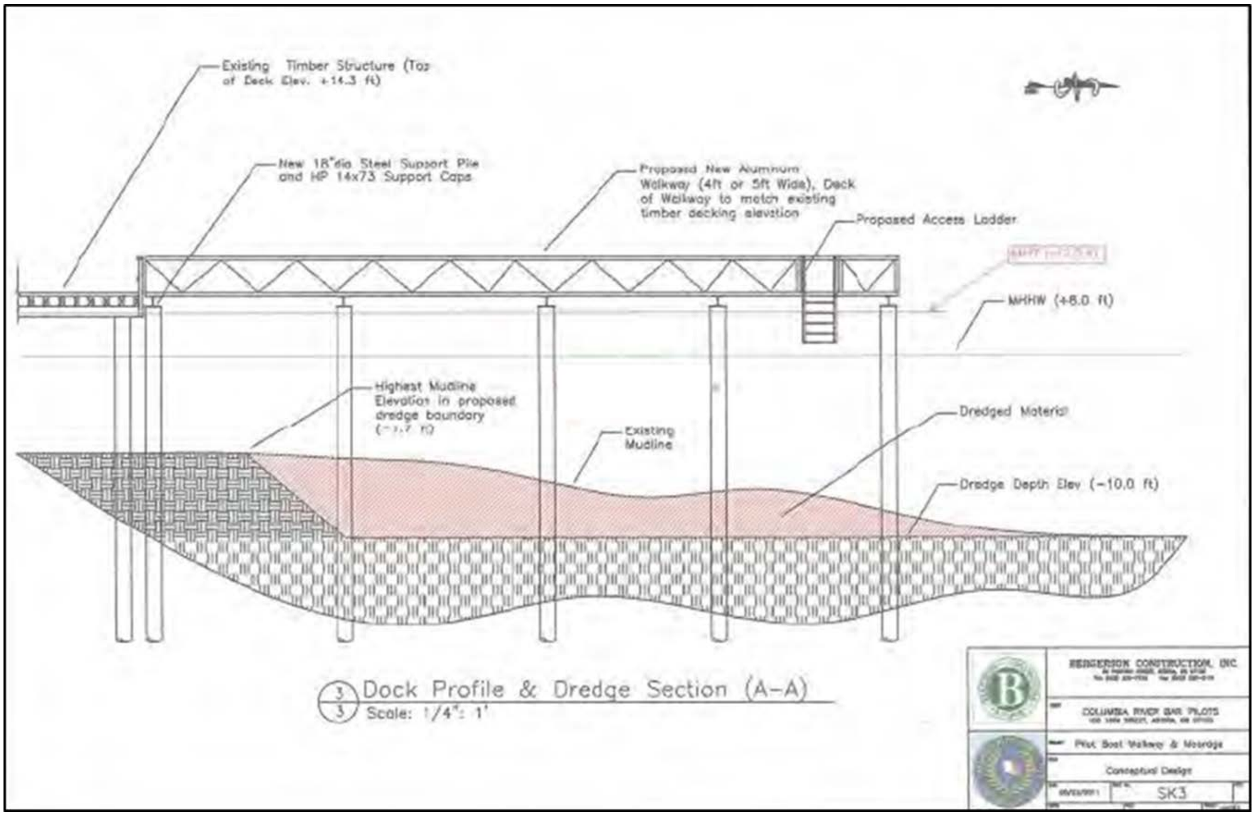

Figure 2. Proposed dredge prism.

The CRBP also proposes to remove 100 timber piles from the Columbia River, many of which are currently located in the footprint where the CRBP intends to dredge and moor its vessel (Figure 3). CRBP anticipates about 10-30 minutes will be necessary to remove each timber pile. No piles in this location are known to contain creosote-based chemical preservatives. However, the applicant proposes to surround the area with a surface boom to capture floating debris to minimize release of contaminants, if any are present.

Contractors anticipate 15-30 minutes necessary to install each new pile. Contractors estimate a total of 2-4 hours of pile driving each day, with installation being completed within 8-10 days. In total, CRBP estimates the proposed project will require approximately 2 to 4 weeks of in-water/over-water work to complete.

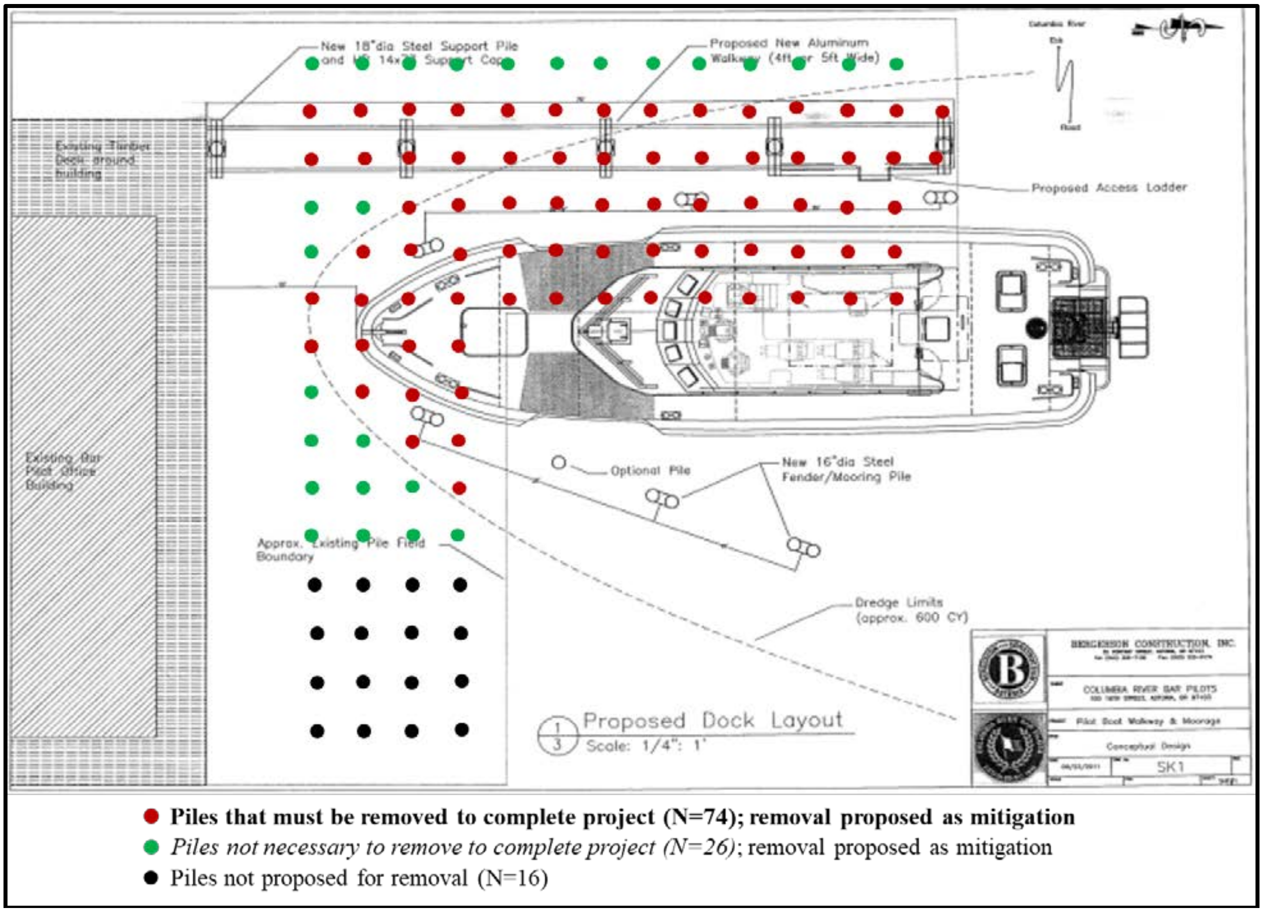

Figure 3. Piles proposed for removal and post-construction ramp placement and vessel moorage.

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02). Vessel operation is not identified as an interdependent action because the current location used by the CRBP for vessel moorage is about 0.25 miles of the proposed construction site and no change in vessel operations are proposed. Therefore, any potential interrelated or interdependent effects associated with vessel operation in the federal navigation channel are considered part of the Environmental Baseline and discussed in section 2.4.

The applicant proposes to use the following measures to minimize adverse effects on ESA-listed species and/or their designated critical habitats:

- All inwater construction will be conducted below the high mean tide will occur between November 1 and February 28 of the ODFW-preferred in-water work window.
- Heavy equipment (i.e., construction crane) will access the project site via existing roadways and floating barges.
- All pilings will be installed with a vibratory hammer.
- The applicant will minimize creosote release, sediment disturbance and resuspension.
- The applicant will install a floating surface boom to capture floating surface debris.

- All equipment (e.g., cable, vibratory hammer) used for pile removal will not enter the water.
- Inwater construction will be completed during low water and low river flow conditions.

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

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

The COE determined the proposed action is likely to adversely affect Lower Columbia River (LCR) Chinook salmon (*Oncorhynchus tshawytscha*), Snake River (SR) fall-run Chinook salmon, SR spring/summer run Chinook salmon, Upper Columbia River (UCR) spring-run Chinook salmon, Upper Willamette River (UWR) Chinook salmon, Columbia River (CR) chum salmon (*O. keta*), LCR coho salmon (*O. kisutch*), SR sockeye salmon (*O. nerka*), LCR steelhead (*O. mykiss*), Middle Columbia River (MCR) steelhead, UCR steelhead, Snake River Basin steelhead, UWR steelhead, southern designated population segment (DPS) of green sturgeon (*Acipenser medirostris*), southern DPS of eulachon (*Thaleichthys pacificus*) or their designated critical habitats.

2.1 Analytical Approach

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

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

The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ‘‘destruction or adverse modification’’ analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on October 28, 2019 [84 FR 44976]. This consultation was pending at that time, and we are applying the updated regulations to the consultation. As the preamble to the final rule adopting the regulations noted, “[t]his final rule does not lower or raise the bar on section 7 consultations, and it does not alter what is required or analyzed during a consultation. Instead, it improves clarity and, consistency, streamlines consultations, and codifies existing practice.” We have reviewed the information and analyses relied upon to complete this opinion in light of the updated regulations and conclude the opinion is fully consistent with the updated regulations.

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

- Identify the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an “exposure-response-risk” approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a RPA to the proposed action.

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species’ likelihood of both survival and recovery. The species status section also helps to inform the description of the species’ current “reproduction, numbers, or distribution” as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential PBFs that help to form that conservation value.

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). 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% 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. 2014). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB 2007; Mote et al. 2014). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

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 and Weitkamp 2013; Raymondi et al. 2013).

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

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. Acidification also impacts 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 the Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the essential physical and biological features of that habitat throughout the designated areas. These features are essential to the conservation of the ESA-listed species because they support one or more of the species' life stages (*e.g.*, sites with conditions that support spawning, rearing, migration and foraging).

For most salmon and steelhead, NMFS's critical habitat analytical review teams (CHARTs) ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation value they provide to each ESA-listed species that they support (NMFS 2005). The conservation rankings were high, medium, or low. To determine the conservation value of each watershed to species viability, the CHARTs evaluated the quantity and quality of habitat features, 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. Even if a location had poor habitat quality, it could be ranked with a high conservation value if it were essential due to factors such as limited availability, a unique contribution of the population it served, or is serving another important role.

For southern DPS green sturgeon, a team similar to the CHARTs — a critical habitat review team (CHRT) — identified and analyzed the conservation value of particular areas occupied by southern green sturgeon, and unoccupied areas necessary to ensure the conservation of the species (USDC 2009). The CHRT did not identify those particular areas using HUC nomenclature, but did provide geographic place names for those areas, including the names of freshwater rivers, the bypasses, the Sacramento-San Joaquin Delta, coastal bays and estuaries, and coastal marine areas (within 110 m depth) extending from the California/Mexico border north to Monterey Bay, California, and from the Alaska/Canada border northwest to the Bering Strait; and certain coastal bays and estuaries in California, Oregon, and Washington.

For southern DPS eulachon, critical habitat includes portions of 16 rivers and streams in California, Oregon, and Washington (USDC 2011). We designated all of these areas as migration and spawning habitat for this species.

A summary of the status of critical habitats, considered in this opinion, is provided in Table 1, below.

Table 1. Critical habitat, designation date, federal register citation, and status summary for critical habitat considered in this opinion.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Lower Columbia River Chinook salmon	9/02/05 70 FR 52630	Critical habitat encompasses 10 subbasins in Oregon and Washington containing 47 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some, or high potential for improvement. We rated conservation value of HUC5 watersheds as high for 30 watersheds, medium for 13 watersheds, and low for four watersheds.
Upper Columbia River spring-run Chinook salmon	9/02/05 70 FR 52630	Critical habitat encompasses four subbasins in Washington containing 15 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement. We rated conservation value of HUC5 watersheds as high for 10 watersheds, and medium for five watersheds. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Snake River spring/summer-run Chinook salmon	10/25/99 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers, and all tributaries of the Snake and Salmon rivers (except the Clearwater River) presently or historically accessible to this ESU (except reaches above impassable natural falls and Hells Canyon Dam). Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Upper Willamette River Chinook salmon	9/02/05 70 FR 52630	Critical habitat encompasses 10 subbasins in Oregon containing 56 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement. Watersheds are in good to excellent condition with no potential for improvement only in the upper McKenzie River and its tributaries (NMFS 2005). We rated conservation value of HUC5 watersheds as high for 22 watersheds, medium for 16 watersheds, and low for 18 watersheds.
Snake River fall-run Chinook salmon	10/25/99 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers, and all tributaries of the Snake and Salmon rivers presently or historically accessible to this ESU (except reaches above impassable natural falls, and Dworshak and Hells Canyon dams). Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Columbia River chum salmon	9/02/05 70 FR 52630	Critical habitat encompasses six subbasins in Oregon and Washington containing 19 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 16 watersheds, and medium for three watersheds.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Lower Columbia River coho salmon	2/24/16 81 FR 9252	Critical habitat encompasses 10 subbasins in Oregon and Washington containing 55 occupied watersheds, as well as the lower Columbia River and estuary rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 34 watersheds, medium for 18 watersheds, and low for three watersheds.
Snake River sockeye salmon	10/25/99 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers; Alturas Lake Creek; Valley Creek; and Stanley, Redfish, Yellow Belly, Pettit and Alturas lakes (including their inlet and outlet creeks). Water quality in all five lakes generally is adequate for juvenile sockeye salmon, although zooplankton numbers vary considerably. Some reaches of the Salmon River and tributaries exhibit temporary elevated water temperatures and sediment loads that could restrict sockeye salmon production and survival (NMFS 2015b). Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Upper Columbia River steelhead	9/02/05 70 FR 52630	Critical habitat encompasses 10 subbasins in Washington containing 31 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 20 watersheds, medium for eight watersheds, and low for three watersheds.
Lower Columbia River steelhead	9/02/05 70 FR 52630	Critical habitat encompasses nine subbasins in Oregon and Washington containing 41 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 28 watersheds, medium for 11 watersheds, and low for two watersheds.
Upper Willamette River steelhead	9/02/05 70 FR 52630	Critical habitat encompasses seven subbasins in Oregon containing 34 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. Watersheds are in good to excellent condition with no potential for improvement only in the upper McKenzie River and its tributaries (NMFS 2005). We rated conservation value of HUC5 watersheds as high for 25 watersheds, medium for 6 watersheds, and low for 3 watersheds.
Middle Columbia River steelhead	9/02/05 70 FR 52630	Critical habitat encompasses 15 subbasins in Oregon and Washington containing 111 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PCEs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of occupied HUC5 watersheds as high for 80 watersheds, medium for 24 watersheds, and low for 9 watersheds.
Snake River basin steelhead	9/02/05 70 FR 52630	Critical habitat encompasses 25 subbasins in Oregon, Washington, and Idaho. Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Southern DPS of green sturgeon	10/09/09 74 FR 52300	Critical habitat has been designated in coastal U.S. marine waters within 60 fathoms depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; tidally influenced areas of the Columbia River estuary from the mouth upstream to river mile 46; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor), including, but not limited to, areas upstream to the head of tide in various streams that drain into the bays, as listed in Table 1 in USDC (2009). The CHRT identified several activities that threaten the PCEs in coastal bays and estuaries and necessitate the need for special management considerations or protection. The application of pesticides is likely to adversely affect prey resources and water quality within the bays and estuaries, as well as the growth and reproductive health of Southern DPS green sturgeon through bioaccumulation. Other activities of concern include those that disturb bottom substrates, adversely affect prey resources, or degrade water quality through re-suspension of contaminated sediments. Of particular concern are activities that affect prey resources. Prey resources are affected by: commercial shipping and activities generating point source pollution and non-point source pollution that discharge contaminants and result in bioaccumulation of contaminants in green sturgeon; disposal of dredged materials that bury prey resources; and bottom trawl fisheries that disturb the bottom (but result in beneficial or adverse effects on prey resources for green sturgeon).
Southern DPS of eulachon	10/20/11 76 FR 65324	Critical habitat for eulachon includes portions of 16 rivers and streams in California, Oregon, and Washington. All of these areas are designated as migration and spawning habitat for this species. In Oregon, we designated 24.2 miles of the lower Umpqua River, 12.4 miles of the lower Sandy River, and 0.2 miles of Tenmile Creek. We also designated the mainstem Columbia River from the mouth to the base of Bonneville Dam, a distance of 143.2 miles. Dams and water diversions are moderate threats to eulachon in the Columbia and Klamath rivers where hydropower generation and flood control are major activities. Degraded water quality is common in some areas occupied by southern DPS eulachon. In the Columbia and Klamath river basins, large-scale impoundment of water has increased winter water temperatures, potentially altering the water temperature during eulachon spawning periods. Numerous chemical contaminants are also present in spawning rivers, but the exact effect these compounds have on spawning and egg development is unknown. Dredging is a low to moderate threat to eulachon in the Columbia River. Dredging during eulachon spawning would be particularly detrimental.

