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

Refer to NMFS No.:
WCRO-2023-02346

February 26, 2025

P. Allen Atkins
Chief, Regulatory Branch
Department of the Army
U.S. Army Corps of Engineers, Seattle District
4735 East Marginal Way South, BLDG 1202
Seattle, Washington 98134-2388

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Weyerhaeuser Log Export Dock Replacement (USACE No.: NWS-2023-668)

Dear Mr. Atkins:

Thank you for your letter of September 29, 2023, 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 the U.S. Army Corps of Engineers' (Corps) authorization of the Weyerhaeuser Log Export dock replacement project, located in Township 7 North, Range 2 West, Section 8, near river mile (RM) 66 of the Columbia River. The site is in the Water Resource Inventory Area 25 (Grays-Elochoman) in U.S. Geological Survey HUC: 17080003 (Lower Columbia-Clatskanie Watershed).

Thank you also for your request for essential fish habitat (EFH) consultation. NMFS reviewed the proposed action for potential effects on EFH pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), implementing regulations at 50 CFR 600.920, and agency guidance for use of the ESA consultation process to complete EFH consultation. We have concluded that the action would adversely affect EFH designated under the Pacific Coast Salmon and Pacific Coast Groundfish and have included conservation recommendations to avoid, minimize, or otherwise offset potential adverse effects on EFH.

In this biological opinion, NMFS concludes that the proposed action is likely to adversely affect, but not likely to jeopardize the continued existence nor adversely modify the critical habitat of:

- Chinook Salmon *(Oncorhynchus tshawytscha)*;
    - Lower Columbia River (LCR) Chinook salmon
    - Upper Willamette River (UWR) Chinook salmon
    - Upper Columbia River (UCR) spring-run Chinook salmon
    - Snake River (SR) spring/summer-run Chinook salmon
    - SR fall-run Chinook salmon
- LCR coho salmon (*O. kisutch)*
- Columbia River (CR) chum salmon (*O. keta)*
- SR sockeye salmon (*O. nerka)*

- Steelhead (*O. mykiss*);
    - LCR steelhead
    - UWR steelhead
    - Middle Columbia River (MCR) steelhead
    - UCR steelhead
    - Snake River Basin (SRB) steelhead
- Southern DPS of Pacific Eulachon (*Thaleichthys pacificus*)

NMFS concurred with the Corps' determination that the proposed action is not likely to adversely affect the following species or their designated critical habitat:

- Southern DPS of green sturgeon (*Acipenser medirostris*) (hereafter also referred to as green sturgeon)

This opinion includes an incidental take statement (ITS) that describes reasonable and prudent measures (RPMs) NMFS considers necessary or appropriate to minimize the incidental take associated with this action, and sets forth nondiscretionary terms and conditions that the Corps and the applicant must comply with to meet those 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.

Please contact Logan Kent in Lacey, Washington, at logan.kent@noaa.gov, or (253)-948-4205) if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Kathleen Wells
Assistant Regional Administrator
Oregon Washington Coastal Office

cc: Danette Guy, Project Manager, USACE

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

Weyerhaeuser Log Export Dock Replacement
(USACE No.: NWS-2023-668)

NMFS Consultation Number: WCRO-2023-02346

Action Agency: U.S. Army Corps of Engineers

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	If likely to adversely affect, Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	If likely to adversely affect, is Action Likely to Destroy or Adversely Modify Critical Habitat?
Snake River steelhead	Threatened	Yes	No	Yes	No
Lower Columbia River steelhead	Threatened	Yes	No	Yes	No
Middle Columbia River steelhead	Threatened	Yes	No	Yes	No
Upper Columbia River steelhead	Threatened	Yes	No	Yes	No
Upper Willamette River steelhead	Threatened	Yes	No	Yes	No
Upper Columbia River Spring-Run Chinook salmon	Endangered	Yes	No	Yes	No
Lower Columbia River Chinook salmon	Threatened	Yes	No	Yes	No
Upper Willamette River Chinook salmon	Threatened	Yes	No	Yes	No
Snake River spring/summer Chinook salmon	Threatened	Yes	No	Yes	No
Snake River fall-run Chinook salmon	Threatened	Yes	No	Yes	No
Columbia River chum	Threatened	Yes	No	Yes	No
Lower Columbia River coho salmon	Threatened	Yes	No	Yes	No
Snake River sockeye Salmon	Endangered	Yes	No	Yes	No
Southern DPS eulachon	Threatened	Yes	No	Yes	No
Southern DPS North American green sturgeon	Threatened	No	No	No	No

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

Consultation Conducted By: National Marine Fisheries Service
West Coast Region

Issued By:

Kathleen Wells
Assistant Regional Administrator
Oregon Washington Coastal Office

Date: February 26, 2025

TABLE OF CONTENTS

1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3, below.

1.1. Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 et seq.), as amended, and implementing regulations at 50 CFR part 402.

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

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

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on May 6, 2024 (89 Fed. Reg. 24268). We are applying the updated regulations to this consultation. The 2024 regulatory changes, like those from 2019, were intended to improve and clarify the consultation process, and, with one exception from 2024 (offsetting reasonable and prudent measures), were not intended to result in changes to the Services' existing practice in implementing section 7(a)(2) of the Act. 89 Fed. Reg. at 24268; 84 Fed. Reg. at 45015. We have considered the prior rules and affirm that the substantive analysis and conclusions articulated in this biological opinion and incidental take statement would not have been any different under the 2019 regulations or pre-2019 regulations.

1.2. Consultation History

On September 29, 2023, NMFS received a request for formal consultation from the U.S. Army Corps of Engineers (Corps), on behalf of the applicant Weyerhaeuser Company (Weyerhaeuser), with submitted materials including a Biological Assessment (BA) and site drawings. NMFS initiated formal consultation on December 5, 2024.

Additionally, NMFS Protected Resources Division (PRD) staff received a permit application from Weyerhaeuser and the Corps for authorization to take marine mammals incidental to the project. PRD authorized an Incidental Harassment Authorization (IHA) pursuant to the Marine Mammal Protection Act (MMPA), published in the federal register.

On January 3, 2025, NMFS received an updated Biological Assessment and Hydraulic Project Authorization (HPA) issued by Washington Department of Fish and Wildlife (WDFW). These updated materials were provided by the Corps and filed by NMFS on January 3, 2025. Additionally, the applicant informed NMFS that annual piling replacements (Section 1.3), occurred in 2023 but not in 2024 and that occurrence of this activity during future in-water work window's (IWWW) is anticipated.