2.2.2 Status of the Species

Table 2, below provides a summary of listing and recovery plan information, status summaries and limiting factors for the species addressed in this opinion. More information can be found in recovery plans and status reviews for these species. Acronyms appearing in the table include DPS (Distinct Population Segment), ESU (Evolutionarily Significant Unit), ICTRT (Interior Columbia Technical Recovery Team), MPG (Multiple Population Grouping), NWFSC (Northwest Fisheries Science Center), TRT (Technical Recovery Team), and VSP (Viable Salmonid Population).

Table 2. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for each species considered in this opinion.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Lower Columbia River Chinook salmon	Threatened 6/28/05	NMFS 2013	NWFSC 2015	This ESU comprises 32 independent populations. Twenty-seven populations are at very high risk, 2 populations are at high risk, one population is at moderate risk, and 2 populations are at very low risk Overall, there was little change since the last status review in the biological status of this ESU, although there are some positive trends. Increases in abundance were noted in about 70% of the fall-run populations and decreases in hatchery contribution were noted for several populations. Relative to baseline VSP levels identified in the recovery plan, there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals.	Reduced access to spawning and rearing habitat Hatchery-related effects Harvest-related effects on fall Chinook salmon An altered flow regime and Columbia River plume Reduced access to off-channel rearing habitat Reduced productivity resulting from sediment and nutrient-related changes in the estuary Contaminant
Upper Columbia River spring-run Chinook salmon	Endangered 6/28/05	UCSRB 2007	NWFSC 2015	This ESU comprises four independent populations. Three are at high risk and one is functionally extirpated. Current estimates of natural origin spawner abundance increased relative to the levels observed in the prior review for all three extant populations, and productivities were higher for the Wenatchee and Entiat populations and unchanged for the Methow population. However, abundance and productivity remained well below the viable thresholds called for in the Upper Columbia Recovery Plan for all three populations.	Effects related to hydropower system in the mainstem Columbia River Degraded freshwater habitat Degraded estuarine and nearshore marine habitat Hatchery-related effects Persistence of non-native (exotic) fish species Harvest in Columbia River fisheries

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Snake River spring/summer-run Chinook salmon	Threatened 6/28/05	NMFS 2016	NWFSC 2015	This ESU comprises 28 extant and four extirpated populations. All expect one extant population (Chamberlin Creek) are at high risk. Natural origin abundance has increased over the levels reported in the prior review for most populations in this ESU, although the increases were not substantial enough to change viability ratings. Relatively high ocean survivals in recent years were a major factor in recent abundance patterns. While there have been improvements in abundance and productivity in several populations relative to prior reviews, those changes have not been sufficient to warrant a change in ESU status.	Degraded freshwater habitat Effects related to the hydropower system in the mainstem Columbia River, Altered flows and degraded water quality Harvest-related effects Predation

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Upper Willamette River Chinook salmon	Threatened 6/28/05	NMFS 2011	NWFSC 2015	This ESU comprises seven populations. Five populations are at very high risk, one population is at moderate risk (Clackamas River) and one population is at low risk (McKenzie River). Consideration of data collected since the last status review in 2010 indicates the fraction of hatchery origin fish in all populations remains high (even in Clackamas and McKenzie populations). The proportion of natural origin spawners improved in the North and South Santiam basins, but is still well below identified recovery goals. Abundance levels for five of the seven populations remain well below their recovery goals. Of these, the Calapooia River may be functionally extinct and the Molalla River remains critically low. Abundances in the North and South Santiam rivers have risen since the 2010 review, but still range only in the high hundreds of fish. The Clackamas and McKenzie populations have previously been viewed as natural population strongholds, but have both experienced declines in abundance despite having access to much of their historical spawning habitat. Overall, populations appear to be at either moderate or high risk, there has been likely little net change in the VSP score for the ESU since the last review, so the ESU remains at moderate risk.	Degraded freshwater habitat Degraded water quality Increased disease incidence Altered stream flows Reduced access to spawning and rearing habitats Altered food web due to reduced inputs of microdetritus Predation by native and non-native species, including hatchery fish Competition related to introduced salmon and steelhead Altered population traits due to fisheries and bycatch

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Snake River fall-run Chinook salmon	Threatened 6/28/05	NMFS 2017b	NWFSC 2015	This ESU has one extant population. Historically, large populations of fall Chinook salmon spawned in the Snake River upstream of the Hells Canyon Dam complex. The extant population is at moderate risk for both diversity and spatial structure and abundance and productivity. The overall viability rating for this population is 'viable.' Overall, the status of Snake River fall Chinook salmon has clearly improved compared to the time of listing and compared to prior status reviews. The single extant population in the ESU is currently meeting the criteria for a rating of 'viable' developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Dam complex.	Degraded floodplain connectivity and function Harvest-related effects Loss of access to historical habitat above Hells Canyon and other Snake River dams Impacts from mainstem Columbia River and Snake River hydropower systems Hatchery-related effects Degraded estuarine and nearshore habitat.
Columbia River chum salmon	Threatened 6/28/05	NMFS 2013	NWFSC 2015	Overall, the status of most chum salmon populations is unchanged from the baseline VSP scores estimated in the recovery plan. A total of 3 of 17 populations are at or near their recovery viability goals, although under the recovery plan scenario these populations have very low recovery goals of 0. The remaining populations generally require a higher level of viability and most require substantial improvements to reach their viability goals. Even with the improvements observed during the last five years, the majority of populations in this ESU remain at a high or very high risk category and considerable progress remains to be made to achieve the recovery goals.	Degraded estuarine and nearshore marine habitat Degraded freshwater habitat Degraded stream flow as a result of hydropower and water supply operations Reduced water quality Current or potential predation An altered flow regime and Columbia River plume Reduced access to off-channel rearing habitat in the lower Columbia River Reduced productivity resulting from sediment and nutrient-related changes in the estuary Juvenile fish wake strandings Contaminants

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Lower Columbia River coho salmon	Threatened 6/28/05	NMFS 2013	NWFSC 2015	Of the 24 populations that make up this ESU, 21 populations are at very high risk, 1 population is at high risk, and 2 populations are at moderate risk. Recent recovery efforts may have contributed to the observed natural production, but in the absence of longer term data sets it is not possible to parse out these effects. Populations with longer term data sets exhibit stable or slightly positive abundance trends. Some trap and haul programs appear to be operating at or near replacement, although other programs still are far from that threshold and require supplementation with additional hatchery-origin spawners .Initiation of or improvement in the downstream juvenile facilities at Cowlitz Falls, Merwin, and North Fork Dam are likely to further improve the status of the associated upstream populations. While these and other recovery efforts have likely improved the status of a number of coho salmon populations, abundances are still at low levels and the majority of the populations remain at moderate or high risk. For the Lower Columbia River region land development and increasing human population pressures will likely continue to degrade habitat, especially in lowland areas. Although populations in this ESU have generally improved, especially in the 2013/14 and 2014/15 return years, recent poor ocean conditions suggest that population declines might occur in the upcoming return years	Degraded estuarine and near-shore marine habitat Fish passage barriers Degraded freshwater habitat: Hatchery-related effects Harvest-related effects An altered flow regime and Columbia River plume Reduced access to off-channel rearing habitat in the lower Columbia River Reduced productivity resulting from sediment and nutrient-related changes in the estuary Juvenile fish wake strandings Contaminants

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Snake River sockeye salmon	Endangered 6/28/05	NMFS 2014	NWFSC 2015	This single population ESU is at very high risk dues to small population size. There is high risk across all four basic risk measures. Although the captive brood program has been successful in providing substantial numbers of hatchery produced fish for use in supplementation efforts, substantial increases in survival rates across all life history stages must occur to re-establish sustainable natural production In terms of natural production, the Snake River Sockeye ESU remains at extremely high risk although there has been substantial progress on the first phase of the proposed recovery approach – developing a hatchery based program to amplify and conserve the stock to facilitate reintroductions.	Effects related to the hydropower system in the mainstem Columbia River Reduced water quality and elevated temperatures in the Salmon River Water quantity Predation
Upper Columbia River steelhead	Threatened 1/5/06	UCSRB 2007	NWFSC 2015	This DPS comprises four independent populations. Three populations are at high risk of extinction while 1 population is at moderate risk. Upper Columbia River steelhead populations have increased relative to the low levels observed in the 1990s, but natural origin abundance and productivity remain well below viability thresholds for three out of the four populations. The status of the Wenatchee River steelhead population continued to improve based on the additional year’s information available for the most recent review. The abundance and productivity viability rating for the Wenatchee River exceeds the minimum threshold for 5% extinction risk. However, the overall DPS status remains unchanged from the prior review, remaining at high risk driven by low abundance and productivity relative to viability objectives and diversity concerns.	Adverse effects related to the mainstem Columbia River hydropower system Impaired tributary fish passage Degraded floodplain connectivity and function, channel structure and complexity, riparian areas, large woody debris recruitment, stream flow, and water quality Hatchery-related effects Predation and competition Harvest-related effects

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Lower Columbia River steelhead	Threatened 1/5/06	NMFS 2013	NWFSC 2015	This DPS comprises 23 historical populations, 17 winter-run populations and six summer-run populations. Nine populations are at very high risk, 7 populations are at high risk, 6 populations are at moderate risk, and 1 population is at low risk. The majority of winter-run steelhead populations in this DPS continue to persist at low abundances. Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to prior reviews. Summer-run steelhead populations were similarly stable, but at low abundance levels. The decline in the Wind River summer-run population is a source of concern, given that this population has been considered one of the healthiest of the summer-runs; however, the most recent abundance estimates suggest that the decline was a single year aberration. Passage programs in the Cowlitz and Lewis basins have the potential to provide considerable improvements in abundance and spatial structure, but have not produced self-sustaining populations to date. Even with modest improvements in the status of several winter-run DIPs, none of the populations appear to be at fully viable status, and similarly none of the MPGs meet the criteria for viability.	Degraded estuarine and nearshore marine habitat Degraded freshwater habitat Reduced access to spawning and rearing habitat Avian and marine mammal predation Hatchery-related effects An altered flow regime and Columbia River plume Reduced access to off-channel rearing habitat in the lower Columbia River Reduced productivity resulting from sediment and nutrient-related changes in the estuary Juvenile fish wake strandings Contaminants

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Upper Willamette River steelhead	Threatened 1/5/06	NMFS 2011	NWFSC 2015	This DPS has four demographically independent populations. Three populations are at low risk and one population is at moderate risk. Declines in abundance noted in the last status review continued through the period from 2010-2015. While rates of decline appear moderate, the DPS continues to demonstrate the overall low abundance pattern that was of concern during the last status review. The causes of these declines are not well understood, although much accessible habitat is degraded and under continued development pressure. The elimination of winter-run hatchery release in the basin reduces hatchery threats, but non-native summer steelhead hatchery releases are still a concern for species diversity and a source of competition for the DPS. While the collective risk to the persistence of the DPS has not changed significantly in recent years, continued declines and potential negative impacts from climate change may cause increased risk in the near future.	Degraded freshwater habitat Degraded water quality Increased disease incidence Altered stream flows Reduced access to spawning and rearing habitats due to impaired passage at dams Altered food web due to changes in inputs of microdetritus Predation by native and non-native species, including hatchery fish and pinnipeds Competition related to introduced salmon and steelhead Altered population traits due to interbreeding with hatchery origin fish
Middle Columbia River steelhead	Threatened 1/5/06	NMFS 2009b	NWFSC 2015	This DPS comprises 17 extant populations. The DPS does not currently include steelhead that are designated as part of an experimental population above the Pelton Round Butte Hydroelectric Project. Returns to the Yakima River basin and to the Umatilla and Walla Walla Rivers have been higher over the most recent brood cycle, while natural origin returns to the John Day River have decreased. There have been improvements in the viability ratings for some of the component populations, but the DPS is not currently meeting the viability criteria in the MCR steelhead recovery plan. In general, the majority of population level viability ratings remained unchanged from prior reviews for each major population group within the DPS.	Degraded freshwater habitat Mainstem Columbia River hydropower-related impacts Degraded estuarine and nearshore marine habitat Hatchery-related effects Harvest-related effects Effects of predation, competition, and disease

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Snake River basin steelhead	Threatened 1/5/06	NMFS 2016	NWFSC 2015	This DPS comprises 24 populations. Two populations are at high risk, 15 populations are rated as maintained, 3 populations are rated between high risk and maintained, 2 populations are at moderate risk, 1 population is viable, and 1 population is highly viable. Four out of the five MPGs are not meeting the specific objectives in the draft recovery plan based on the updated status information available for this review, and the status of many individual populations remains uncertain A great deal of uncertainty still remains regarding the relative proportion of hatchery fish in natural spawning areas near major hatchery release sites within individual populations.	Adverse effects related to the mainstem Columbia River hydropower system Impaired tributary fish passage Degraded freshwater habitat Increased water temperature Harvest-related effects, particularly for B-run steelhead Predation Genetic diversity effects from out-of-population hatchery releases
Southern DPS of green sturgeon	Threatened 4/7/06	NMFS 2018	NMFS 2015c	The Sacramento River contains the only known green sturgeon spawning population in this DPS. The current estimate of spawning adult abundance is between 824-1,872 individuals. Telemetry data and genetic analyses suggest that Southern DPS green sturgeon generally occur from Graves Harbor, Alaska to Monterey Bay, California and, within this range, most frequently occur in coastal waters of Washington, Oregon, and Vancouver Island and near San Francisco and Monterey bays. Within the nearshore marine environment, tagging and fisheries data indicate that Northern and Southern DPS green sturgeon prefer marine waters of less than a depth of 110 meters.	Reduction of its spawning area to a single known population Lack of water quantity Poor water quality Poaching

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Southern DPS of eulachon	Threatened 3/18/10	NMFS 2017	Gustafson et al. 2016	The Southern DPS of eulachon includes all naturally-spawned populations that occur in rivers south of the Nass River in British Columbia to the Mad River in California. Sub populations for this species include the Fraser River, Columbia River, British Columbia and the Klamath River. In the early 1990s, there was an abrupt decline in the abundance of eulachon returning to the Columbia River. Despite a brief period of improved returns in 2001-2003, the returns and associated commercial landings eventually declined to the low levels observed in the mid-1990s. Although eulachon abundance in monitored rivers has generally improved, especially in the 2013-2015 return years, recent poor ocean conditions and the likelihood that these conditions will persist into the near future suggest that population declines may be widespread in the upcoming return years	Changes in ocean conditions due to climate change, particularly in the southern portion of the species' range where ocean warming trends may be the most pronounced and may alter prey, spawning, and rearing success. Climate-induced change to freshwater habitats Bycatch of eulachon in commercial fisheries Adverse effects related to dams and water diversions Water quality, Shoreline construction Over harvest Predation

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 includes the physical, biological, and chemical extent of the action effects that are altered by the proposed action. In this case, the action area will extend 150 feet from all locations where new steel piles will be installed (i.e., threshold distance for sound pressure at 150dB). The spatial extent of effects within the construction area due to elevated sound pressure is about 1.75 acres and encompasses the extent of area affected by dredging and turbidity (Figure 4). In addition, the action area also includes an area located 700 feet to the northwest of the construction site where sediment disposal and high levels of turbidity will temporarily occur, an area of approximately 1 acre. The effects of the proposed action resulting from sound pressure (i.e., pile driving) and turbidity (sediment dredging and disposal) will not extend beyond these two zones. In total, these two sites comprise about 2.75 acres in area.