Prior to the current request for formal consultation to determine the feasibility of reconstructing the dock using larger pile sizes, the applicant implemented a Test Pile Program in November 2021, that involved the installation of two 30-inch diameter steel test piles. The Test Pile Program was the subject of a previous Endangered Species Act (ESA) Section 7 consultation, resulting in a Biological Opinion from NMFS (refer to NMFS No.: WCRO-2020-03117). The purpose of the Test Pile Program was to validate previous geotechnical assumptions and confirm pile bearing capacities and drivability during the conceptual design phase. The results were used to inform the design and impact minimization measures proposed for the dock replacement (i.e., the subject of this requested consultation).

Further email exchange is as follows:

- On January 13, the applicant responded to our request for more information regarding stormwater treatment on site, the specs of pile sizing during annual replacements, and rationale for a confined vs. unconfined bubble curtain.
- On January 14, NMFS communicated questions regarding the inclusion of hydroacoustic monitoring in the proposed action.
- On January 14, the applicant responded requesting further clarification from NMFS.

This opinion is based on the information in the documents and emails identified above; recovery plans, status reviews, and critical habitat designations for ESA-listed species; published and unpublished scientific information on the biology and ecology of those species; and relevant scientific and gray literature (see References).

1.3. Proposed Federal Action

Project justification and Background

Under the ESA, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (see 50 CFR 402.02).

The Corps is proposing to authorize the reconstruction of the applicant's existing log export dock, located on the lower Columbia River (LCR) near Longview, Washington at RM 66 (Figure 1). The dock serves as a major part of the applicant's marine terminal facility and is used primarily to stage and un/load logs from and onto ships for global export.

The existing (original) timber dock was constructed in the early 1970s and has exceeded its designed lifespan. The existing structure consists of more than 2,000 16-inch diameter creosote timber piles, with 16-inch square timber caps supporting a glulam deck and is approximately two football fields in size. The dock requires regular maintenance to repair deteriorated structural elements. These repairs have included the replacement of deteriorated creosote-treated timber piles with steel piles and the reinforcement of creosote-treated timber pile caps with steel. Recent structural condition assessments indicate that deterioration is accelerating due to age and increased shipping operations in recent years. Approximately 50 to 55 vessels are loaded annually at the existing dock and the level of vessel traffic would be maintained following reconstruction of the dock.

Continued deterioration and the associated repairs of timber structural elements that support the dock have led the applicant to pursue a reconstruction design that would replace all of the timber elements with steel and concrete. They propose to replace the existing dock with a new, modern structure that requires less maintenance and is capable of supporting larger ships and heavier equipment. Of further importance, previous geotechnical investigations (GRI 2022) determined that the substrate in which the dock's existing piles are embedded would likely liquefy during a large-magnitude earthquake, causing significant damage to the dock and potentially to surrounding aquatic resources.

To address the abovementioned, the proposed action includes the following elements, each discussed in more detail below. Additionally, to minimize effects on ESA-listed species, the proposed construction schedule is as follows and is additionally summarized in Table 1:

1) September 1 – December 31:
    - *Pile removal* including direct pulling, vibratory extraction, and/or cutting existing piles at or below the mudline.
    - *Pile installation* using a vibratory hammer.

2) October 1 – December 31:
    - *Pile installation*, proofing with an impact hammer. No impact driving would commence prior to October 1.
    - *Placement of armor rock* along the shoreline.

3) Schedule Notes:
    - To complete pile installation within the IWWW, multiple crews are anticipated to work simultaneously to remove and install piles. It is therefore possible that up to two hammers, including any combination of impact and/or vibratory hammers, could be in use simultaneously on any day during the work window.
    - It is anticipated that pile installation would require up to 120 days of pile driving during each phase.
    - Prior to the completion of the dock reconstruction, the annual replacement of 6-10 piles (vibratory removal and installation) would be performed in the currently established IWWW for the LCR (October 1 to December 31).
    - Over-water work and work conducted below the OHWM but outside the wetted perimeter of the river (in the dry) would be conducted year-round.
    - Placement of armor rock along the shoreline would occur outside the IWWW, at any time when the work area is in the dry (low tide, seasonally low water, etc.).

To simplify construction and allow the dock to remain operational during construction, dock replacement would be divided into two phases: Phase 1 consists of demolition and replacement of Berth A (Figure 1) and approximately 10 feet of Berth B (approximately 52 percent of the total dock); Phase 2 consists of demolition and replacement of Berth B, minus the 10 feet that were previously replaced during Phase 1 (approximately 48 percent of the total dock). Both Berth A and B are approximately 600 feet in length. Berth A is located on the upstream side of the dock; Berth B is located downstream of Berth A (Figure 1). Replacement of Berth A & Berth B would require one IWWW to complete pile installation each; Berth B replacement would occur approximately 2 to 5 years after Berth A replacement.

Figure 1 Log Export Dock Plan View, Courtesy of HDR Inc.

Construction staging would occur within developed upland areas at the marine terminal facility adjacent to the existing dock. No clearing of existing vegetation is required. The new dock would have the same overwater footprint as the existing dock, and no expansion of the dock is proposed.

The mooring system at the current facility consists of four mooring dolphins, including two central mooring dolphins and an upstream and downstream dolphin. The interior mooring dolphins have been constructed such that the dock wraps around them. The mooring dolphins are constructed of steel pipe piles and reinforced concrete and are in good condition. Therefore, the existing mooring system would not be removed or replaced as part of the proposed action.

Removal of existing overwater structure
Phase 1 (~2025) - would include the removal of 60,109 square feet of the existing deck (Berth A and 10 feet of Berth B). The existing concrete bulkhead would also be removed during dock replacement. The bulkhead is located landward of the ordinary high-water mark (OHWM) of the LCR; therefore, no in-water work would be required for bulkhead removal. The existing sheet pile wall would remain (Figure 2).