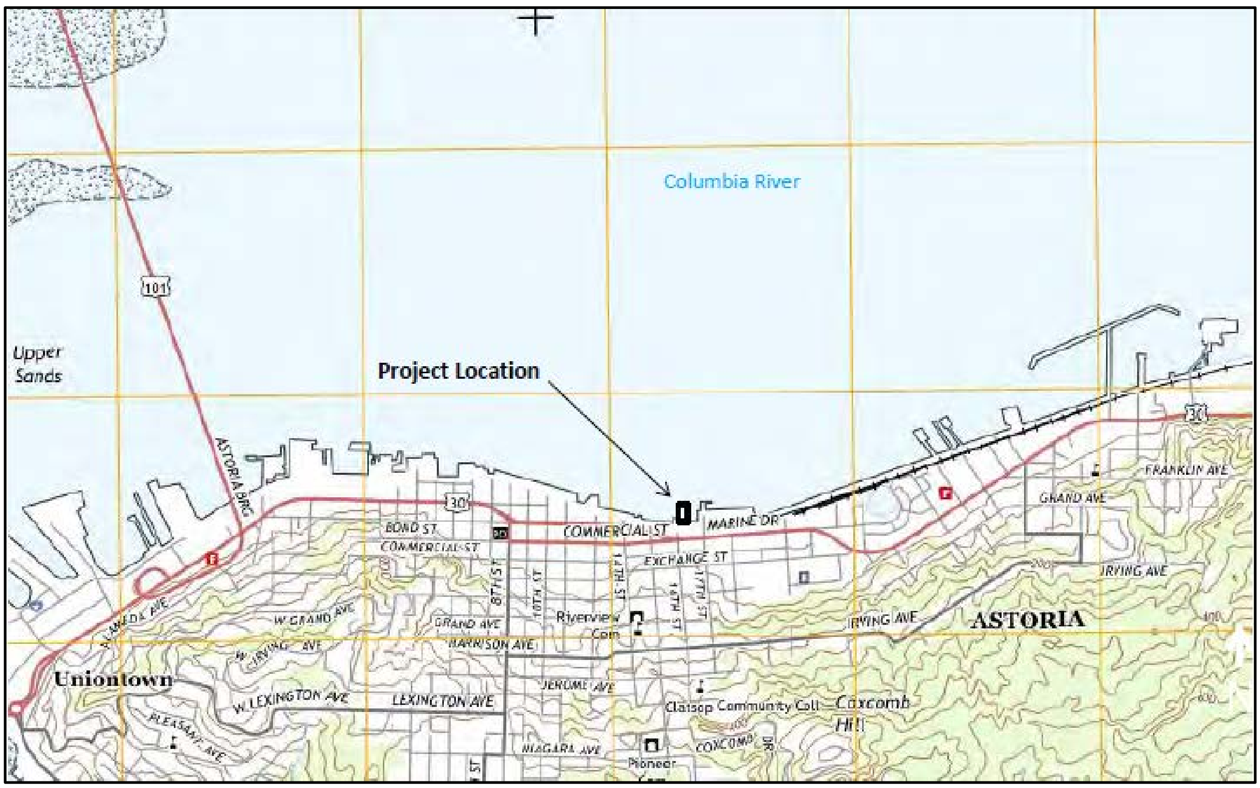

Figure 4. Vicinity Map with location of proposed vessel mooring facility.

2.4 Environmental Baseline

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

The CRBP plans full-time moorage for one vesses at the office building located at 100 16th Street, Astoria, Oregon (Figure 5). The current site conditions adjacent to the office building is characterized by dozens of dilapidated timber piles that were installed to support commercial cannery buildings on the Astoria waterfront. The exact date these piles were installed is not documented, but is known to pre-date use of creosote treatment (Campbell Environmental, personal communication, September 9, 2019).

Figure 5. Baseline conditions at the proposed construction site.

Status of the designated critical habitats in the Action Area

Habitat conditions within the action are characterized by high degradation of the physical and biological features necessary to support listed species. Apart from a thin strip of grass, shrubs, and occasional trees that can grow amidst the armored streambank there is virtually no riparian vegetation. The surrounding terrestrial landscape is developed for commercial and industrial use with extensive impervious surface, and lack of stormwater treatment prior to discharge into the Columbia River. Aquatic habitats are similarly degraded by historic waterfront development of commercial canneries that extended over shallow water areas to allow vessel moorage and cargo access. Dozens of piles are present within 5-100 feet from the shoreline, interrupting migratory pathways and shallow water rearing areas. Large buildings constructed within the past 50 years are ubiquitous, creating a patchwork of overwater structure that shades out benthic communities that would otherwise serve as prey for listed fishes. Shallow water areas contain more fine sediment, mud/silt substrate. Most of the streambank exposed to wave action is armored with rock riprap. Deep water portions of the action area where sediment disposal is proposed consist of predominantly coarse to medium sand. There is no submerged aquatic vegetation located either at the construction site or at the sediment disposal site.

Figure 6. Waterward view of existing conditions at the construction site.

Status of the species in the Action Area

The action area is used by 15 species of salmon and steelhead and by the sDPS of green sturgeon and the sDPS of eulachon. Because the action area is located in the lower five miles of the Columbia River, all populations of ESA listed species utilizing the Columbia River will be present in the action area during the construction period as either adults or juveniles. All populations of all species will also be present in the action area at some point during their life history, when they will experience the habitat conditions modified by the proposed action. The action area serves both migrating and rearing fishes.

Juvenile salmon are most abundant in the action area during one or two periods from late winter through summer, with lesser presence in the fall, as summarized on the Columbia River Research Data Access in Real Time website (http://www.cbr.washington.edu/dart). Juvenile sockeye salmon, or steelhead likely spend the least amount of time in the LCR. Various life history types of Chinook salmon and most chum salmon may remain in the LCR for longer periods, while they actively feed and grow before ocean entrance (Healey 1982; Thorpe 1994).

Most species of salmonids exhibit either a stream-maturing or ocean-maturing life history type during their first few months. Stream-type juvenile salmon and steelhead typically rear in upstream tributary habitats for over a year. These include LCR Chinook salmon (spring runs), LCR steelhead, LCR coho salmon, MCR steelhead, UWR steelhead, UWR Chinook salmon, SR spring/summer Chinook salmon, UCR Chinook salmon, SR steelhead, SR sockeye, and UCR steelhead. These fish tend to be 100 to 200 mm in size during migration through the action area. Species exhibiting a stream-type life history typically migrate as smolts, which migrate quickly downstream, and will pass through the action area within one to two days. Ocean-type juvenile salmon tend to move out of spawning streams and migrate towards the LCR estuary as subyearlings and are actively rearing within the Lower Columbia River. This includes LCR Chinook salmon (fall runs), CR Chum salmon, SR fall-run Chinook salmon, and UWR Chinook salmon that are smaller in size (less than 100 mm) and more likely to spend days to weeks in the action area foraging (Carter et al. 2009, McNatt et al. 2016, NMFS 2013; Schroeder et al. 2007; 2016). Juvenile salmonids species migrate through the action area at different rates and periods such that at any period one or more species of salmon or steelhead may be present (Dawley et al. 1986; Bottom et al. 2005; NMFS 2011c), with the most vulnerable species being those that occupy nearshore habitats for extended periods.

In addition to variations in outmigration timing, juvenile ESA-listed species also have a wide horizontal and vertical distribution in the CR related to size and life history stage. In general, juvenile salmonids will occupy the action area across the width of the river, and to average depths of up to 35 feet (Carter et al. 2009). Smaller-sized fish use the shallow inshore habitats and larger fish will use the channel margins and main channel. The pattern of use generally shifts between day and night (Dawley et al. 1986; Ledgerwood et al. 1990). Juvenile salmon typically occupy shallower waters during the day and deeper waters along the channel margins. Smaller subyearling salmonids will likely congregate along the nearshore areas in shallow water and extend into the channel margins (Bottom et al. 2011). Yet, as Carlson et al. (2001) indicated, there is higher use of the channel margins than previously thought and considering the parameters above, relative juvenile position in the water column suggests subyearling migrants occasionally use areas 20 to 30 feet deep as they migrate downstream.

Subyearling Chinook salmon extensively use nearshore habitat in the Lower Columbia River at depths to 0-10 feet for rearing and migration (Dawley et al. 1986; McCabe et al. 1986; Ledgerwood et al. 1990, Bottom et al. 2005). This primarily includes the following species: LCR Chinook salmon and SR fall Chinook salmon, because as previously noted Willamette River species enter the LCR downstream of the construction footprint. Dawley et al. (1986) estimated nearshore usage by subyearling Chinook salmon was 15 times greater than in the adjacent channel area in comparison to yearling Chinook salmon, coho salmon, and steelhead that were more often caught in deeper waters.

Adult salmonids from locations upriver of Bonneville Dam will be in the action area from early spring to early fall. Chinook salmon species returning to locations upstream of Bonneville Dam (i.e., SR spring/summer Chinook salmon, SR fall Chinook salmon, UCR spring Chinook salmon) migrate through the action area during the spring and early summer. Adult SR sockeye salmon migrate through the action area during late spring through late summer. Most adult salmonids are present in the action area and migrate through the action area within hours to days (Dawley et al. 1986; Matter and Sandford 2003). As salmonids grow and their swimming ability increases, their dependence on shallow nearshore habitat declines rapidly (Groot and Margolis 1991). Adult salmonids will typically be in the main river channel at depths of 10 to 20 feet below the water surface and off the bottom (Johnson et al. 2005).

The LCR Chinook salmon are classified as spring, fall, or late fall based on when adults return to fresh water. Spring-run adults enter the LCR from March through June, fall–run adults enter freshwater from August to September, and late-fall run adults enter the Columbia River from August to October (NMFS 2013). LCR coho salmon are typically categorized into early and late-returning stocks (NMFS 2013). Early-returning (Type S) adult coho salmon enter the Columbia River in mid-August and begin entering tributaries in early September, with peak spawning from mid-October to early November (NMFS 2013). Late-returning (Type N) coho salmon pass through the lower Columbia from late September through December and enter tributaries from October through January. Adult CR chum salmon are fall-run fish that enter fresh water from mid-October through November and spawn from early November to late December (LCFRB 2010). LCR steelhead are present from May through October (summer run) and December through May (winter run) (NMFS 2013). Other salmonid species that utilize the action area include UWR Chinook salmon and UWR steelhead. Adult UWR Chinook salmon appear in the action area during January, with fish entering the Clackamas River as early as March (NMFS 2011a). Adult UWR steelhead are present from mid-February to mid-May (NMFS 2011a).

Adult eulachon ascend large tributaries of the CR such as the Cowlitz, Elochoman, Grays, Kalama, Lewis, and Sandy rivers during late winter and spring (Smith and Saalfeld 1955; Gustafson 2010; NMFS 2016). It is not well known how long adults reside in the brackish ocean water mixing zone in the lower five miles of the Columbia River, but it is thought that eulachon migrate rapidly to their preferred spawning areas to avoid predator aggregations (Marston et al. 2002). Eulachon spawning aggregations can produce millions, if not hundreds of millions of eggs (Smith and Saalfeld 1955) as females produce 7,000 to 60,000 eggs each. Eulachon eggs are measure about one millimeter in diameter and have a sticky exterior covering that adheres to the substrate until larvae hatch and are rapidly transported downstream as free-floating drift (Parente and Snyder 1970). Eulachon regularly spawn in the Grays River, located about 10 miles upstream of the action area (Smith and Saalfeld 1955).

Green sturgeon are anadromous, spending one to three years in their natal river and estuaries as juveniles before entering the ocean. Southern DPS green sturgeon move north from natal tributaries in California to feed and rear in estuaries in the LCR estuary, Grays Harbor, and Willapa Bay during the summer through fall months when water temperatures in estuaries are at least 2° Celsius warmer than the ocean (Moser and Lindley 2007). These authors found sDPS green sturgeon were present in the Columbia River from May through October and frequently make extensive and rapid movements between and among estuaries. Green sturgeon are often found at depths greater than 20 feet where they consumed benthic-oriented prey that includes small fish, macrocrustaceans, and bivalves, amphipods, and *Neomysis* shrimp (Moser et al. 2014).

However, in intertidal estuaries, green sturgeon have been noted to move into relatively shallow water areas to feed on mudflats during high tide (Moser et al. 2014). Green sturgeon sub-adult fish are between 25 to 150 inches in length and adults are larger than 150 inches in length (NMFS 2018). Moser and Lindley (2007) reported observed adult fish in Willapa Bay were from about 4 to 6.5 feet in length. In general, sub-adult and adult green sturgeon are strong swimmers, and because they are tolerant of high levels of turbidity, individuals are often found foraging in turbid waters near dredging operations (Wilkens et al. 2015).

Green sturgeon adults and sub-adults use the estuary habitat to rear and take advantage of abundant benthic forage during the summer and early fall months (Moser and Lindley 2007; Moser et al. 2016). All species of sturgeons are noted to utilize highly turbid habitats where vision is limited. As cited by these authors, commercial catches of green sturgeon peak in October in the Columbia River estuary, and records from other estuarine fisheries (Willapa Bay and Grays Harbor, Washington) support the idea that sturgeon are only present in these estuaries from June until October. Furthermore, these Moser and Lindley (2007) note that green sturgeon move rapidly and cover long distances within the LCR and nearby estuaries such as Grays Harbor and Willapa Bay.

2.5 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b). Construction effects during pile extraction, pile installation, and initial of dredging and dredge disposal include 1) turbid conditions/water quality reduction, and 2) noise.

The effects of each episode of dredge and dredge disposal also include 3) reductions in benthic prey communities (abundance and species composition) and 4) disruption of migratory pathways, The effects of the new piles, pier, and moored vessel in being located in aquatic habitat are migratory obstruction (analyzed with construction effects on migration pathways) and 5) impaired rearing conditions due to shade and structures.

2.5.1 Effects to Critical Habitat

2.5.1.1 Salmonid Critical Habitat

The COE proposes to authorize CRBP to dredge a 0.13 acre of shallow water habitat in the LCR, dispose of dredged sediment in nearby deep water habitat, remove timber piles, and install new steel piles and an aluminum walkway. Within the action area, the physical and biological features (PBFs) of critical habitat 13 species of salmonids are:

- Freshwater rearing sites with: (i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; (ii) Water quality and forage supporting juvenile development; and (iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks;

- Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival;

- Estuarine areas free of obstruction and excessive predation with: (i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; (ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and (iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

1. Water Quality/Turbidity: Water quality is a PBF common to rearing, migration, and estuarine critical habitat areas for all both juvenile and adult life stages exhibited by the 13 species of salmonids in the action area. Water quality conditions will be degraded during sediment dredging and disposal activities, and to a lesser extent, pile removal and placement. The intensity of suspended sediment produced during dredging and disposal activities will impair water quality to sublethal levels as defined by the Newcombe and Jensen (1996) severity of ill effects model. These detrimental conditions will persist for the duration of in-water construction activities, and the subsequent dredging and disposal activities.

The total duration of in-water construction, and sediment dredging and disposal, is likely to require several weeks. Able et al. (2010) found that dredging increased turbidity, a measurement of water clarity, by as much as five times that of baseline levels while significantly increasing temperature and decreasing dissolved oxygen, but had no effect on salinity level. This is largely dependent on the dredging method used. During hydraulic dredging, the vast majority of sediment resuspension occurs near the point of sediment removal (i.e., at the cutterhead) (Herbich and Brahme 1991) because sediments are suctioned into the dredge and carried away via pipeline and do not enter the middle and upper water column. Operational dewatering and filtration equipment onboard the temporary sediment storage barge decrease the likelihood that effluent entering the river will carry noticeably higher levels of suspended sediment. If dewater and filtration equipment are not operational the overflow wastewater effluent may result increase the location and duration of the turbidity plume (Anchor Environmental 2003).

The proposed removal of 100 timber piles will also resuspend sediment during and immediately after each pile is removed. Observations reported by Weston Solutions (2006) noted turbidity levels produced during vibratory hammer operation in similar conditions yielded relatively low intensity sediment plumes that extended about 15-30 feet from the point of work. Weston Solutions (2006) noted that some vibratory hammer operation and pile extraction events caused no clear increase in turbidity, presumably due to local variation in sediment composition. Findings from this report suggest that elevated levels of suspended sediment generated during pile removal typically lasted from 5 to 10 minutes in duration and was primarily the result of agitation by the tugboat propeller during maneuvering of the equipment barge. In the case of the proposed action, the equipment barge will require a minimal amount of maneuvering because the piles are densely aggregated and the Columbia River is a large, fast moving river. This will result in low volumes of suspended sediment being rapidly transported downstream and remaining within a few feet of the sediment.

The effects on water quality from dredge material disposal will be significantly different than from in-water construction discussed above, because sediment will be dispersed throughout the 40 feet water column. This disposal method will result in a single pulse of suspended sediment that will persist for several minutes and extend several hundred feet (i.e., depending on tidal flow) from the disposal location. Although, it should be noted that nearly all of the sediment will rapidly cascade through the water column to the substrate within seconds, leaving only a small proportion of sediment suspended and transported downstream. The sediment disposal site is located within open water habitat, which is an area important for salmonids migration at both adult and juvenile life stages.

In terms of vertical distribution of suspended sediment, dredging and pile driving will disperse sediment within a few feet of the benthos. Given these activities are proposed to occur at depths of less than 15 feet, suspended sediment will not be distributed near the water surface. However, in-water sediment disposal will increase turbidity throughout the water column to extremely high levels that may cause injury such as gill abrasion, or even suffocation. The small volume of material, the medium to coarse grain composition of mainstem sediments, and the open water location of the placement site will combine to limit the duration of suspended sediment at adverse water quality levels to approximately 30 minutes after disposal activities have ceased.

<u>2. Noise</u>: The proposed use of dredging equipment and the vibratory hammer will create elevated sound pressure levels within a 150 foot radius surrounding the construction site. Each piece of equipment produces a different acoustic signature with varying effects of duration and intensity. Dickerson (2001) characterized 6 distinct intervals during operation of a clamshell bucket dredge in Alaska: 1) winch noise as the dredge derrick and bucket swing outward and the bucket is lowered; 2) a splash sound as the bucket penetrates the water surface followed by a sudden and often very intense impact sound as the bucket makes strikes the benthos; 3) a grinding sound is produced during closure of the bucket and dredged material is removed; 4) a snap or clank as the jaws of the bucket close; 5) winch noise as the bucket is raised to the surface and the derrick swings over the barge; 6) sound produced while material is dumped dropped on the barge deck. This series is repeated about once every 1 minute, with sound pressures from 124 decibels (dB) to 162 dB when measured more than 500 feet from the source (Dickerson 2001). In their reports on noise produced during cutterhead dredging both Clarke et al. (2002) and Robinson et al. (2011) found this dredging equipment ranged from 110 to 140 dB. The sound pressure threshold resulting in adverse effects to behavior of salmonids is 150 dB, a threshold at which is consistently exceeded during vibratory hammer installation of steel piles of nearly any size (Caltrans 2015; Popper and Hastings 2009; Popper et al. 2014). As a result, sound pressure thresholds will be exceeded primarily as a result of vibratory hammer operation. Because sound

can create effects in fish that impair both prey and predator detection, this condition degrades the habitat for both rearing and migrating life stages.

<u>3. Available Prey</u>: Forage, or prey species, is a feature of juvenile rearing and juvenile migration habitats. The proposed sediment dredging will result in the complete loss of benthic invertebrates that constitute forage items for salmonids at the juvenile life stage. Three types of benthic invertebrates tend to dominate main channel habitats in the Columbia River: *Turbellaria* (flatworms), *Oligochaeta* (annelids), *Corbicula fluminea* (bivalve clam), *Chironomid* larvae (midges), *Certaopongonidae* larvae, and *Corophium spp*. (McCabe et al. 1997). Other notable species that constitute benthic forage items for juvenile salmonids include *Corbicula fluminea* and *Certaopongonidae* larvae. Bolam (2011; 2012) described physical (e.g., organic carbon, sand content, placement depth, and tidal bed stress) and biological characteristics of benthic organisms (e.g., body size, fecundity, growth rate, and vertical migration ability) resulting in differential recovery rates of benthic invertebrates in response to dredge placements in a marine ecosystem. The generic response of benthic communities to physical stress is a gradual replacement of the benthic community by smaller-bodied, faster-growing taxa that are more adapted to survive in the disturbed environment (Pearson and Rosenberg 1978; Odum 1985; Rhoads and Germano 1986). Although a complete loss of benthic invertebrates will occur within the 0.13 acre vessel mooring footprint this reduction will persist for 3-6 months (McCabe et al. 1998) as the benthic invertebrates recolonize exposed sediments.

Disposal of dredged sediments in deep water habitats will cover and suffocate benthic invertebrates. The total amount of area affected by sediment disposal will be significantly larger than that affected by dredging due to the amount of area in which sediment may be dispersed. This is due to site-specific sediment composition within shallow waters at the construction site (i.e., primarily coarse to medium sand and low percentage of fine-grained sediments) in addition to the method of sediment disposal whereby material is dispersed over a larger area by river flow as it as it passes through the water column. Based on sediment composition, quantity of sediment required for disposal, and prevailing river flow conditions at the disposal site the amount of benthic habitat altered by sediment placement is about 1.0 acre.

Bollam (2011) reported some benthic invertebrate species had low survival rates when covered by 2 or more inches of sediment. This author also found only one species had the ability to migrate when covered with more than 6 inches of sediment, although this was more or less restricted to dredge sediments with low organic content. Thus, the effect on temporarily degrading species abundance and diversity with the benthic invertebrate community is likely to occur. Strong currents in this location of the river are likely to disperse and redistribute disposed sediments away from the disposal site and attenuate effects on the benthic invertebrate community. Due to the proposed repeated needs for dredging and disposal on an annual basis, the effects associated with these activities (i.e., degraded water quality and reduced benthic forage) will occur each year and create two relatively small areas that may favor smaller-bodied rapidly-colonizing benthic invertebrate species (Odum 1985).

<u>4. Migratory Pathway</u>: Safe passage is an essential feature of rearing and migratory habitat for all 13 species of salmonids as fish rear in the LCR prior to ocean entry and as they return to access spawning tributaries. Operating dredging and pile driving equipment will degrade safe passage

conditions by creating a risk of entrainment and elevated sound pressure. CRBP proposes to use a hydraulic dredge that uses a cutterhead to agitate and loosen sediment that is drawn through a pipe as a water/sediment slurry mixture or a clamshell bucket that grabs sediment. Regardless of the equipment used by CRBP there is a risk that fish may become drawn into the suction pipe or struck or enclosed by the clamshell bucket. In both cases the proposed dredging will degrade safe passage conditions for salmonids, particularly at the juvenile life stage. Kjelland et al. (2015) report migratory behavior changes as follows: "Carlson et al. (2001) documented the behavioral responses of salmonids to dredging activities in the Columbia River using hydroacoustics. During dredging operations, out-migrating salmon smolt (*Oncorhynchus spp*., likely fall-run Chinook salmon and coho salmon) behavioral responses ranged from (1) salmon orienting to the channel margin move inshore when encountering the dredge, (2) most out-migrating salmon passing inshore moved offshore upon encountering the discharge plume, and (3) out-migrating salmon were observed to assume their prior distribution trends within a short time after encountering both the dredging activity and dredge plume (as cited in Carlson et al. 2001)." These behaviors indicate that the disturbance caused by the equipment and the dredge plume each are factors contributing to degradation of the migratory pathway.

5. Rearing Habitat/Shade and Structure: In addition to the temporary effects related to construction CRBP's proposed installation of the aluminum access ramp and steel piles will create shade and localized hydraulic microhabitats that degrade the functioning of rearing and migratory habitat. Nightingale and Simenstad (2001) and Carrasquero (2001) found that changes to light caused by presence of piles and other overwater structures affect the behavior of salmon. Salmon fry have been seen avoiding travel under docks and piers during daylight hours. As small fish move away from the shore, they become subject to attack by larger predators that typically stay in deeper waters. Tabor et al. (2011) found that juvenile salmonids were commonly found within about 15 feet of overwater structures, but were rarely found under overwater structures, suggesting the PBFs directly below the overwater structures were less desirable or less conducive to salmon habitat. Several researchers noted that presence of inwater and overwater structures created microhabitats for predatory species of salmonids (Carrasquero 2001; Kahler et al. 2000; Rondorf et al. 2010; Tabor et al. 2011). Others report result the installation and subsequent permanently altered habitat by presence of piles redistributes sediments that permanently modifies substrate bathymetry (WDOE 2011). Piles reduce space for fish to swim; cast shade, affecting light; catch floating debris, affecting light and habitat. In many cases piles host a community of sessile organisms, resulting in shell hash on the substrate that affects habitat. As such, the presence of inwater and overwater structure will permanently degrade the value of critical habitat for safe passage in addition to rearing and migratory features of critical habitat.

2.5.1.2 Green Sturgeon Critical Habitat

The proposed action area is also located in designated critical habitat for sDPS green sturgeon. At this location the physical and biological features (PBFs) of critical habitat support the following life stages for sDPS of green sturgeon:

- Food resources. Abundant prey items within estuarine habitats and substrates for juvenile, subadult, and adult life stages. Prey species for juvenile, subadult, and adult green sturgeon within bays and estuaries primarily consist of benthic invertebrates and fishes, including crangonid shrimp, burrowing thalassinidean shrimp (particularly the burrowing ghost shrimp), amphipods, isopods, clams, annelid worms, crabs, sand lances, and anchovies. These prey species are critical for the rearing, foraging, growth, and development of juvenile, subadult, and adult green sturgeon within the bays and estuaries.

- Water quality. Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages. Suitable water temperatures for juvenile green sturgeon should be below 24 °C. At temperatures above 24 °C, juvenile green sturgeon exhibit decreased swimming performance (Mayfield and Cech 2004) and increased cellular stress (Allen et al. 2006). Suitable salinities range from brackish water (10 parts per thousand) to salt water (33 parts per thousand). Juveniles transitioning from brackish to salt water can tolerate prolonged exposure to salt water salinities, but may exhibit decreased growth and activity levels and a restricted temperature tolerance range (Allen and Cech 2007; Sardella et al. 2008), whereas subadults and adults tolerate a wide range of salinities (Kelly et al. 2007). subadult and adult green sturgeon occupy a wide range of dissolved oxygen levels, but may need a minimum dissolved oxygen level of at least 6.54 milligrams oxygen per liter (Kelly et al. 2007; Moser and Lindley 2007). As described above, adequate levels of dissolved oxygen are also required to support oxygen consumption by juveniles (ranging from 61.78 to 76.06 milligrams oxygen per liter kg/1) (Allen and Cech 2007). Suitable water quality also includes water with acceptably low levels of contaminants (e.g., pesticides, polyaromatic hydrocarbons, elevated levels of heavy metals) that may disrupt the normal development of juvenile life stages, or the growth, survival, or reproduction of subadult or adult stages.

- Migratory corridor. A migratory pathway necessary for the safe and timely passage of green sturgeon within estuarine habitats and between estuarine and riverine or marine habitats. We define safe and timely passage to mean that human-induced impediments, either physical, chemical, or biological, do not alter the migratory behavior of the fish such that its survival or the overall viability of the species is compromised (e.g., an impediment that compromises the ability of fish to reach thermal refugia by the time they enter a particular life stage). Unimpeded passage is necessary for adult and subadult green sturgeon to access feeding areas, holding areas, and thermal refugia, and to ensure passage back out into the ocean.

- Water depth. A diversity of depths necessary for shelter, foraging, and migration of juvenile, subadult, and adult life stages. Subadult and adult green sturgeon occupy a diversity of depths within bays and estuaries for feeding and migration. Tagged adults and subadults within the San Francisco Bay estuary primarily occupied waters over shallow depths of less than 10 m, either swimming near the surface or foraging along the bottom (Kelly et al. 2007). In a study of juvenile green sturgeon in the Delta, relatively large numbers of juveniles were captured primarily in shallow waters from 1–3 meters deep, indicating juveniles may require even shallower depths for rearing and foraging (Radtke 1966). Thus, a diversity of depths is important to support different life stages and habitat uses for green sturgeon within estuarine areas.

- Sediment quality. Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages. This includes sediments free of elevated levels of contaminants (e.g., selenium, polyaromatic hydrocarbons, and pesticides) that can cause adverse effects on all life stages of green sturgeon.

Migratory Pathway: CRBP's proposed action will create a risk to safe passage conditions for green sturgeon from entrainment, burial during sediment disposal, and elevated sound pressure. Degraded safe passage conditions from entrainment will occur within the 0.13-acre footprint and will persist for days to weeks. Sediment disposal will occur within the 0.25-acre flow lane deposition area once each year and will be brief (e.g., less than 30 minutes). However, as previously noted, depending on the volume of material and river flow conditions at the time of disposal as much as one acre may be adversely affected by dispersal of suspended sediment. Elevated sound pressure levels caused by pile installation will degrade safe passage conditions within 150 feet from construction area.

Food Resources: The proposed sediment dredging will temporarily reduce the abundance of benthic invertebrates causing degraded foraging conditions for green sturgeon for a period of 3-6 months (McCabe et al. 1997; 1998) during the late fall and winter months. Sediment disposal destroys benthic invertebrates if they are buried by large volumes of material in areas where flows do not rapidly disperse sediments (Bolam 2012). These conditions regularly occur in the mainstem LCR when tides change. Therefore, the abundance of benthic invertebrates destroyed may vary considerably.

Water Quality/Turbidity: Sturgeon are adapted to turbid conditions, and the degradation of water quality by suspended sediment is not detrimental to this species' critical habitat.

Noise: Initial studies by Popper (2005) suggest that sturgeon may be able to detect sounds from below 100 Hz to perhaps 1,000 Hz. However, the author did not establish thresholds indicating physiological responses resulting in harm or injury. The results do suggest, however, that sturgeon may be able to localize sound (determine the direction from which it comes) but data are very limited. It is uncertain if sound produced at any phase of the proposed action would render critical habitat less suitable for sturgeon presence.

2.5.1.3 Eulachon Critical Habitat

At this location, critical habitat supports physical and biological features (PBFs) for freshwater and estuarine migration corridors of larval and adult life stages of the sDPS of eulachon listed below:

- Migratory Corridor: Safe and unobstructed migratory pathways for eulachon adults to pass from the ocean through estuarine areas to riverine habitats in order to spawn, and for larval eulachon to access rearing habitats within the estuaries and juvenile and adults to access habitats in the ocean. Lower reaches of larger river systems (e.g., the Columbia River) are used as migration routes to upriver or tributary spawning areas. Outmigrating larval eulachon are distributed throughout the water column in some rivers (e.g., the Fraser River) but are more abundant in mid-water and bottom portions of the water column in others (e.g., the Columbia River; Smith and Saalfeld, 1955, Howell et al. 2001).

- Flow: A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of freshwater discharge over time) that supports spawning migration of adults and outmigration of larval eulachon from spawning sites. Most eulachon spawning rivers experience a spring freshet (Hay and McCarter 2000) that may influence the timing of spawning adult migration. In general, eulachon spawn at low water levels before spring freshets (Lewis et al. 2002). In the Kemano River water velocity greater than 0.4 meters per second (1.3 meters per second) begins to limit upstream movements (Lewis et al. 2002).

- Water Quality: Water quality suitable for survival and migration of spawning adults and larval eulachon. Adult eulachon can take up and store pollutants from their spawning rivers, despite the fact that they do not feed in fresh water and remain there only a few weeks (Rogers et al. 1990, WDFW and ODFW 2001). Eulachon avoid polluted waters when possible (Smith and Saalfeld 1955).

- Water Temperature: Water temperature suitable for survival and migration. Eulachon run timing may be influenced by water temperature (Willson et al. 2006) and high water temperatures can increase adult mortality (Blahm and McConnell 1971). Given the range of temperatures that eulachon spawn in throughout their range, Langer et al. (1977) suggested that the contrast between ocean and river temperatures might be more critical than absolute river or ocean temperatures.