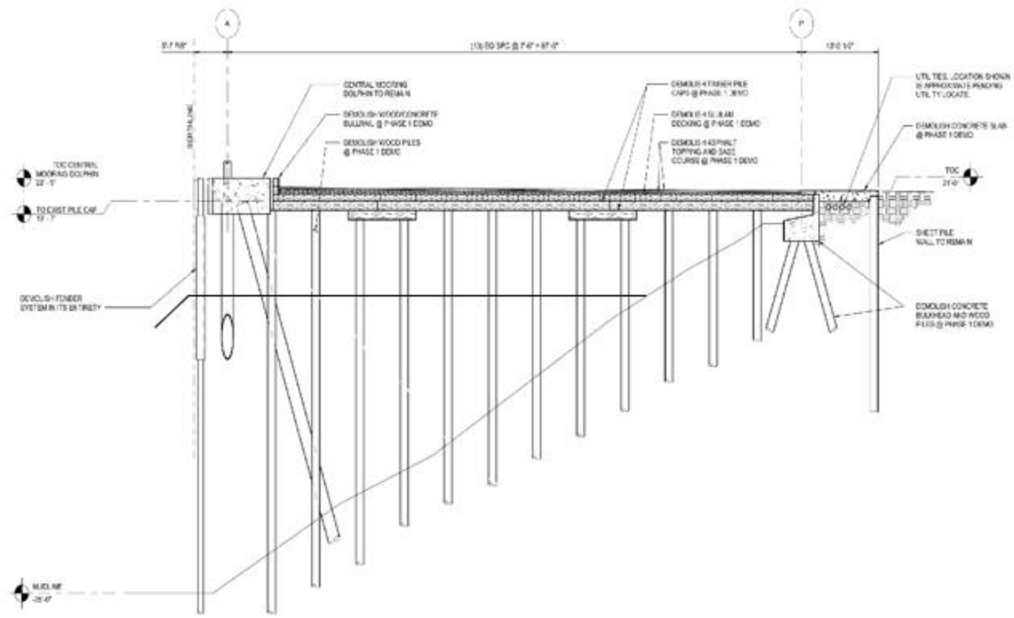

Figure 2. Profile of the existing dock and pile support structure at the Weyerhaeuser facility.

Phase 2 (2-5 years post Phase 1, 2027-30) - would include the removal of the remaining 56,598 square feet of existing deck and would consist of the replacement of Berth B, minus approximately 10 feet of Berth B that would be replaced during Phase 1.

Under both phases, the existing deck would be cut from above using a chainsaw or other means. Netting or similar containment systems would be used to prevent construction materials from falling into the river below. Because the existing timber is creosote-treated, the selected contractor would dispose of existing materials at an approved disposal facility in accordance with applicable laws and regulations.

Pile Removal

Existing piles would be removed from the substrate using the direct pull method. If direct pulling is unsuccessful, vibratory hammer extraction would be utilized. Broken or damaged pilings that cannot be removed by either the vibratory hammer or direct pull would be cut off at or below the mudline. Based on the substrate conditions at the site, it is anticipated that most of the existing timber piles would be removed by direct pull. Existing steel piles would likely be removed by vibratory hammer.

Phase 1 would include the removal of 983 16-inch creosote timber piles, 53 steel piles (primarily 16-inch steel pipe piles with some 12-inch pipe piles and H-piles), and 20 fender piles (14-inch or 16-inch steel pipe piles). Phase 2 would include the removal of 921 16-inch creosote timber piles, 52 steel piles (primarily 16-inch steel pipe piles with some 12-inch pipe piles and H-piles), and 20 fender piles.

When removing creosote piling, containment booms and absorbent booms (or other oil absorbent fabric) would be placed around the perimeter of the work area to capture wood debris, oil, and other materials released into waters as a result of construction activities to remove creosote pilings. All debris on the bed and accumulated in containment structures would be collected and disposed upland at an approved disposal site and in accordance with any local, state and federal statutes. Additional best management practices are discussed in more detail below.

New pile installation

To attain the required seismic resilience, the proposed action would install 30-inch-diameter steel pipe piles rather than the 16-inch-diameter steel pipe piles that have been used in recent years to replace several of the 16-inch timber piles that have deteriorated. The 30-inch piles would be installed much deeper than the existing timber piles and the previously installed steel replacement piles.

In total, the new dock would have approximately 624 30-inch steel pipe piles. Approximately 325 piles would be installed during Phase 1, and 299 piles would be installed during Phase 2. The wall thickness of the 30-inch steel pipe piles would likely be 0.5 inch; however, heavier wall thickness, likely 0.75 inch, may be considered in selected locations as the design progresses. As mentioned previously, the replacement dock would have the same footprint as the existing structure; no expansion of the dock is proposed.

The installation of temporary piles may be installed during the construction period. During each construction phase, up to 26 24-inch steel pipe piles may be temporarily installed to address unforeseen conditions. The temporary piles will be driven with a vibratory hammer.

To complete pile installation within the IWWW, multiple crews would need to work simultaneously to remove and install piles. Installation would require a derrick barge driving piles from the river and another crane driving piles from the shore. The barge would be anchored into the substrate using four spud pipes. Up to two additional barges may be tied to the derrick barge and used to stage pile and dock construction materials, construction equipment, refuse, and personnel. Construction materials would be brought to the site via land-based transport using existing highways or via barge, whichever proves more cost effective.

Each 30-inch steel pipe pile would be installed with both vibratory and impact hammers due to the nature of the substrate. In general, piles can be installed with a vibratory hammer to the dense gravel layer and then would require impact driving between 20 and 30 feet into the gravel layer to achieve the required 400,000-pound allowable capacity.

Piles would be aligned with steel templates to ensure the correct position of the piles relative to each other. An alternative approach to pile installation sequencing involves cutting holes in the existing deck and using the existing dock as a driving template to install new piles. Under this alternative, the existing deck would be demolished and removed following pile installation in each phase. This alternative approach to pile driving sequencing would have the same impacts and overall schedule as the approach described above; therefore, both alternatives are included as part of the Proposed Action.

Pile Driving Schedule

Pile installation would be conducted during standard daylight working hours. Each pile would be installed alternately with vibratory and impact hammers. Each pile would require approximately 1 hour of vibratory hammering and up to 1,000 impact hammer strikes to install. Vibratory pile installation would likely be intermittent and involve multiple starts and stops, as opposed to 1 continuous hour of use. Additionally, it is likely that impact installation would require fewer than 1,000 impact hammer strikes. To reduce underwater noise produced by impact pile driving, an unconfined bubble curtain is proposed to be used during impact pile installation. Pile installation for dock replacement would be conducted during the proposed IWWW to minimize effects to ESA-listed fish. It is conservatively assumed that up to eight piles would be installed each day. This results in a total of 8 hours of vibratory driving and up to 8,000 impact hammer strikes per day. It is conservatively estimated that pile installation would occur up to 120 total days during each Phase, but may not always occur on consecutive days.

Prior to impact pile driving, the contractor is proposing to use a soft start. Soft start would be implemented at the start of each day's pile driving and at any time following cessation of pile driving for a period of 30 minutes or longer. Soft start for impact drivers requires that contractors provide an initial set of three strikes at reduced energy, followed by a 30-second waiting period, and then two subsequent reduced-energy strike sets.