- Food: Prey resources to support larval eulachon survival. Eulachon larvae need abundant prey items (especially copepod larvae; Hart 1973) when they begin exogenous feeding after the yolk sac is depleted. The eulachon yolk sac can be depleted between 6 and 21 days after hatching (Howell 2001), and larvae may be retained in low salinity, surface waters of the natal estuary for several weeks or longer (Hay and McCarter 2000), making this an important component in migratory corridor habitat.

Migratory Corridor: The proposed action will degrade safe passage through the migratory corridor that is used by eulachon at the egg, larval, and adult life stages. The mainstem portion of the river, including deep water and shallow water habitats are important for eulachon at the egg, larval, and adult life stages. The effects will occur due to risks from entrainment, elevated sound pressure, and sediment burial that are similar to those to other species described above.

Water Quality/Turbidity: In-water construction activities will also increase turbidity, causing temporary degradation to water quality. The mechanisms of exposure (i.e., dredging, inwater sediment disposal, pile driving) are the same as those described above for other species.

Food Resources: Larval eulachon begin feeding on free-floating plankton such as copepod nauplii (Barraclough 1967; Robinson et al. 1968) once they grow to about 5-8 millimeters in length and the yolk sac is nearly, or completely absorbed. Adult eulachon do not exhibit feeding upon entry into freshwater, as they absorb minerals from scales and teeth during the onset of the spawning migration (Cambria Gordon LTD 2006)As such, the proposed action will not reduce food resources for eulachon at either life stage.

2.5.2 Effects on ESA-Listed Species

Based on migratory behavior described in section 2.4, species migrating through the action area to the ocean as juveniles or to upstream spawning areas as adults will have potential exposure to the proposed actions. Effects from the action on species is based on exposure to the effects occurring to the fish themselves, or experienced by fish as a result of habitat changes, as described above, plus one direct effect on fish. Those effects are exposure to:

1. Suspended sediment/water quality diminishment from dredging, sediment disposal, and pile removal
2. Noise/Elevated sound pressure
3. Loss of benthic forage
4. Modified migration and rearing habitats (salmonids only)
5. Dredging entrainment

Effects to salmon and steelhead
Based on the timing of actions discussed in section 1.3, it is reasonably certain that all 13 species of salmonids will be present in the action area during the proposed construction and/or be exposed to altered critical habitat. Co-occurrence with habitat conditions described above may result in adverse effects at either the juvenile and/or adult life stage. Species that are reasonably likely to be present in the action area at the adult life stage include: LCR Chinook salmon, LCR coho salmon, CR chum salmon, and UWR steelhead. Species that are reasonably likely to be present in the action area at the juvenile life stage include: all five species of Chinook salmon, LCR coho salmon, CR chum salmon, and LCR steelhead. However, because adverse effects on PBFs of critical habitat will persist after construction actions are completed all species are reasonably likely to be exposed to lingering adverse conditions resulting from the proposed action.

1. Exposure and response-suspended sediment. Dredging, sediment disposal, and pile removal and installation will occur for several weeks. These activities will redistribute suspended sediment to varying degrees as noted above in the effects to critical habitat, section 2.5.2. With the exception of in-water sediment disposal, increased levels of suspended sediment will generally be limited with a few feet of the river bottom.

Adult salmonids typically migrate through the LCR in open water 10 to 20 feet from the water surface (Johnson et al. 2005) and are not within close proximity to the shoreline. As such they are unlikely to swim within close proximity to the construction site and be exposed to elevated levels of suspended sediment generated by dredging and pile installation or removal. Because adult salmonids are strong swimmers that are relatively tolerant of increased levels of suspended sediment (Servizi and Martens 1991; 1992) these individuals are unlikely to be exposed to levels of suspended sediment considered adverse. Due to their increased tolerance of turbid conditions, adult salmonids that do experience increased levels of suspended sediment are likely to exhibit only behavioral effects such as alarm reaction and avoidance that do not result in adverse effects associated with reduced growth or fitness (Newcombe and Jensen 1996). Bisson and Bilby

(1982) found that salmonids are able to detect and distinguish turbidity and other water quality gradients.

The amount and intensity of exposure experienced by adult fish will likely result in no more than a slight alteration in migratory path away from the shoreline before individuals find refuge and/or passage conditions within unaffected adjacent areas. A few individuals may be exposed to high levels of suspended sediment during dredge material disposal operations resulting in harassment and/or harm. Adult fish are able to avoid high suspended sediment conditions and therefore will otherwise avoid more severe exposure. To the extent that any adults are exposed to turbidity generated by project activities, they are expected to respond by avoiding excessively turbid conditions and find passage within unaffected adjacent areas. Specifically, we expect adult salmonids will be present several hundred feet to the north of the construction site where suspended sediment levels are low and inconsistent with any adverse effect (Newcombe and Jensen 1996).

Species are typically less tolerant of increased levels of suspended sediment at early life stages (Newcombe and Jensen 1996). Juvenile salmonids will experience degraded rearing and migratory conditions near the construction area and the sediment disposal location. Although juveniles may experience a reduction in predation from piscivorous fish and birds by occupying turbid waters (Gregory and Levings 1998) chronic exposure to these conditions can cause physiological stress responses that can increase maintenance energy needs and reduce feeding and growth (Lloyd 1987; Redding et al. 1987; Servizi and Martens 1991; Newcombe and Jensen 1996). There is greater likelihood that juvenile salmonids will be exposed to increased levels of suspended sediment due to their slower swimming speed and increased use of shallow water habitats where the majority of suspended sediment will be generated.

Although the different aspects of construction will generate suspended sediment for several weeks it is extremely unlikely that individual salmonids at the juvenile life stage will be exposed to degraded water quality conditions for more than a few hours. This will result in a short-term reduction in growth and fitness of a small number of individuals. Smaller, ocean-type subyearling migrants (e.g., LCR Chinook salmon, SR fall Chinook salmon, and UWR Chinook salmon) that rear in the LCR will be more likely to experience adverse effects than larger, stream-type yearling migrants (UCR Chinook salmon, SR spring/summer Chinook salmon, LCR coho salmon, and yearling migrants of UWR Chinook salmon).

The limited spatial extent of turbid conditions will cause some fish to avoid the construction site and seek refuge elsewhere. This will likely reduce growth, lipid stores, and ultimately fitness and survival in a small number of juvenile fish. Species most likely to be exposed to the turbidity plume include fall migrants, such as LCR Chinook salmon, LCR coho salmon, SR fall Chinook salmon, and UWR Chinook salmon (subyearling migrants).

2. Exposure and response-sound pressure. The proposed action will result in underwater noise created by pile driving and vessel operation. The NMFS estimates acoustic threshold distances experienced by fish are summarized below and based upon application of the practical spreading loss model and empirical sound attenuation formula described in Caltrans (2015). The onset of physical injury to juvenile fishes (i.e., individuals less than 2 grams) will extend about 150 feet from the point of installation. The CRBP proposes to conduct pile driving during the fall, which will reduce the abundances and life stages of species exposed.

Adverse effects caused by elevated sound pressures vary from temporary decreased hearing sensitivity consistent with of reduced fitness, growth and reproductive, to immediate injury or death (Popper and Hastings 2009; Stadler and Woodbury 2009). Even fish exposed to underwater noise not leading to immediate death may exhibit latent, sub-lethal effects (Caltrans 2015). Injuries to capillaries and soft tissues may heal after a short period, or lead to a slow death (e.g., breakdown of tissues in some organ system). Injuries may also result in temporary or permanent hearing loss, movement of fish away from feeding grounds, and increased vulnerability to predators, reduction or elimination of the ability to locate prey, inability to communicate, and inability to sense the physical environment (Caltrans 2015). Furthermore, although initial responses may include changes in swimming behavior, orientation, and startle reactions fish may not perceive the origin of sound (Pearson et al. 1992; Wardle et al. 2001; Hassel et al. 2004) and habituate to continuously repeated sounds produced at levels causing injury (Popper et al. 2014).

Species known to be present in the action area at the time of pile driving, particularly those that rear in the LCR for extended periods are most likely to be injured from pile driving. This includes all five species of Chinook salmon, LCR coho salmon, CR chum salmon, and LCR steelhead. Due to the orientation away from the shoreline during migration it is very unlikely that salmonids will be exposed at the adult life stage. The main channel of the CR within the action area is about 4 miles wide. Because the effects and intensity of pile driving will be greatest within shallow water nearshore habitat a distance of 150 feet of the Oregon shoreline species exposed to sound pressure causing injury within 150 feet limits the potential exposure to salmonids at the juvenile life stage. Juvenile salmonids exposed to elevated sound pressures will respond by exhibiting increased heart rate and elevated cortisol levels that may interrupt normal rearing and migratory activities (Wysocki et al. 2006).

Species at greatest risk of exposure to effects related to pile driving are those exhibiting ocean type life histories with slower migration rates that rear within the LCR for extended periods during the late fall. This includes five species of Chinook salmon, LCR coho salmon, CR chum salmon, and LCR steelhead. Adult CR chum salmon and LCR coho salmon as discussed above, will be present in the action area, but more likely to migrate through the mid-channel (Carter et al. 2009) and not close enough to be injured.

3. Exposure and response-loss of benthic forage. The loss of benthic forage occurring as a result of sediment dredging and disposal will take place in shallow water at the construction site and in deeper water (e.g., 30+ feet deep) several hundred feet away from the construction site. During disposal activity dredged sediments may be dispersed through the 30-foot water column by high flows and settle on an area of up to one acre. Thus, some potential reduction in benthic invertebrates exists within this footprint that is greater than the 0.13 acre footprint at the construction site where sediment will be removed. The benthic invertebrates most likely to be destroyed that are forage items for juvenile salmonids consist of flatworms (*Turbellaria*), annelid worms (*Oligocheata*), bivalve clams (*Corbicula fluminea*), amphipods (*Corophium salmonis*), and midges (*Chironomidae* and *Ceratopogonidae*) (McCabe et al. 1997). Benthic invertebrate productivity in the LCR is relatively high in shallow water habitats where juvenile salmonids regularly forage (Simenstad et al. 1990; McCabe et al. 1997; Bottom et al. 2005). Dredging for vessel moorage is most likely to reduce the amount of benthic invertebrates to juvenile salmonids because this action will occur in shallow water where young fish are most likely forage and seek refuge. Yet, the intensity of prey reduction will be relatively small because it will occur when juveniles absent, or present in low abundances and last for a period of 3-6 months (McCabe et al. 1998). By the time more species are present and utilizing the action area for rearing and forage, benthic productivity is likely to have increased to pre-construction conditions.

The species most likely to be affected by reduced benthic forage are subyearling, ocean-type migrants LCR Chinook salmon, SR fall Chinook salmon LCR coho salmon, CR chum salmon, and UWR Chinook salmon. Several researchers have noted that ocean-type Chinook salmon migrants extensively use nearshore habitat in the Lower Columbia River at depths to 0-10 feet (Dawley et al. 1986; McCabe et al. 1986; Ledgerwood et al. 1990, Bottom et al. 2005). These species rear in shallow water habitats in the mainstem Columbia River for weeks to months prior to outmigrating into the ocean (Dawley et al. 1986; Bottom et al. 2005; McNatt et al. 2016).

A few subyearling migrating salmonids that reside in the action area during the fall and winter months, especially those present during and after sediment dredging and disposal may experience a slight decrease in growth and fitness associated with the diminished prey base. These species include LCR Chinook salmon, CR chum salmon, SR fall Chinook salmon, and UWR Chinook salmon. In comparison, yearling stream-type migrating species such as LCR Chinook salmon (spring runs), LCR steelhead, LCR coho salmon, MCR steelhead, UWR steelhead, UWR Chinook salmon, SR spring/summer Chinook salmon, UCR Chinook salmon, SR steelhead, SR sockeye, and UCR steelhead will not experience a reduction in benthic forage or potential reduction in growth or fitness.

4. Exposure and response-alteration of rearing and migratory habitat. The proposed installation of about and about on the south shore of the Columbia River and vessel moorage will permanently degrade migratory and rearing habitat within the LCR estuary. This footprint includes 400 square feet of overwater structure, 22 square feet of piles, and the dredge prism where the 72-foot bar pilot vessel will be moored. The total area degraded by permanent presence of these features is about 0.15 acres.

Overwater structures produce shade that disruptions migration of juvenile salmonids by creating a visual barrier resulting in disorientation (Carrasquero 2001). Simenstad et al. (1999) reported that changes in the underwater light environment affect juvenile salmonid physiology and behavior that alter fish migration behavior and increase mortality risk. Tabor et al. (1998) noted that fry migrants delayed migration and sought lower velocity habitats upon experiencing visual barriers created by overwater structures, thus increasing their exposure to piscine predators. Tabor et al. (2011) found further evidence that juvenile salmonids were commonly found within about 15 feet of overwater structures, but were rarely found under overwater structures, suggesting that the habitat near these structures were diminished.

We anticipate that juvenile salmonids exposed to overwater structures and marine vessels, particularly those with no light permeability (i.e., barges and vessels and concrete staging pad), will respond by swimming around the perimeter of the structure. Anderson et al. (2005) found that for small fish minor adjustments to the migration route: 1) increases energetic expenditure, and 2) can increase opportunities for piscivorous predators to prey on affected juveniles. Juvenile salmonids may have to transit about 80 feet (i.e., length of the access ramp) to navigate around the structure and vessel to encounter habitat that is unaffected by presence of overwater structure.

Juvenile salmonids will respond by moving around the structures into deeper waters. Aside from a slight increase in energy expenditure and a delay necessary to navigate around the structure most fish will not exhibit an obvious adverse response because the action area is not characterized by aggregations of fish, marine mammals, or avian species that consume juvenile salmonids. Most adult salmonids migrate through in mid-channel locations in relatively deep water. The likelihood that adult salmonids will interact with the overwater structure is extremely small. The conversion of this habitat from sub-standard conditions for rearing and migration described in the environmental baseline (i.e., a large field of 100+ degrading timber piles) to a large overwater vessel and access ramp is unlikely to change the use of this habitat by salmonids at either life stage.

5. Exposure and response-dredging entrainment. The CRBP proposes to prepare the footprint for vessel moorage by dredging sediment to maintain a depth of -10 feet within a 0.13-acre dredge prism. The proposed method may include use of a clamshell bucket or hydraulic suction dredge. The CRBP proposes to dredge on an annual basis.

Clamshell buckets operate by mechanically embedding the dredge bucket into the substrate and remove three to five CY of material on each lift cycle. Given that it is unlikely the bucket will remove the maximum quantity each lift cycle we conservatively estimate about 100 bucket strikes during the initial year and up to about 150 bucket strikes during the subsequent four year period. Hydraulic suction dredges operate using a rotating cutterhead that is embedded into the substrate causing liquefaction of the sediment that is then drawn into a receiving pipe. Small hydraulic dredges are capable of pumping 50 to 100 CY per day. Thus, salmonids may be at risk to dredging entrainment for several days each year. Both methods use a transport barge to temporarily store sediment prior to disposal.

Hydraulic and clamshell dredging both pose a risk of fish becoming entrapped by high velocity flows adjacent to the cutterhead or the clamshell bucket. Each time the clamshell bucket strikes the substrate there is a small risk fish may be injured or killed as the result of entrainment or a bucket strike. We anticipate salmonids will perceive construction activity and respond by avoiding the area in close proximity to the dredge footprint. The greatest risk is likely to occur when dredging activity first begins because individual salmonids have not detected disturbance from dredge equipment and have not vacated the construction area. Adult salmonids are extremely unlikely to be residing in shallow water during dredging. As such no adult salmonids are at risk to entrainment. In their review of dredge-related entrainment to salmonids in Grays Harbor, Armstrong et al. (1984) reported entrainment of only one juvenile chum salmon, furthering the understanding that the likelihood of injury remains very low. Nonetheless, because the CRBP proposes to dredge in an area where juvenile salmonids are likely to reside there is a risk of entrainment for several species present.

Limiting dredge operations to the proposed in-water work window will reduce the potential risk of five species. Those species include LCR steelhead, SR spring/summer Chinook salmon, SR sockeye salmon, MCR steelhead, UCR Chinook salmon, UCR steelhead, and SR steelhead. The species at greatest risk of entrainment are smaller subyearling migrants such as LCR Chinook salmon, LCR coho salmon, UWR Chinook salmon, and SR fall Chinook salmon due to co-occurrence in the mainstem LCR during the late fall. Other species of salmonids have no risk of entrainment due to the lack of presence during the proposed inwater work window.