Slope Armoring Restoration

After pile removal and installation is completed during each phase, the slope under the dock is proposed to be graded to restore the intended slope and restore the riprap and filter rock blanket. Approximately 2,000 cubic yards of filter rock and 2,667 cubic yards of Class II riprap would be placed underneath the dock. Filter rock and riprap would be placed in the same footprint as existing armoring and is intended to replace armoring that has been lost over time or is damaged or disturbed due to construction. No expansion of this fill material is proposed compared to existing conditions.

Excavation of the slope would be conducted using land-based or barge-mounted excavators or a clamshell bucket and derrick barge. Riprap would be placed using a clamshell bucket or conveyor. All in-water materials would be placed under the footprint of the existing dock. Turbidity curtains would be placed around equipment operating in-river to remove deteriorated bank armoring and replace with new slope armoring. New rock armoring would be free from organic matter and obtained from Washington State Department of Transportation (WSDOT) approved sources. This work will only be completed when in the dry or during the IWWW.

Deck Construction and Fender System Installation

The new structure is proposed to be a concrete deck supported on steel piles, matching the footprint of the existing dock. Most of the concrete elements would be precast. Once the piles are driven, the use of precast concrete would allow for rapid construction and eliminate the need for complex elevated falsework for most elements. Working from the top of the pile caps up, the structure would be built as follows:

- 12-inch (nominal) precast deck planks;
- 5-inch cast-in-place topping slab;
- Varying thickness of aggregate base; and

- 6-inch asphalt wearing surface.

The finished surface of the replacement dock would match the slope of the existing dock, and the existing stormwater system[1] would not change under the Proposed Action.

The existing fender system uses leg-type fenders to dissipate energy from ships with high-density polyethylene pipe sleeves around the piles that allow barges to use the facility. The fender system would be demolished and replaced with a new fender system. Twenty steel fender piles would be removed from Berth A, and 20 fender piles would be removed from Berth B. The new fender panel system is proposed to have rubber fender units, similar to the existing system; however, no fender piles would be used. The fender panels would be of sufficient length to allow smaller barges to berth, in addition to Handysize vessels, with concrete dropdowns cast into the bullrail to support an additional conical fender unit (two per fender panel).

Annual Pile Replacement
For maintenance purposes, the applicant proposes to replace approximately 6-10 piles annually until both berths of the existing dock are replaced. As part of this activity, deteriorated timber piles would be replaced with 16-inch steel piles as steel piles have more weight-bearing capacity and are preferred for structural integrity, particularly along the face of the structure where piles are much longer. Steel piles installed as part of this annual maintenance activity would be retained and used as part of the replacement dock structure. Piling replacements would be completed using a vibratory hammer.

Best Management Practices (BMP)
Under the Proposed Action, the Corps proposes to authorize the applicant to implement a number of impact minimization measures to avoid or reduce the potential for adverse effects upon aquatic resources, including ESA-listed species and their habitat. Construction will be completed in compliance with Washington State Water Quality Standards (Chapter 173-201A Washington Administrative Code [WAC]). The following conservation measures are proposed as part of the Proposed Action:

- Petroleum products, fresh cement, lime, uncured concrete, chemicals, or other toxic or deleterious materials will not be allowed to enter surface waters.
- No oil, fuels, or chemicals will be discharged to surface waters or onto land where there is a potential for re-entry into surface waters.
- Forms for any cast-in-place concrete structure will be constructed to prevent leakage of wet concrete; concrete forms will not be removed until concrete is cured for a minimum of 7 days.
- Water used during the placement of concrete for washdown or related operations will not be allowed to enter the LCR. Any process water/contact water will be routed to a contained area for treatment and will be disposed of at an authorized upland location.

[1] Existing stormwater sheet flows from the dock away from the berthline toward the laydown yard and then to a detention pond on the North side of the site via sheet flow and catch basins/piping.

- Pile Installation and Removal:
    - To reduce underwater noise produced by impact pile driving, an unconfined bubble curtain will be used during impact pile installation.
    - A vibratory hammer will be used to drive steel piles to the greatest extent possible to minimize underwater noise levels.
    - Pile installation for dock replacement will be conducted during the pile installation work window of September 1 to December 31, impact driving will only occur starting October 1) to minimize effects to ESA-listed fish.
    - Prior to full dock replacement, the annual replacement of 6-10 piles will be performed in the currently established IWWW for the LCR (October 1 to December 31).
    - Pile installation will only occur during daylight hours, when visual monitoring of marine mammals and fish can be conducted.
    - Prior to impact pile driving, the contractor will be required to use a soft start. Soft start for impact drivers requires that contractors provide an initial set of three strikes at reduced energy, followed by a 30-second waiting period, and then two subsequent reduced-energy strike sets.
    - Soft start shall be implemented at the start of each day’s pile driving and at any time following cessation of pile driving for a period of 30 minutes or longer.
    - When removing creosote piling, containment booms and absorbent booms (or other oil absorbent fabric) must be placed around the perimeter of the work area to capture wood debris, oil, and other materials released into waters as a result of construction activities to remove creosote pilings. All debris on the bed and accumulated in containments structures must be collected and disposed upland at an approved disposal site.
    - Vibratory or direct pull extraction is the preferred method of pile removal.
    - Pilings will be placed on a construction barge or other dry storage site after the piling is removed. The piling will not be shaken, hosed off, left hanging to dry or any other action intended to clean or remove adhering material from the piling near waters of the U.S.
    - If a treated wood piling breaks during extraction, the remaining pile portion will be removed from the water column by fully extracting. If the remaining pile cannot be fully extracted, the remaining portion will be removed with a clamshell bucket, chain, or similar means, or cut off three feet below the mudline. If broken piles are cut below the mud line, the sediment and remaining pile will be capped; all holes left by piling extraction will be filled with clean sediment that matches the native material in size and character.
- Slope Restoration:
    - Turbidity curtains will be placed around equipment operating in-river when removing deteriorated bank armoring and replacing it with new slope armoring.
    - New rock armoring will be free from organic matter and obtained from WSDOT approved sources.
- Overwater Work:
    - Netting or a similar system will be used to prevent demolition debris from falling into the LCR.

    - Excess or waste materials will not be disposed of or abandoned waterward of the OHWM or allowed to enter surface waters. Waste material will be disposed of in an appropriate manner consistent with applicable local, state, and federal regulations.
    - Construction materials will not be stored where wave action can cause materials to enter surface waters.
- Spill Response and Prevention**:**
    - Fuel hoses, oil drums, oil or fuel transfer valves, fitting, and similar equipment will be checked regularly for leaks, and materials will be maintained and stored properly to prevent spills.
    - Corrective actions will be taken in the event of any discharge of oil, fuel, or chemicals into the water. These actions will include beginning containment and cleanup efforts immediately upon discovery of the spill and completing them in an expeditious manner in accordance with all applicable local, state, and federal regulations. Spill response will take precedence over normal work. Cleanup will include proper disposal of any spilled material and used cleanup material.
    - Oil-absorbent materials will be present on-site for use in the event of a spill or if any oil product is observed in the water.
    - Vessel operators will have industry-standard spill containment equipment on board, including oil booms.
    - Crane and pile hammer operators will evaluate the use of vegetable oil for lubricants, rather than hydrocarbon-based lubricants, to the greatest extent possible.
    - The Corps and applicant will require that the selected Contractor create a Spill Prevention, Control, and Countermeasures Plan (SPCCP). The SPCCP will be developed, implemented, and maintained to manage toxic materials associated with construction activities (e.g., equipment leakage, disposal of oily wastes, cleanup of spills, and storage of petroleum products/chemicals in contained areas away from streams and wetlands). The SPCCP will outline BMPs, responsive actions in the event of a spill or release, and notification and reporting procedures. The SPCCP will also outline management elements such as personnel responsibilities, site security, site inspections, and training.
    - Applicable spill response equipment and material designated in the SPCCP will be maintained at the job site.

Table 1. Summary of pile size, number, and material proposed for removal and installation.

Project Phase	Number Piles	Diameter of Piles	Material of Piles	Method	Timeline
Phase 1 Removal	990	16-inch	Creosote	Direct Pull[1]	Sep 1 – Dec 31; Up to 1 hour per pile[2]
	46	16-inch or 12-inch	Steel (pipe and H pile)	Vibratory Hammer	
	20	14-ich or 16-inch	Steel fender pile cans		
	26	24-inch	Steel pile (temporary)	Vibratory Hammer	Sep 1 – Dec 31, Up to 1 hour per pile
Phase 1 Installation	325	30-inch	Steel pile	Vibratory (V) followed by Impact (I) Hammer[3]	Sep 1 – Dec 31 (V), Oct 1 – Dec 31 (I), Up to 1,000 strikes per pile[5], Up to 1 hour per pile, up to 8 piles per day
	26[6]	24-inch	Steel pipe pile (temporary)	Vibratory Hammer[4]	
Phase 2 Removal	921	16-inch	Creosote	Direct Pull	Sep 1 – Dec 31, Up to 1 hour per pile
	52	16-inch or 12-inch	Steel (pipe and H pile)	Vibratory Hammer	
	20	14-inch or 16-inch	Steel fender pile cans		
	26	24-inch	Steel pipe pile (temporary)	Vibratory Hammer	Sep 1 – Dec 31, Up to 1 hour
Phase 2 Installation	229	30-inch	Steel pile	Vibratory followed by Impact Hammer	Sep 1 – Dec 31 (V), Oct 1 – Dec 31 (I), Up to 1,000 strikes per pile (up to 8 piles per day)
	26	24-inch	Steel pile (temporary)	Vibratory Hammer	

[1] Based on substrate conditions at the site, it is anticipated that most of the existing timber piles will be removed by direct pull. If direct pull is unsuccessful, vibratory hammer will be used. Steel piles will likely be removed by vibratory hammer.
[2] It is conservatively assumed that the duration of vibratory pile removal will be roughly the same as vibratory pile installation (i.e., up to 1 hour).
[3] Each 30-inch steel pipe pile will be installed with both vibratory and impact hammers due to the nature of the substrate.
[4] Vibratory pile installation will likely be intermittent and involve multiple starts and stops, as opposed to 1 continuous hour of use.
[5] It is likely that impact installation will require fewer than 1,000 impact hammer strikes; however, a conservative estimate has been provided to assist take evaluation for ESA-listed fish.
[6] Up to twenty-six 24-inch steel pipe piles will be installed and later removed during each construction phase.

We considered, under the ESA, whether or not the proposed action would cause any other activities and determined that it would cause the following activities: Reconstruction of the existing dock facilitates, prolongs and potentially expands upon (in volume of shipped goods or frequency) the use of said dock for vessel traffic and related heavy industrial practices into the future. The consequence is an unrealized opportunity for critical habitat restoration in the project footprint, continued degradation of baseline conditions due to regular and recurring maintenance and continued unintentional introduction of legacy contaminants and chemicals into the habitat. This prolonged use is likely to chronically expose ESA-listed species and their critical habitat to a variety of disturbances.

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

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

2.1. Analytical Approach

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

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

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

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

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

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

2.2. Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that 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. Major ecological realignments are already occurring in response to climate change (IPCC WGII, 2022). Long-term trends in warming have continued at global, national and regional scales. Global surface temperatures in the last decade (2010s) were estimated to be 1.09 °C higher than the 1850-1900 baseline period, with larger increases over land ~1.6 °C compared to oceans ~0.88 (IPCC WGI, 2021). The vast majority of this warming has been attributed to anthropogenic releases of greenhouse gases (IPCC WGI, 2021). Globally, 2014-2018 were the 5 warmest years on record both on land and in the ocean (2018 was the 4th warmest) (NOAA NCEI 2022). Events such as the 2013-2016 marine heatwave

(Jacox et al. 2018) have been attributed directly to anthropogenic warming in the annual special issue of Bulletin of the American Meteorological Society on extreme events (Herring et al. 2018). Global warming and anthropogenic loss of biodiversity represent profound threats to ecosystem functionality (IPCC WGII 2022). These two factors are often examined in isolation, but likely have interacting effects on ecosystem function.

Updated projections of climate change are similar to or greater than previous projections (IPCC WGI, 2021). NMFS is increasingly confident in our projections of changes to freshwater and marine systems because every year brings stronger validation of previous predictions in both physical and biological realms. Retaining and restoring habitat complexity, access to climate refuges (both flow and temperature) and improving growth opportunity in both freshwater and marine environments are strongly advocated in the recent literature (Siegel and Crozier 2020). Climate change is systemic, influencing freshwater, estuarine, and marine conditions. Other systems are also being influenced by changing climatic conditions. Literature reviews on the impacts of climate change on Pacific salmon (Crozier 2014, 2016, 2017, Crozier and Siegel 2018, Siegel and Crozier 2019, 2020) have collected hundreds of papers documenting the major themes relevant for salmon. Here we describe habitat changes relevant to Pacific salmon and steelhead, prior to describing how these changes result in the varied specific mechanisms impacting these species in subsequent sections.

Forests

Climate change will impact forests of the western U.S., which dominate the landscape of many watersheds in the region. Forests are already showing evidence of increased drought severity, forest fire, and insect outbreak (Halofsky et al. 2020). Additionally, climate change will affect tree reproduction, growth, and phenology, which will lead to spatial shifts in vegetation. Halofsky et al. (2018) projected that the largest changes will occur at low- and high-elevation forests, with expansion of low-elevation dry forests and diminishing high-elevation cold forests and subalpine habitats.