Effects to sDPS green sturgeon
Green sturgeon migrate into and out of the Columbia River estuary May through October and are known to utilize deep and shallow water habitats for foraging and rearing (Moser and Lindley 2007; Hansel et al. 2017). Residence times in the estuary varies from hours to months, with fish occupying habitats within about 3 miles of the CR mouth for minutes to hours and fish occupying habitats further upstream typically residing for days to months (Hansel et al. 2017). These authors noted that most fish tended to occupy areas within 10 miles of the CR mouth with several observations near the action area. Given these observations, it appears likely that a few individuals adult or subadult green sturgeon may be exposed to the temporary construction effects.

1. Exposure and response-suspended sediment. Green sturgeon typically forage in the benthos stirring up the sediment to access benthic prey such as burrowing shrimp (Moser and Lindley 2007). Wilkens et al. (2015) found that juveniles of a closely related species, Atlantic sturgeon, exposed to 500 milligrams per liter of suspended sediment for three consecutive days did not exhibit any effects on survival or swimming performance. As such, we anticipate that all species of sturgeon, including green sturgeon, are very tolerant of higher suspended sediment concentrations. In the unlikely event that individual green sturgeon are present and encounter elevated suspended sediment related the project, the species is not expected to exhibit any adverse effects.

Dredging, pile removal, and pile installation will resuspend sediment at levels that are too low and too short in duration to have any adverse effects on green sturgeon. However, sediment disposal poses a small risk that individual green sturgeon may be buried by the en-masse placement of sediment into the deep water. Due to the species orientation on or close to the sediment benthos they are vulnerable to large volumes of sediment rapidly descending to through the water column and may not be able to escape the large volume of sediment early enough to avoid injury or death. Individuals at the sub-adult life stage are more vulnerable due to their slower swimming speed. Given the relatively small quantity of sediment, limited frequency of sediment disposal (e.g., once or twice during the November through December work window), and lack of overlap with species presence in the LCR estuary is it unlikely that more than a few individual fish will be at risk to the burial during sediment disposal.

2. Exposure and response-sound pressure. As with other construction-related effects discussed above, the timing of the proposed action November through February will likely reduce the amount of potential overlap of green sturgeon presence in the LCR and elevated sound pressure created by pile driving. Therefore, only a few fish are likely to be subjected to potential detrimental effects from sound pressure. Shortnose sturgeon (*Acipenser brevirostrum*) exposed at close range to air blast tests at significantly greater sound pressures than vibratory hammers resulted in injury to relatively few individuals (Moser 1999). This author did note that some individuals suffered from gas bladder hemorrhaging, yet appeared to exhibit normal swim behavior. It is somewhat uncertain whether latent effects to injuries resulting from pile driving will result in further injury or death to green sturgeon. Therefore, it is possible that a few green sturgeon may be present when pile driving occurs and harmed or injured.

3. Exposure and response-reduced benthic forage. Green sturgeon forage on a wide variety of benthic-oriented prey, including small fish, macrocrustaceans, and bivalves, amphipods, and *Neomysis* shrimp (Moser et al. 2014). The reduction in these prey items will occur as a result of dredging and dredge material disposal. Yet, the timing of these impacts will occur when green sturgeon presence in the LCR estuary is very low or the species is absent. As previously discussed, McCabe et al. (1997; 1998) found that benthic invertebrate colonies re-established to pre-construction conditions within 3-6 months following dredging actions. In this case we anticipate benthic forage will be restored by the following spring when green sturgeon will once again be present in the LCR estuary. As a result, a few green sturgeon may be exposed to an incredibly small reduction in benthic forage for a period of days. This level of forage reduction will be too small to impact the growth, survival, or fitness of any individuals.

4. Exposure and response to entrainment.
Green sturgeon that may be present during sediment dredging are large fish that are able to avoid the dredge head or clamshell bucket with minimal risk of entrainment. Yet, evidence of sub-adult sturgeon entrainments from dredging operations is not without precedent (Hoover et al. 2011; Buell 1992) and suggesting that green sturgeon entrainment is possible despite the low probability of presence at the time dredging occurs. Thus, the potential incidental take of green sturgeon by dredging entrainment is possible, although highly unlikely.

Effects to sDPS eulachon
The annual number of adult eulachon returning to spawn in the CR and its tributaries can vary by orders of magnitude and it is extremely difficult to predict when and where adult may spawn (NMFS 2016). Historically, most spawning has occurred in the Cowlitz, Grays, Elochoman, Kalama, Lewis, and Sandy rivers (NMFS 2016). Little is known about habitat use of eulachon as they enter the LCR, but it is thought that individuals migrate through the main channel areas and tend to avoid shallow water, nearshore habitats until they are ready to spawn (Smith and Saalfeld 1955). Larval eulachon do not begin feeding until they reach salt water. Furthermore, this species is far too small to consume benthic invertebrates that will be destroyed by dredging or sediment disposal. Adult eulachon will not be affected either, because individuals are known to cease feeding shortly before entering freshwater and instead absorb minerals and energy from scales and teeth as they prepare for spawning (Cambria Gordon LTD 2006). Therefore, the reduction in benthic invertebrates will have no effect on this species at any life stage.

1. Exposure and response-suspended sediment. Inwater construction is planned from November through February, which encompasses the early migration and spawning period of eulachon in the Columbia River. Eulachon may be exposed to risk of increased levels of suspended sediment, sound pressure, and dredging entrainment if these actions occur in the late December through February. The species is at greatest risk of exposure at the egg and larvae life stages because eulachon larvae and eggs are feeble swimmers and migrating as free-floating passive drift (Parente and Snyder 1970). As such eulachon are completely incapable of avoiding harm at the egg/larval life stages. In contrast, adult eulachon are highly mobile and are capable of distinguishing and avoiding localized sediment plumes and dredging entrainment (Smith and Saalfeld 1955). The ability of the species to perceive and avoid harm from effects identified above is important in determining the level of exposure and subsequent response.

Eulachon may encounter intense turbidity plumes resulting from dredging and sediment disposal activities. The species may be exposed at both adult and egg/larval life stages because these activities will include both nearshore shallow water and mid-channel habitats. Adult eulachon are typically 6-8 inches in length when they enter freshwater and return to spawn and are tolerant of a wide variety of turbidity conditions (Gustafson et al. 2010). Furthermore, adult eulachon are capable swimmers and are easily able to avoid the turbidity plume during sediment disposal. Because the intensity of effects resulting from exposure to suspended sediment ranges widely from low intensity distribution of fine sediments caused by pile installation to high intensity cascading of dredge materials the eulachon may be exhibit a wide range of responses at the egg/larval life stage. These responses may include no response, harassment, harm, injury, and immediate mortality (Newcombe and Jensen 2003). The majority of actions are likely to include harm from dredging and sediment disposal activities. However, it is important to note that the likelihood of exposure remains low because eggs and larvae are not usually present in the LCR estuary until late January through March (Smith and Saalfeld 1955; Howell and Uusitalo 2000). Thus, it remains possible that the species may be exposed to suspended sediment at the most vulnerable life stage.

2. Exposure and response-sound pressure. Adult eulachon will be exposed to the acoustic effects of pile driving during their upstream migration, as will larvae during their rapid downstream migration to salt water. Eulachon exposure to underwater noise and resulting effects will be similar to those of salmonids, although due to their lack of swim bladder, eulachon are not as susceptible to barotrauma injury (Caltrans 2015). The effects of underwater noise exposure to eggs and larvae are not well documented (Buehler et al. 2015). We anticipate that some eulachon may be injured from pile driving as this activity may occur during periods when all life stages are present. Yet, we anticipate that exposure will be relatively short duration and most eulachon will pass through the area after construction ceases in the late winter.

Due to the proximity of the action area at the mouth of the Columbia River we anticipate millions of eulachon eggs and larvae will drift through the action area. Most eulachon eggs and larvae will be present after February, and thus not be exposed to any of the construction-related effects described above. The duration, intensity, and timing of the proposed construction suggests that, while some individuals may be harmed, injured, or killed the overall effect on the Columbia River sub-population of eulachon will be incomprehensibly small.

3. Exposure and response-entrainment. Eggs or larvae of eulachon that are within the immediate vicinity of the dredge cutterhead or enclosed within the clamshell bucket are likely to be entrained and killed. Even during years of poor eulachon runs, there are likely millions if not hundreds of millions of eulachon eggs and larvae in the Columbia River during late winter and spring. The vast majority of eulachon spawning takes place in Washington State tributaries, including the Cowlitz, Elochoman, Kalama, and others. Spawning takes place atop sand and fine gravel substrates to which the eggs adhere and mature, often being transported downstream through this maturation process through sediment transport processes that occur along the riverine corridor. Once eggs are hatched, typically after about 30 days, the larvae disperse throughout the water column and are widely distributed as they drift downstream passively. The proposed work window for this project ends in late February, prior to the peak of eulachon larval outmigration (March through May) (Smith and Saalfeld 1955; Howell and Uusitalo 2000). Thus, timing and limited duration of dredging will reduce the likelihood for exposure to dredging entrainment of eulachon eggs, but does not eliminate the potential risk.

2.6 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed 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. Because the new pier, pilings and moorage are expected to last for many years, we expect that, contemporaneously, some future environmental conditions caused by global climate change that were described in the environmental baseline will become more pronounced as cumulative effects. This array of changes is difficult to predict at a site specific level, but is likely to include more frequent episodes of warmer water, particularly in summer and fall, more dynamic hydrograph as flood and drought become more variable, changing salinity and acidity, and modified food webs. Each of these is likely to make restoration and recovery more difficult.

Human population growth is expected to occur throughout the Columbia River Basin, increasing conversion of uplands to more urbanized watersheds, which in turn create more sources of stormwater inputs, non-point pollution, and introduction of trash. Such effects accrue within this action area. We also assume that future private and public actions will occur near the action area based on trends in development. Clatsop County is identified as one of the fastest growing counties in Oregon (OEDO 2004), with considerable development occurring in and around the city of Astoria. As the human population in the action area increases the demand for agricultural, commercial, or residential development and supporting infrastructure is also likely increase as well. Human population growth will likely increase regional trade and need for greater commercial vessel traffic in the Columbia River with associated environmental stressors occurring to riparian and streambank habitats.

The majority of environmental effects related to future growth will likely occur as a result of land clearing, associated land-use changes from agricultural or forestry use to residential or intense commercial and industrial development uses. Land use changes and development of the built environment that are detrimental to listed species and their habitats are likely to continue under existing zoning regulations (Baker et al. 2004). The accrual of contaminants from upstream sources will continue to degrade water quality conditions into the future. Though these existing regulations could decrease potential adverse effects on habitat function, as currently constructed and implemented, they still allow incremental degradation to occur.

Considerable development has occurred on the City of Astoria waterfront within the last 15-20 years. The majority of this development is located in terrestrial areas and has resulted in changes to stormwater effluent discharge into the shallow water habitats adjacent to the shoreline. There has been little modification of overwater structures to improve aquatic habitat for fishes. Increases in commercial ship traffic in the nearby federal navigation channel and docking in Port of Astoria marine anchorage area will continue to present effects associated with industrial ports and waterways, such as vessel noise, discharges of ballast water containing invasive species, and contaminated effluent. Effects from these actions will continue to impart a depressive effect on listed species in the action area.

2.7 Integration and Synthesis

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

Critical habitat is designated for each species considered in this opinion. Habitat has systemically been altered by anthropogenic modifications affecting the amount of and quality of their habitat. Many of the habitat changes are both factors for decline, and limiting factors which constrain the capacity for recovery. Degraded conditions occur within the action area as well, impairing both migration and rearing values.

We evaluate the additional project effects on critical habitat in this context. The degraded habitat conditions in the action area are likely to improve only slightly over time, as derelict piles and overwater structures are slowly removed and replaced with structures that improve PBFs relative to baseline conditions. The action proposed by CRBP is likely to be characteristic of those occurring in the action area into the future insofar as derelict piles are removed to make room for overwater structures with modern infrastructure. Thus, the proposed pile removal, aluminum access ramp installation, and vessel moorage will not significantly benefit or further detriment overall habitat features, and degraded values will remain largely static. Overall, this proposed action will result in relatively small scale increase in dredging and overwater structure. Both threats are characterized as relatively low-level threats in NMFS' LCR estuary recovery module (NMFS 2011c). Despite this, regular dredging and presence of overwater structure will delay restoration of normal habitat function in the action area for salmonids. Critical habitat values for green sturgeon and eulachon are not significantly altered.

Considering the status of the ESA-listed species, all but two of the species considered in this opinion are threatened with extinction, and those two (UCR Chinook salmon and SR sockeye salmon) are endangered. Most of the component populations of each of the species are at a low level of persistence, or presented differently, at moderate to high risk of extinction. Some individuals from several populations are likely to move through the action area during the several weeks required for dredging, pile driving, and installation of the vessel access ramp. But most individuals from most species will be exposed only to the post-construction effects related to the presence of overwater structure, and annual dredging needs.

The timing of the proposed action means construction effects are likely to impair fitness of some subyearling ocean-type species of salmonids based on perturbations in habitat conditions, and could reduce survival among exposed cohorts, via entrainment; reductions are likely only among five of the listed species, based on their rearing behaviors (and not inclusive of the endangered species). This impaired fitness and survival reduction suggests reduced abundance among these five species, but not to a degree that could be discerned among adult returns, meaning that productivity is unlikely to be diminished. Spatial structure and diversity are also unlikely to be affected by construction effects among individuals.

Regarding permanent habitat effects, the limited number of piles removed, together with new piles installed will reduce the presence of in-water structure, providing an incremental improvement in habitat that should in turn slightly improve carrying capacity, but that benefit is somewhat offset by shade from the new a dock and moorage of a large marine vessel. Salmon abundance among the numerous populations that will rear or migrate through this action area is not expected to benefit from or be degraded by the permanent habitat conditions as modified by this project.

November through February eulachon may be completely absent or have potential for exposure to three life stages. If the project occurs during periods when eulachon are present at the juvenile life stage, entrainment is likely. However, we expect too few of these individuals will be entrained by dredge equipment or injured during construction activities to decrease the three other viability parameters.

The timing of the work relative to green sturgeon presence in the LCR indicates the project will adversely affect only a few individuals, via dredge placement and benthic prey reduction. The high tolerance of this species to physical injury from sound pressure and elevated suspended sediment yields little in terms of exposure risk. Further, the life stage affected (i.e., subadult and adult) are relatively large fish that can easily evade construction activities and find suitable rearing and foraging resources in alternate locations without incurring any adverse effects. We expect no reduction in any of the viability parameters.

When also consider the cumulative effects that are anticipated to co-occur with the effects of the proposed action. While cumulative effects are more likely to have negative implications for habitat than positive effects, we construe the minimal effects on species abundance from both the temporary and permanent project effects are insufficient to alter any of the species trends for survival and recovery.

2.8 Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of LCR Chinook salmon, UCR Chinook salmon, SR spring/summer run Chinook salmon, UWR spring-run Chinook salmon, SR fall-run Chinook salmon, CR chum salmon, LCR coho salmon, SR sockeye salmon, LCR steelhead, MCR steelhead, UCR steelhead, SRB steelhead, UWR steelhead, southern DPS of green sturgeon, or southern DPS of eulachon, or destroy or adversely modify critical habitat designated for those species.

2.9 Incidental Take Statement

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

2.9.1 Amount or Extent of Take

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

- Harm caused by temporary loss of benthic forage and permanent degradation of rearing and migratory habitat. Take is likely as the result of a temporary reduction in prey availability to adult and subadult life stages of sDPS of green sturgeon and 13 species of juvenile salmonids. The overwater structure and use of aquatic habitats for vessel moorage will permanently degrade rearing and migratory habitat for 13 species of salmonids at the juvenile life stage. We cannot quantify the number of fish likely to be harmed because the number and location of individuals exposed cannot be reliably predicted. Thus, NMFS will use surrogates to describe the extent of take resulting from the proposed action. The harm is directly related to the quantity and area in which 1) sediment is dredged and 2) the area of overwater structure installed. The extent of take associated with temporary loss of benthic forage from sediment dredging and disposal is limited to 250 cubic yards of sediment dredged annually and a dredge prism size of 0.15 acres. The extent of take associated with permanent degradation to rearing and migratory habitat of immobile overwater structure is limited to 450 square feet. Both of these areal measures are directly related to the reduction in benthic prey.