Forest fires affect salmon streams by altering sediment load, channel structure, and stream temperature through the removal of canopy. Holden et al. (2018) examined environmental factors contributing to observed increases in the extent of forest fires throughout the western U.S. They found strong correlations between the number of dry-season rainy days and the annual extent of forest fires, as well as a significant decline in the number of dry-season rainy days over the study period (1984-2015). Consequently, predicted decreases in dry-season precipitation, combined with increases in air temperature, will likely contribute to the existing trend toward more extensive and severe forest fires and the continued expansion of fires into higher elevation and wetter forests (Alizedeh 2021).

Agne et al. (2018) reviewed literature on insect outbreaks and other pathogens affecting coastal Douglas-fir forests in the Pacific Northwest and examined how future climate change may influence disturbance ecology. They suggest that Douglas-fir beetle and black stain root disease could become more prevalent with climate change, while other pathogens will be more affected by management practices. Agne et al. (2018) also suggested that due to complex interacting effects of disturbance and disease, climate impacts will differ by region and forest type.

Freshwater Environments
The following is excerpted from Siegel and Crozier (2019), who present a review of recent scientific literature evaluating effects of climate change, describing the projected impacts of climate change on instream flows:

Cooper et al. (2018) examined whether the magnitude of low river flows in the western U.S., which generally occur in September or October, are driven more by summer conditions or the prior winter's precipitation. They found that while low flows were more sensitive to summer evaporative demand than to winter precipitation, interannual variability in winter precipitation was greater. Malek et al. (2018), predicted that summer evapotranspiration is likely to increase in conjunction with declines in snowpack and increased variability in winter precipitation. Their results suggest that low summer flows are likely to become lower, more variable, and less predictable.

The effect of climate change on ground water availability is likely to be uneven. Sridhar et al. (2018) coupled a surface-flow model with a ground-flow model to improve predictions of surface water availability with climate change in the Snake River Basin. Projections using RCP 4.5 and 8.5 emission scenarios suggested an increase in water table heights in downstream areas of the basin and a decrease in upstream areas.

As cited in Siegel and Crozier (2019), Isaak et al. (2018), examined recent trends in stream temperature across the Western U.S. using a large regional dataset. Stream warming trends paralleled changes in air temperature and were pervasive during the low-water warm seasons of 1996-2015 (0.18-0.35°C/decade) and 1976-2015 (0.14-0.27°C/decade). Their results show how continued warming will likely affect the cumulative temperature exposure of migrating sockeye salmon *O. nerka* and the availability of suitable habitat for brown trout *Salmo trutta* and rainbow trout *O. mykiss*. Isaak et al. (2018) concluded that most stream habitats will likely remain suitable for salmonids in the near future, with some becoming too warm. However, in cases where habitat access is currently restricted by dams and other barriers salmon and steelhead will be confined to downstream reaches typically most at risk of rising temperatures unless passage is restored (FitzGerald et al. 2020, Myers et al. 2018).

Streams with intact riparian corridors and that lie in mountainous terrain are likely to be more resilient to changes in air temperature. These areas may provide refuge from climate change for a number of species, including Pacific salmon. Krosby et al. (2018), identified potential stream refugia throughout the Pacific Northwest based on a suite of features thought to reflect the ability of streams to serve as such refuges. Analyzed features include large temperature gradients, high canopy cover, large relative stream width, low exposure to solar radiation, and low levels of human modification. They created an index of refuge potential for all streams in the region, with mountain area streams scoring highest. Flat lowland areas, which commonly contain migration corridors, were generally scored lowest, and thus were prioritized for conservation and restoration. However, forest fires can increase stream temperatures dramatically in short time-spans by removing riparian cover (Koontz et al. 2018), and streams that lose their snowpack with climate change may see the largest increases in stream temperature due to the removal of temperature buffering (Yan et al. 2021). These processes may threaten some habitats that are currently considered refugia.

Marine and Estuarine Environments
Along with warming stream temperatures and concerns about sufficient groundwater to recharge streams, a recent study projects nearly complete loss of existing tidal wetlands along the U.S. West Coast, due to sea level rise (Thorne et al. 2018). California and Oregon showed the greatest threat to tidal wetlands (100%), while 68% of Washington tidal wetlands are expected to be submerged. Coastal development and steep topography prevent horizontal migration of most wetlands, causing the net contraction of this crucial habitat.

Rising ocean temperatures, stratification, ocean acidity, hypoxia, algal toxins, and other oceanographic processes will alter the composition and abundance of a vast array of oceanic species. In particular, there will be dramatic changes in both predators and prey of Pacific salmon, salmon life history traits and relative abundance. Siegel and Crozier (2019) observe that changes in marine temperature are likely to have a number of physiological consequences on fishes themselves. For example, in a study of small planktivorous fish, Gliwicz et al. (2018) found that higher ambient temperatures increased the distance at which fish reacted to prey. Numerous fish species (including many tuna and sharks) demonstrate regional endothermy, which in many cases augments eyesight by warming the retinas. However, Gliwicz et al. (2018) suggest that ambient temperatures can have a similar effect on fish that do not demonstrate this trait. Climate change is likely to reduce the availability of biologically essential omega-3 fatty acids produced by phytoplankton in marine ecosystems. Loss of these lipids may induce cascading trophic effects, with distinct impacts on different species depending on compensatory mechanisms (Gourtay et al. 2018). Reproduction rates of many marine fish species are also likely to be altered with temperature (Veilleux et al. 2018). The ecological consequences of these effects and their interactions add complexity to predictions of climate change impacts in marine ecosystems.

Perhaps the most dramatic change in physical ocean conditions will occur through ocean acidification and deoxygenation. It is unclear how sensitive salmon and steelhead might be to the direct effects of ocean acidification because of their tolerance of a wide pH range in freshwater (although see Ou et al. 2015 and Williams et al. 2019), however, impacts of ocean acidification and hypoxia on sensitive species (e.g., plankton, crabs, rockfish, groundfish) will likely affect salmon indirectly through their interactions as predators and prey. Similarly, increasing frequency and duration of harmful algal blooms may affect salmon directly, depending on the toxin (e.g., saxitoxin vs domoic acid), but will also affect their predators (seabirds and mammals). The full effects of these ecosystem dynamics are not known but will be complex. Within the historical range of climate variability, less suitable conditions for salmonids (e.g., warmer temperatures, lower streamflows) have been associated with detectable declines in many of these listed units, highlighting how sensitive they are to climate drivers (Ford 2022, Lindley et al. 2009, Williams et al. 2016, Ward et al. 2015). In some cases, the combined and potentially additive effects of poorer climate conditions for fish and intense anthropogenic impacts caused the population declines that led to these population groups being listed under the ESA (Crozier et al. 2019).

Climate change effects on salmon and steelhead
In freshwater, year-round increases in stream temperature and changes in flow will affect physiological, behavioral, and demographic processes in salmon, and change the species with

which they interact. For example, as stream temperatures increase, many native salmonids face increased competition with more warm-water tolerant invasive species. Changing freshwater temperatures are likely to affect incubation and emergence timing for eggs, and in locations where the greatest warming occurs may affect egg survival, although several factors impact intergravel temperature and oxygen (e.g., groundwater influence) as well as sensitivity of eggs to thermal stress (Crozier et al. 2020). Changes in temperature and flow regimes may alter the amount of habitat and food available for juvenile rearing, and this in turn could lead to a restriction in the distribution of juveniles, further decreasing productivity through density dependence. For migrating adults, predicted changes in freshwater flows and temperatures will likely increase exposure to stressful temperatures for many salmon and steelhead populations, and alter migration travel times and increase thermal stress accumulation for ESUs or DPSs with early-returning (i.e. spring- and summer-run) phenotypes associated with longer freshwater holding times (Crozier et al. 2020, FitzGerald et al. 2020). Rising river temperatures increase the energetic cost of migration and the risk of en route or pre-spawning mortality of adults with long freshwater migrations, although populations of some ESA-listed salmon and steelhead may be able to make use of cool-water refuges and run-timing plasticity to reduce thermal exposure (Keefer et al. 2018, Barnett et al. 2020).

Marine survival of salmonids is affected by a complex array of factors including prey abundance, predator interactions, the physical condition of salmon within the marine environment, and carryover effects from the freshwater experience (Holsman et al. 2012, Burke et al. 2013). It is generally accepted that salmon marine survival is size-dependent, and thus larger and faster growing fish are more likely to survive (Gosselin et al. 2021). Furthermore, early arrival timing in the marine environment is generally considered advantageous for populations migrating through the Columbia River. However, the optimal day of arrival varies across years, depending on the seasonal development of productivity in the California Current, which affects prey available to salmon and the risk of predation (Chasco et al. 2021). Siegel and Crozier (2019) point out the concern that for some salmon populations, climate change may drive mismatches between juvenile arrival timing and prey availability in the marine environment. However, phenological diversity can contribute to metapopulation-level resilience by reducing the risk of a complete mismatch. Carr-Harris et al. (2018), explored phenological diversity of marine migration timing in relation to zooplankton prey for sockeye salmon *O. nerka* from the Skeena River of Canada. They found that sockeye migrated over a period of more than 50 days, and populations from higher elevation and further inland streams arrived in the estuary later, with different populations encountering distinct prey fields. Carr-Harris et al. (2018) recommended that managers maintain and augment such life-history diversity.

Synchrony between terrestrial and marine environmental conditions (e.g., coastal upwelling, precipitation and river discharge) has increased in spatial scale causing the highest levels of synchrony in the last 250 years (Black et al. 2018). A more synchronized climate combined with simplified habitats and reduced genetic diversity may be leading to more synchrony in the productivity of populations across the range of salmon (Braun et al. 2016). For example, salmon productivity (recruits/spawner) has also become more synchronized across Chinook populations from Oregon to the Yukon (Dorner et al. 2018, Kilduff et al. 2014). In addition, Chinook salmon have become smaller and younger at maturation across their range (Ohlberger 2018). Other

Pacific salmon species (Stachura el al. 2014) and Atlantic salmon (Olmos et al. 2020) also have demonstrated synchrony in productivity across a broad latitudinal range.

At the individual scale, climate impacts on salmon in one life stage generally affect body size or timing in the next life stage and negative impacts can accumulate across multiple life stages (Healey 2011; Wainwright and Weitkamp 2013, Gosselin et al. 2021). Changes in winter precipitation will likely affect incubation and/or rearing stages of most populations. Changes in the intensity of cool season precipitation, snow accumulation, and runoff could influence migration cues for fall, winter and spring adult migrants, such as coho and steelhead. Egg survival rates may suffer from more intense flooding that scours or buries redds. Changes in hydrological regime, such as a shift from mostly snow to more rain, could drive changes in life history, potentially threatening diversity within an ESU (Beechie et al. 2006). Changes in summer temperature and flow will affect both juvenile and adult stages in some populations, especially those with yearling life histories and summer migration patterns (Crozier and Zabel 2006; Crozier et al. 2010, Crozier et al. 2019).

At the population level, the ability of organisms to genetically adapt to climate change depends on how much genetic variation currently exists within salmon populations, as well as how selection on multiple traits interact, and whether those traits are linked genetically. While genetic diversity may help populations respond to climate change, the remaining genetic diversity of many populations is highly reduced compared to historic levels. For example, Johnson et al. (2018), compared genetic variation in Chinook salmon from the Columbia River Basin between contemporary and ancient samples. A total of 84 samples determined to be Chinook salmon were collected from vertebrae found in ancient middens and compared to 379 contemporary samples. Results suggest a decline in genetic diversity, as demonstrated by a loss of mitochondrial haplotypes as well as reductions in haplotype and nucleotide diversity. Genetic losses in this comparison appeared larger for Chinook from the mid-Columbia than those from the Snake River Basin. In addition to other stressors, modified habitats and flow regimes may create unnatural selection pressures that reduce the diversity of functional behaviors (Sturrock et al. 2020). Managing to conserve and augment existing genetic diversity may be increasingly important with more extreme environmental change (Anderson et al. 2015), though the low levels of remaining diversity present challenges to this effort (Freshwater 2019). Salmon historically maintained relatively consistent returns across variation in annual weather through the portfolio effect (Schindler et al. 2015), in which different populations are sensitive to different climate drivers. Applying this concept to climate change, Anderson et al (2015) emphasized the additional need for populations with different physiological tolerances. Loss of the portfolio increases volatility in fisheries, as well as ecological systems, as demonstrated for Fraser River and Sacramento River stock complexes (Freshwater et al. 2019, Munsch et al. 2022)