- Harassment, and harm caused by exposure to suspended sediment. Take caused by sediment disposal and in-water construction may vary widely in severity depending on timing. As a result the proposed action may expose sDPS eulachon at all life stages, and all 13 species of salmonids at the juvenile life stage to harassment, harm, injury, or death. We cannot quantify the number of fish likely to be harmed because the number and location of individuals exposed cannot be reliably predicted. Take caused by these actions is directly related to the number of days required to complete construction and sediment dredging and disposal because the longer in-water work occurs, the longer the sediment is suspended in aquatic habitat. Therefore, NMFS will use surrogates as the extent of take resulting from these activities as indicated by the number of days in which activities generating suspended sediment will occur. The extent of take for construction of the mooring facility is limited to a total of 120 days.

- Harassment, harm, injury, or death caused by dredging entrainment. Sediment dredging may result in take in the form of injury or death to sDPS eulachon at all life stages, harassment or harm of sDPS green sturgeon at the adult and sub-adult life stages, and harm, injury or death of individuals from 13 species of salmonids at the juvenile life stage. We cannot quantify the number of fish likely to be harmed because the number and location of individuals exposed within the proposed work window cannot be reliably predicted. Therefore, NMFS will use a surrogate as the extent of take resulting from sediment dredging as indicated by the number of days in which dredging occurs. The extent of take associated with sediment dredging is limited to a maximum of 45 days occurring over the course of the proposed 4 month inwater work window. The surrogate is causally related to the take because the longer the dredging occurs the greater the amount of exposure among fish to the entraining equipment.

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.9.3 Reasonable and Prudent Measures

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

To implement Reasonable and Prudent Measures the COE shall ensure the permitee:

1. Minimize take due to entrainment, sound pressure, and water quality degradation
2. Minimize take due to altered rearing and migratory habitat
3. Conduct monitoring

2.9.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and the COE or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The COE 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. To implement reasonable and prudent measure 2 (minimize take due to entrainment, sound pressure, and water quality degradation) the COE shall:
   a. To the maximum extent practicable, ensure that sediment dredging and disposal activities are completed during November 1 through December 31.
   b. Ensure that the sediment containment barge is fitted with filtration equipment to reduce the amount of suspended sediment in overflow water.

2. To implement reasonable and prudent measure 2 (minimize take from altered rearing and migratory habitat) the COE shall ensure that the CRBP removes at least 4 additional timber piles adjacent to those already proposed for removal.

3. To implement reasonable and prudent measure 3 the COE shall ensure the CRBP provides a post-construction monitoring report with the following documentation submitted electronically to NMFS email inbox at projectreports.wcr@noaa.gov by March 31, 2020:
   a. Dredge method used
   b. Areal extent of dredge prism
   c. Estimated quantity of sediment removed
   d. Number of days in which sediment is dredged
   e. Number of piles removed
   f. Dimension of the ramp and gangway structure

2.10 Conservation Recommendations

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

NMFS recommends the COE consult with the service to identify comprehensive mitigation strategies that the COE could employ to enhance ecosystem function and conservation of listed species, and restoring the biological integrity of the nation’s waters.

2.11 Reinitiation of Consultation

This concludes formal consultation for the Columbia River Bar Pilots 16th Street Moorage Dock Project.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the 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 agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

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. The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. This analysis is based, in part, on the EFH assessment provided by the COE and descriptions of EFH for 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

As part of the information provided in the request for ESA concurrence, the COE determined that the proposed action would adversely affect EFH designated for Chinook and coho salmon. The effects of the proposed action on EFH are the same as those described above in the ESA portion of this document. The proposed action and action area for this consultation are described in Section 1.3 and 2.3 of this document. The action area includes areas designated as EFH for various life history stages of Chinook salmon and coho salmon (PFMC 2014).

3.2 Adverse Effects on Essential Fish Habitat

Based on the information provided in the BA and the analysis of effects presented in the ESA portion of this document, NMFS concludes the proposed action will have adverse effects on EFH designated for Chinook salmon and coho salmon. These effects include:

1. Loss of benthic forage
2. Permanent alteration of shallow water rearing habitat
3. Suspended sediment from dredging, sediment disposal, and pile removal
4. Elevated sound pressure

3.3 Essential Fish Habitat Conservation Recommendations

The effects of the action will adversely affect rearing habitat for Chinook salmon and coho salmon. NMFS recommends the COE require the following actions to minimize effects on Pacific Coast salmon EFH:

1. CRBP should remove the maximum number of piles technically feasible to restore benthic habitat for juvenile Chinook salmon and coho salmon.
2. CRBP should complete dredging and pile installation in as brief a period as is technically feasible.
3. CRBP should complete dredging and pile installation during November 1 through December 31.

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in Section 3.2, above, approximately 0.2 acres of designated EFH for Pacific Coast salmon.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the COE must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, 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 COE 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 are the COE and its applicant. Other interested users could include the Columbia River Estuary Study Taskforce and the city of Astoria. Individual copies of this opinion were provided to the COE. The format and naming adheres to conventional standards for style.

4.2 Integrity

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

4.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

5. REFERENCES

Abatzoglou, J.T., D.E. Rupp, and P.W. Mote. 2014. Seasonal climate variability and change in the Pacific Northwest of the United States. Journal of Climate 27(5): 2125-2142.

Able, K.W., J. Dobarro, and A.M Muzeni-Corino. 2010. An Evaluation of Boat Basin Dredging Effects: Response of Fishes and Crabs in a New Jersey Estuary. North American Journal of Fisheries Management, 30:4, 1001-1015, DOI: 10.1577/M09-195.1

Allen, P.J., B. Hodge, I. Werner, and J.J. Cech. 2006. Effects of ontogeny, season, and temperature on the swimming performance of juvenile green sturgeon (*Acipenser medirostris*). Canadian Journal of Fisheries and Aquatic Sciences 63:1360-1369.

Allen, P.J. and J.J. Cech. 2007. Age/size effects on juvenile green sturgeon, *Acipenser medirostris*, oxygen consumption, growth, and osmoregulation in saline environments. Environmental Biology of Fishes 79:211-229.

Anchor Environmental. 2003. Literature review of effects of resuspended sediments due to dredging operations. Prepared for Los Angeles Contaminate Sediments Task Force. June 2003. 140 pages.

Anderson, J.J., E. Gurarie, and R. Zabel. 2005. Mean free-path length theory of predator-prey interactions: application to juvenile salmon migration. Ecological Modelling 186:196-211.

Armstrong, D.A., B.G. Stevens, and J.C. Hoeman. 1984. Distribution and abundance of Dungeness crab and Crangon shrimp and dredging-related mortality of invertebrates and fish in Grays Harbor, Washington. Technical Report by Washington Department of Fisheries to the U.S. Army Corps of Engineers, Seattle District. Contract number: DACW67-80-C-0086. July 1981.

Barraclough, W.E. 1967. Data record. Number, size composition, and food of larval and juvenile fish caught with a two-boat surface trawl in the Strait of Georgia, June 6–8, 1966. Bulletin of Fisheries Research Board of Canada. Manuscript. Rep. Ser. 928.

Blahm, T. H., and McConnell, R. J. 1971. Mortality of adult eulachon (*Thaleichthys pacificus*) subjected to sudden increases in water temperature. Northwest Sci. 45:178–82.

Bolam, S.G. 2011. Burial survival of benthic macrofauna following deposition of simulated dredged material. Environmental Monitoring Assessment 181:13-27.

Bolam, S.G. 2012. Impacts of dredged material disposal on macrobenthic invertebrate communities: A comparison of structural and functional (secondary production) changes at disposal sites around England and Wales. Marine Pollution Bulletin 64:2199-2210.

Bottom, D.L., C.A. Simenstad, J. Burke, A.M. Baptista, D.A. Jay, K.K. Jones, E. Casillas, M.H. Schiewe. 2005. Salmon at river's end: The role of the estuary in the decline and recovery of Columbia River salmon. U.S. Department of Commerce, NOAA Technical Memorandum MFS-NWFSC-68, 246 pages.

Bottom, D.L., A. Baptista, J. Burke, L. Campbell, E. Casillas, S. Hinton, D.A. Jay, M.A. Lott, G. McCabe, R. McNatt, M. Ramirez, G.C. Roegner, C.A. Simenstad, S. Spilseth, L. Stamatiou, D. Teel, and J.E. Zamon. 2011. Estuarine habitat and juvenile salmon: current and historical linkages in the Lower Columbia River and estuary. Report of research by the Northwest Fisheries Science Center to the U.S. Army Corps of Engineers, Portland District. Contract W66QKZ20374382. December 2011.

Buehler, P.E., R. Oestman, J. Reyff, K. Pommerenck, and B. Mitchell. 2015. Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish. California Department of Transportation, Division of Environmental Analysis. November 2015. 532 pages.

Buell, J.W. 1992. Fish entrainment monitoring of the Western Pacific Dredge R.W. Lofgren during operations outside the preferred work period. Contract Report prepared for Western-Pacific Dredging Company.

Cambria Gordon LTD. 2006. Eulachon of the Pacific Northwest: A life history. Report to Living Landscapes Program, Royal BC Museum. Victoria, BC. January 11, 2006.

Carrasquero, J. 2001. Over-water structures: freshwater issues. Washington State Department of Fish and Wildlife White Paper. Report of Herrera Environmental Consultants to Washington Department of Fish and Wildlife, Washington Department of Ecology, and Washington Department of Transportation.

Carlson, T., G. Ploskey, R. L. Johnson, R. P. Mueller and M. A. Weiland. 2001. Observations of the behavior and distribution of fish in relation to the Columbia River navigation channel and channel maintenance activities. Review draft report to the Portland District COE of Engineers prepared by Pacific Northwest National Laboratory, Richland, Washington. 35 pages.

Carter, J.A., G.A. McMichael, I.D. Welch, R.A. Harnish, and B.J. Bellgraph. 2009. Seasonal Juvenile Salmonid Presence and Migratory Behavior in the Lower Columbia River. PNNL-18246, Pacific Northwest National Laboratory, Richland, Washington.

Clarke, D., C. Dickerson, and K. Reine. 2002. Characterization of underwater sounds produced by dredges. *Dredging*. ASCE: 64-81.

Collins, M.A. 1995. Dredging-induced near-field resuspended sediment concentrations and source strengths. *Prepared for* U.S. Army Corps of Engineers Waterways Experiment Station. 229 pages.

Crozier, L.G., A.P. Hendry, P.W. Lawson, T.P. Quinn, N.J. Mantua, J. Battin, R.G. Shaw, and R.B. Huey. 2008. Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. *Evolutionary Applications* 1(2): 252-270.

Crozier, L.G., M.D. Scheuerell, and E.W. Zabel. 2011. Using Time Series Analysis to Characterize Evolutionary and Plastic Responses to Environmental Change: A Case Study of a Shift Toward Earlier Migration Date in Sockeye Salmon. *The American Naturalist* 178 (6): 755-773.

Dawley, E.M., R.D. Ledgerwood, T.H. Blahs, C.W. Sims, J.T. Durkin, R.A. Rica, A.E. Rankis, G.E. Mohan and F.J. Ossiander. 1986. Migrational Characteristics, Biological Observations, and Relative Survival of Juvenile Samonids entering the Columbia River Estuary, 1966-1983. Report of Research to the Bonneville Power Administration and U.S. Department of Energy from the National Marine Fisheries Service, Seattle, Washington. 269 pages.

Dickerson, C., K. J. Reine, and D. G. Clarke. 2001. Characterization of underwater sounds produced by bucket dredging operations. DOER Technical Notes Collection (ERDC TN-DOER-E14), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army.mil/el/dots/doer.

Dominguez, F., E. Rivera, D.P. Lettenmaier, and C.L. Castro. 2012. Changes in Winter Precipitation Extremes for the Western United States under a Warmer Climate as Simulated by Regional Climate Models. *Geophysical Research Letters* 39(5).

Doney, S.C., M. Ruckelshaus, J.E. Duffy, J.P. Barry, F. Chan, C.A. English, H.M. Galindo, J.M. Grebmeier, A.B. Hollowed, N. Knowlton, J. Polovina, N.N. Rabalais, W.J. Sydeman, and L.D. Talley. 2012. Climate Change Impacts on Marine Ecosystems. *Annual Review of Marine Science* 4: 11-37.

Feely, R.A., T. Klinger, J.A. Newton, and M. Chadsey (*editors*). 2012. Scientific summary of ocean acidification in Washington state marine waters. NOAA Office of Oceanic and Atmospheric Research Special Report.

Glick, P., J. Clough, and B. Nunley. 2007. Sea-Level Rise and Coastal Habitats in the Pacific Northwest: An analysis for Puget Sound, southwestern Washington, and northwestern Oregon. National Wildlife Federation, Seattle, WA.

Goode, J.R., Buffington, J.M., Tonina, D., Isaak, D.J., Thurow, R.F., Wenger, S., Nagel, D., Luce, C., Tetzlaff, D. and Soulsby, C., 2013. Potential effects of climate change on streambed scour and risks to salmonid survival in snow-dominated mountain basins. *Hydrological Processes* 27(5): 750-765.

Groot, C. and L. Margolis. 1991. Pacific salmon life histories. The UBC Press, Vancouver, Canada. 564 pages.

Gustafson, R. G., L. Weitkamp, Y.W. Lee, E. Ward, K. Somers. V. Tuttle, and J. Jannot. 2016. Status Review Update of Eulachon (*Thaleichthys pacificus*) Listed under the Endangered Species Act: Southern Distinct Population Segment. US Department of Commerce, NOAA, Online at: http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/other_species/eulachon/eulachon_2016_status_review_update.pdf

Hart, J. L. 1973. Pacific fishes of Canada. Bulletin of Fisheries Research Board of Canada. 180.

Hassel, A., T. Knutsen, and J. Dalen. 2004. Influence of seismic shooting on the lesser sand eel (*Ammodytes marinus*). Journal of Marine Science 61:1165–1173.

Hay, D. E., and McCarter, P. B. 2000. Status of the eulachon *Thaleichthys pacificus* in Canada. Canadian Stock Assessment Secretariat research document 2000-145. DFO, Ottawa, ON. Online at http://www.dfo-mpo.gc.ca/csas/csas/DocREC/2000/PDF/2000_145e.pdf [accessed 23 February 2010].

Healey, M.C. 1982. Juvenile Pacific salmon in estuaries: The life support system, pages 315-341. *In* V.S. Kennedy (*editor*), Estuarine Comparisons. Academic Press, New York.

Herbich, J. B., and Brahme, S. B. 1991. Literature review and technical evaluation of sediment resuspension during dredging. Contract Report HL-91-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hoover, J.J., K.A. Boysen, J.A. Beard and J. Smith. 2011. Assessing the risk of entrainment by cutterhead dredges to juvenile lake sturgeon (*Acipenser fulvenscens*) and juvenile pallid sturgeon (*Scaphirhynchus albus*). Journal of Applied Ichthyology 27:369-375.

Howell, M.D. and N. Uusitalo. 2000. Eulachon (*Thaleichthys pacificus*) studies related to Lower Columbia River channel deepening operations. 30 pages.

Howell, M. D. 2001. Characterization of development in Columbia River prolarval eulachon, *Thaleichthys pacificus*, using selected morphometric characters. Washington Dept. Fish and Wildlife, Vancouver. Online at http://wdfw.wa.gov/fish/creel/smelt/USACE-20larval-20development.pdf.

Howell, M.D., M.D. Romano, and T.A. Rien. 2001. Outmigration timing and distribution of larval eulachon, *Thaleichthys pacificus*, in the lower Columbia River, spring 2001. Washington Dept. Fish and Wildlife, Vancouver, and Oregon Dept. Fish and Wildlife, Clackamas.

ISAB (Independent Scientific Advisory Board; *editor*). 2007. Climate change impacts on Columbia River Basin fish and wildlife. *In:* Climate Change Report, ISAB 2007-2. Independent Scientific Advisory Board, Northwest Power and Conservation Council. Portland, Oregon.

IPCC (Intergovernmental Panel on Climate Change). 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Isaak, D.J., S. Wollrab, D. Horan, and G. Chandler, 2012. Climate change effects on stream and river temperatures across the northwest US from 1980–2009 and implications for salmonid fishes. *Climatic Change* 113(2): 499-524.

Johnson, B.H., and T.M. Parchure. 2000. Estimating Dredging Sediment Resuspension Sources. DOER Technical Notes Collection, TN DOER-E6, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Johnson, E.L. , T.S. Clabough , D.H. Bennett , T.C. Bjornn , C.A. Peery , C.C. Caudill & L.C. Stuehrenberg. 2005. Migration Depths of Adult Spring and Summer Chinook Salmon in the Lower Columbia and Snake Rivers in Relation to Dissolved Gas Supersaturation, Transactions of the American Fisheries Society, 134:5, 1213-1227, DOI: 10.1577/T04-116.1

Kahler, T., M. Grassley, and D. Beauchamp. 2000. A summary of the effects of bulkheads, piers, and other artificial structures and shorezone development on ESA-listed salmonids in lakes. Final Report to the City of Bellevue. The Watershed Company, Kirkland, Washington.

Kelly, J.T., A.P. Klimley, and C.E. Crocker. 2007. Movements of green sturgeon, *Acipenser medirostris*, in the San Francisco Bay Estuary, California. Environmental Biology of Fishes 79:281-295.

Kjelland, M.E., C.M. Woodley, T.M. Swannack, and D.I. Smith. 2015. A review of the potential effects of suspended sediment on fishes: potential dredging-related physiological, behavioral, and transgenerational implications. Environ. Syst. Decis. (2015) 35:334-350.

Kunkel, K. E., L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K. T. Redmond, and J. G. Dobson. 2013. Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 6. *Climate of the Northwest U.S. NOAA Technical Report NESDIS 142-6*. 83 pp. National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, Washington, D.C.

Langer, O. E., B. G. Shepherd, and P. R. Vroom. 1977. Biology of the Nass River eulachon (*Thaleichthys pacificus*). Canadian Fisheries and Marine Service Tech. Rep. 77-10.

Lawson, P.W., E.A. Logerwell, N.J. Mantua, R.C. Francis, and V.N. Agostini. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (*Oncorhynchus kisutch*). *Canadian Journal of Fisheries and Aquatic Sciences* 61(3): 360-373.

Ledgerwood, R.D., F.P. Thrower, and E.M. Dawley. 1990. Diel sampling of migratory juvenile salmonids in the Columbia River estuary. Fishery Bulletin 89:69-78.

Lewis, A. F. J., M. D. McGurk, and M. G. Galesloot. 2002. Alcan's Kemano River eulachon (*Thaleichthys pacificus*) monitoring program 1988–1998. Consultant's report prepared by Ecofish Research Ltd. for Alcan Primary Metal Ltd., Kitimat, BC.

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. *In* The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate, edited by M.M. Elsner, J. Littell, and L.W. Binder, 217-253. The Climate Impacts Group, University of Washington, Seattle, Washington.

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. *Climatic Change* 102(1): 187-223.

Mayfield, R.B. and J.J. Cech. 2004. Temperature effects on green sturgeon bioenergetics. Transactions of the American Fisheries Society 133:961-970.

McMahon, T.E., and G.F. Hartman. 1989. Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 46: 1551–1557.

Moser, M. 1999. Cape Fear River blast mitigation tests: results of caged fish necropsies. Final Report to CZR, Inc. June 30, 1999. 49 pages.

Moser, M.L. and S.T. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes 79:243-253.

Moser, M.L., J.A. Israel, M. Neuman, S.T. Lindley, D.L. Erickson, B.W. McCovey Jr., and A.P. Klimley. Biology and life history of Green Sturgeon (*Acipenser medirostris Ayres*, 1854): state of science. Journal of Applied Ichthyology 32(1):67-86.

Mote, P.W., J.T. Abatzglou, and K.E. Kunkel. 2013. Climate: Variability and Change in the Past and the Future. In Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, edited by M.M. Dalton, P.W. Mote, and A.K. Snover, 41-58. Island Press, Washington, D.C.

Mote, P.W, A.K. Snover, S. Capalbo, S.D. Eigenbrode, P. Glick, J. Littell, R.R. Raymondi, and W.S. Reeder. 2014. Ch. 21: Northwest. *In* Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, T.C. Richmond, and G.W. Yohe, (*editors*), U.S. Global Change Research Program, 487-513.

Mote, P.W., D.E. Rupp, S. Li, D.J. Sharp, F. Otto, P.F. Uhe, M. Xiao, D.P. Lettenmaier, H. Cullen, and M.R. Allen. 2016. Perspectives on the cause of exceptionally low 2015 snowpack in the western United States, Geophysical Research Letters, 43, doi:10.1002/2016GLO69665.

Meyer, J.L., M.J. Sale, P.J. Mulholland, and N.L. Poff. 1999. Impacts of climate change on aquatic ecosystem functioning and health. Journal of the American Water Resources Association 35(6): 1373-1386.

Nightingale, B. and C. Simenstad. 2001. Overwater Structures: Marine Issues for Washington Departments of Fish and Wildlife, Ecology and Transportation.

NMFS. 2005. Assessment of NOAA Fisheries' critical habitat analytical review teams for 12 evolutionarily significant units of West Coast salmon and steelhead. NMFS, Protected Resources Division, Portland, Oregon.

NMFS. 2008. Recovery plan for Southern Resident killer whales (*Orcinus orca*). National Marine Fisheries Service, Northwest Region, Seattle, Washington.

NMFS. 2009. Middle Columbia River steelhead distinct population segment ESA recovery plan. National Marine Fisheries Service, Northwest Region. Seattle.

NMFS. 2011a. Upper Willamette River conservation and recovery plan for Chinook salmon and steelhead. *Prepared by* Oregon Department of Fish and Wildlife and the National Marine Fisheries Service Northwest Region. August 5, 2011.

NMFS. 2011b. Critical Habitat for the Southern Distinct Population Segment of Eulachon. Final Biological Report. Protected Resources Division, Northwest Region. September 2011.

NMFS. 2011c. Columbia River estuary ESA recovery plan module for salmon and steelhead. Prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc. (subcontractor). National Marine Fisheries Service, Northwest Region. Portland, Oregon. January. Available online at: http://www.nwr.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/willamette_lowercol/lower_columbia/estuary-mod.pdf.

NMFS. 2013. ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead. National Marine Fisheries Service, Northwest Region. June 2013.

NMFS. 2014. Proposed ESA Recovery Plan for Snake River sockeye salmon (*Oncorhynchus nerka*). National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, Oregon. June 30, 2014.

NMFS. 2015b. Southern Distinct Population Segment of the North American Green Sturgeon (*Acipenser medirostris*) 5-Year Review: Summary and Evaluation. West Coast Region, Long Beach, California. 42 pages.

NMFS. 2016. Proposed ESA Recovery Plan for Snake River Spring/Summer Chinook Salmon and Snake River Steelhead. West Coast Region, Protected Resources Division, Portland, OR.

NMFS. 2017a. Recovery Plan for Eulachon (*Thaleichthys pacificus*). National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, Oregon. September 2017.

NMFS. 2017b. Proposed ESA Recovery Plan for Snake River fall Chinook salmon (*Oncorhynchus tshawytscha*). National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, Oregon. November 2017.

NMFS. 2018. Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon (*Acipenser medirostris*). National Marine Fisheries Service, Sacramento, CA.

NWFSC (Northwest Fisheries Science Center). 2015. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest.

OEDO (Oregon Economic Development Office). 2004. Forecasts of Oregon's County Populations and Components of Change, 2000—2040.

Odum, E.P. 1985. Trends expected in stressed ecosystems. Bioscience 35, 419–422.

Parente, W.D., and G.R. Snyder. 1970. A pictorial record of the hatching and early development of the eulachon (*Thaleichthys pacificus*). Northwest Science. 44:50–57.

Pearson, T.H., and R. Rosenberg. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology—Annual Review, 16, 229-311.

Pearson, T.H., J.R. Skalski, and C.I. Malme. Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes spp*.). Canadian Journal of Fisheries and Aquatic Sciences 49:1343-1356.

PFMC. 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by Amendment 18. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon.

Popper, A.N. 2005. A review of hearing by sturgeon and lamprey. Report submitted to the U.S. Army Corps of Engineers, Portland District, by Environmental BioAcoustics, LLC, Rockville, Maryland. August 12, 2005, 23 pages.

Popper, A.N., M.E. Smith, P.A. Cott, B.W. Hanna, A.O. MacGillivray, M.E. Austin, and D.A. Mann. 2005. Effects of Exposure to Seismic Airgun Use on Hearing of Three Fish Species. Journal of American Acoustic Society, 117:3958-3971.

Popper, A.N., and M.C. Hastings. 2009. The effects of human-generated sound on fish. Integrative Zoology 4:43-52.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, M.B. Halvorsen, S. Løkkeberg, P.H. Rogers, B.L. Southall, D.G. Zeddies, and W.N. Tavolga. 2014. Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. 87 pages.

Radtke, L.D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin Delta with observations on food of sturgeon. Pages 115-129 in: J.L. Turner and D.W. Kelley (*editors*). Ecological studies of the Sacramento-San Joaquin Delta Part II: Fishes of the Delta. California Department of Fish and Game Fish Bulletin.

Raymondi, R.R., J.E. Cuhaciyan, P. Glick, S.M. Capalbo, L.L. Houston, S.L. Shafer, and O. Grah. 2013. Water Resources: Implications of Changes in Temperature and Precipitation. *In* Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, edited by M.M. Dalton, P.W. Mote, and A.K. Snover, 41-58. Island Press, Washington, D.C.

Reeder, W.S., P.R. Ruggiero, S.L. Shafer, A.K. Snover, L.L Houston, P. Glick, J.A. Newton, and S.M Capalbo. 2013. Coasts: Complex Changes Affecting the Northwest's Diverse Shorelines. *In* Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, edited by M.M. Dalton, P.W. Mote, and A.K. Snover, 41-58. Island Press, Washington, DC.

Rhoads, D.C., and J.D. Germano. 1986. Interpreting long-term changes in benthic community structure: a new protocol. Hydrobiology 142, 291–308.

Robinson, D.G., W.E. Barraclough, and J.D. Fulton. 1968. Data record. Number, size composition, weight, and food of larval and juvenile fish caught with a two-boat surface trawl in the Strait of Georgia, June 5–9, 1967. Fisheries Research Board of Canada Manuscript. Rep. Ser. 972.

Robinson, S.P., P.D. Theobald, G. Hayman, L.S. Wang, P.A. Lepper, V. Humphrey, and S. Mumford. 2011. Measurement of underwater noise arising from marine aggregate dredging operations. Marine Aggregate Levy Sustainability Fund (MALSF). MEPF 09/P108.http://www.cefas.defra.gov.uk/media/462859/mepf%20p108%20final%20report.pdf

Rogers, I. H., I. K. Birtwell, and G. M. Kruzynski. 1990. The Pacific eulachon (*Thaleichthys pacificus*) as a pollution indicator organism in the Fraser River estuary, Vancouver, British Columbia. Sci. Total Environ. 97(98):713–727.

Rondorf, D.W., G.L. Rutz, and J.C. Charrier. 2010. Minimizing Effects of Over-Water Docks on Federally Listed Fish Stocks in McNary Reservoir: A Literature Review for Criteria. Report U.S. Geological Survey, Columbia River Research Laboratory to the U.S. Army Corps of Engineers, Walla Walla District, Report number: 2010-W68SBV91602084.

Sardella, B.A., E. Sanmarti, and D. Kultz. 2008. The acute temperature tolerance of green sturgeon (*Acipenser medirostris*) and the effect of environmental salinity. Journal of Experimental Zoology 309(A):477-483.

Scheuerell, M.D., and J.G. Williams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*). Fisheries Oceanography 14:448-457.Shared Strategy for Puget Sound. 2007. Puget Sound salmon recovery plan. Volume 1, recovery plan. Shared Strategy for Puget Sound. Seattle.

Schroeder, R.K., K.R. Kenaston, and L.K. McLaughlin. 2007. Spring Chinook in the Willamette and Sandy Basins. Annual Progress Report, Fish Research Project Number F-163-R- 11/12. Oregon Department of Fish and Wildlife, Salem, OR.

Schroeder, R.K., L.D. Whitman, B. Cannon, and P. Olmsted. 2016. Juvenile life-history diversity and population stability of spring Chinook salmon in the Willamette River basin, Oregon. Canadian Journal of Fisheries and Aquatic Sciences 73:921-934.

Simenstad, C.A., L.F. Small, and C.D. McIntire. 1990. Consumption process and food web structure in the Columbia River Estuary. Progress in Oceanography 25(1-4): 271-297.

Smith, W. E., and R. W. Saalfeld. 1955. Studies on Columbia River smelt *Thaleichthys pacificus* (Richardson). Washington Dept. Fisheries, Olympia. Fisheries Research Papers 1(3):3–26.

Stadler, J.H., and D.P. Woodbury. 2009. Assessing the effects to fishes from pile driving: application of new hydroacoustic guidelines. Inter-Noise 2009.

Sunda, W. G., and W. J. Cai. 2012. Eutrophication induced CO2-acidification of subsurface coastal waters: interactive effects of temperature, salinity, and atmospheric p CO2. *Environmental Science & Technology*, 46(19): 10651-10659

Tabor, R.A., K.L. Fresh, R.M. Piaskowski, H.A. Gearns, and D.B. Hayes. Habitat use by juvenile Chinook salmon in the nearshore areas of Lake Washington: effects of depth, lakeshore development, substrate, and vegetation. North American Journal of Fisheries Management 31(4): 700-713. DOI: 10.1080/02755947.2011.611424.

Tague, C.L., J.S. Choate, and G. Grant. 2013. Parameterizing sub-surface drainage with geology to improve modeling streamflow responses to climate in data limited environments. Hydrology and Earth System Sciences 17(1): 341-354

Thorpe, J.E. 1994. Salmonid fishes and the estuarine environment. Estuaries and Coasts 24(1a):74-93.

Tillmann, P. and D. Siemann. 2011. Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation Cooperative Region. National Wildlife Federation.

UCSRB (Upper Columbia Salmon Recovery Board). 2007. Upper Columbia spring Chinook salmon and steelhead recovery plan. August 2007.

USDC (United States Department of Commerce). 2009. Endangered and threatened wildlife and plants: final rulemaking to designate critical habitat for the threatened southern distinct population segment of North American green sturgeon. U.S. Department of Commerce, National Marine Fisheries Service. Federal Register 74(195):52300-52351.

USDC. 2011. Endangered and threatened species: designation of critical habitat for the southern distinct population segment of eulachon. U.S. Department of Commerce, National Marine Fisheries Service. Federal Register 76(203):65324-65352.

Wardle, C.S., T.J. Carter, and G.G. Urquhart. 2001. Effects of seismic airguns on marine fish. Continental Shelf Resources 21: 1005–1027.

WDOE (Washington State Department of Ecology). 2011. Piers, Docks and Overwater Structures. Shoreline Master Planning Program Planning Process Handbook. Phase 3, Task 3.4 Publication Number 11-06-010. 26 pages.

Weston Solutions, Inc. 2004. Jimmycomelately Piling Removal Monitoring Project. Final Report *prepared for* the Jamestown S'Klallam Tribe. March 2006. 109 pages.

Wilkens, J.L., A.W. Katzenmeyer, N.M. Hahn, J.J. Hoover, and B.C. Suedel. 2015. Laboratory tests of suspended sediment effects on short-term survival and swimming performance of juvenile Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*, Mitchell, 1815). Journal of Applied Ichthyology pages 1-7.

Winder, M. and D. E. Schindler. 2004. Climate change uncouples trophic interactions in an aquatic ecosystem. Ecology 85: 2100–2106.

Wissmar, R.C., J.E. Smith, B.A. McIntosh, H.W. Li, G.H. Reeves, and J.R. Sedell. 1994. Ecological Health of River Basins in Forested Regions of Eastern Washington and Oregon. Gen. Tech. Rep. PNW-GTR-326. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, OR. 65 pages.

Wysocki, L.E., J.P. Dittami, and F. Ladich. 2006. Ship noise and cortisol secretion in European freshwater fishes. Biological Conservation 128:501–508.

Zabel, R.W., M.D. Scheuerell, M.M. McClure, and J.G. Williams. 2006. The interplay between climate variability and density dependence in the population viability of Chinook salmon. Conservation Biology 20(1):190-200.