2.2.1. 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	NMFS 2022a; Ford 2022	This ESU comprises 32 independent populations. Relative to baseline VSP levels identified in the recovery plan (Dornbusch 2013), 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; Spring-run Chinook salmon populations in this ESU are generally unchanged; most of the populations are at a "high" or "very high" risk due to low abundances and the high proportion of hatchery-origin fish spawning naturally. Many of the populations in this ESU remain at "high risk," with low natural-origin abundance levels. Overall, we conclude that the viability of the Lower Columbia River Chinook salmon ESU has increased somewhat since 2016, although the ESU remains at "moderate" risk of extinction	• 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	Upper Columbia Salmon Recovery Board 2007	NMFS 2022b; Ford 2022	This ESU comprises four independent populations. Current estimates of natural-origin spawner abundance decreased substantially relative to the levels observed in the prior review for all three extant populations. Productivities also continued to be very low, and both abundance and productivity remained well below the viable thresholds called for in the Upper Columbia Salmon Recovery Plan for all three populations. Based on the information available for this review, the Upper Columbia River spring-run Chinook salmon ESU remains at high risk, with viability largely unchanged since 2016.	• 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 2017a	NMFS 2022c; Ford 2022	This ESU comprises 28 extant and four extirpated populations. There have been improvements in abundance/productivity in several populations relative to the time of listing, but the majority of populations experienced sharp declines in abundance in the recent five-year period Overall, at this time we conclude that the Snake River spring/ summer-run Chinook salmon ESU continues to be at moderate-to-high risk.	• Degraded freshwater habitat • Effects related to the hydropower system in the mainstem Columbia River, • Altered flows and degraded water quality • Harvest-related effects • Predation
Upper Willamette River Chinook salmon	Threatened 6/28/05	NMFS 2011	NMFS 2024; Ford 2022	This ESU comprises seven populations. Abundance levels for all but Clackamas River DIP remain well below their recovery goals. Overall, there has likely been a declining trend in the viability of the Upper Willamette River Chinook salmon ESU since the last review. The magnitude of this change is not sufficient to suggest a change in risk category, however, so the Upper Willamette River Chinook salmon ESU remains at "moderate" risk of extinction.	• 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
Snake River fall-run Chinook salmon	Threatened 6/28/05	NMFS 2017b	NMFS 2022d; Ford 2022	This ESU has one extant population The single extant population in the ESU is currently meeting the criteria for a rating of "viable" developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Complex (NMFS 2017b). The Snake River fall-run Chinook salmon ESU therefore is considered to be at a moderate-to-low risk of extinction.	• 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.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Columbia River chum salmon	Threatened 6/28/05	NMFS 2013	NMFS 2022a; Ford 2022	This species has 17 populations divided into 3 MPGs. 3 populations exceed the recovery goals established in the recovery plan (Dornbusch 2013). The remaining populations have unknown abundances. Abundances for these populations are assumed to be at or near zero. The viability of this ESU is relatively unchanged since the last review (moderate to high risk), and the improvements in some populations do not warrant a change in risk category, especially given the uncertainty regarding climatic effects in the near future.	• 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
Lower Columbia River coho salmon	Threatened 6/28/05	NMFS 2013	NMFS 2022a; Ford 2022	Of the 24 populations that make up this ESUOnly six of the 23 populations for which we have data appear to be above their recovery goals. Overall abundance trends for the Lower Columbia River coho salmon ESU are generally negative. Natural spawner and total abundances have decreased in almost all DIPs, and Coastal and Gorge MPG populations are all at low levels, with significant numbers of hatchery-origin coho salmon on the spawning grounds. Improvements in spatial structure and diversity have been slight, and overshadowed by declines in abundance and productivity. For individual populations, the risk of extinction spans the full range, from “low” to “very high.” Overall, the Lower Columbia River coho salmon ESU remains at “moderate” risk, and viability is largely unchanged since 2016.	• 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 2015	NMFS 2022e; Ford 2022	This single population ESU is at 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. Current climate change modeling supports the "extremely high risk" rating with the potential for extirpation in the near future (Crozier et al. 2020). The viability of the Snake River sockeye salmon ESU therefore has likely declined since the time of the prior review, and the extinction risk category remains "high."	• 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	Upper Columbia Salmon Recovery Board 2007	NMFS 2022b; Ford 2022	This DPS comprises four independent populations. The most recent estimates (five year geometric mean) of total and natural-origin spawner abundance have declined since the last report, largely erasing gains observed over the past two decades for all four populations (Figure 12, Table 6). Recent declines are persistent and large enough to result in small, but negative 15-year trends in abundance for all four populations. The overall Upper Columbia River steelhead DPS viability remains largely unchanged from the prior review, and the DPS is 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	NMFS 2022a; Ford 2022	This DPS comprises 23 historical populations, 17 winter-run populations and 6 summer-run populations. 10 are nominally at or above the goals set in the recovery plan (Dornbusch 2013); however, it should be noted that many of these abundance estimates do not distinguish between natural- and hatchery- origin spawners. The majority of winter-run steelhead DIPs in this DPS continue to persist at low abundance levels (hundreds of fish), with the exception of the Clackamas and Sandy River DIPs, which have abundances in the low 1,000s. Although the five-year geometric abundance means are near recovery plan goals for many populations, the recent trends are negative. Overall, the Lower Columbia River steelhead DPS is therefore considered to be at "moderate" risk.,	• 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
Upper Willamette River steelhead	Threatened 1/5/06	NMFS 2024	NMFS 2024; Ford 2022	This DPS has four demographically independent populations. Populations in this DPS have experienced long-term declines in spawner abundance. Although the recent magnitude of these declines is relatively moderate, continued declines would be a cause for concern. In the absence of substantial changes in accessibility to high-quality habitat, the DPS will remain at "moderate-to-high" risk. Overall, the Upper Willamette River steelhead DPS is therefore at "moderate-to-high" risk, with a declining viability trend.	• 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

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Middle Columbia River steelhead	Threatened 1/5/06	NMFS 2009	NMFS 2022f; Ford 2022	This DPS comprises 17 extant populations. Recent (five-year) returns are declining across all populations, the declines are from relatively high returns in the previous five-to-ten year interval, so the longer-term risk metrics that are meant to buffer against short-period changes in abundance and productivity remain unchanged. The Middle Columbia River steelhead DPS does not currently meet the viability criteria described in the Middle Columbia River steelhead recovery plan.	• 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
Snake River basin steelhead	Threatened 1/5/06	NMFS 2017a	NMFS 2022g; Ford 2022	This DPS comprises 24 populations. Based on the updated viability information available for this review, all five MPGs are not meeting the specific objectives in the draft recovery plan, and the viability of many individual populations remains uncertain. Of particular note, the updated, population-level abundance estimates have made very clear the recent (last five years) sharp declines that are extremely worrisome, were they to continue.	• 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 eulachon	Threatened 3/18/10	NMFS 2017c	NMFS 2022h	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

2.2.2 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 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 3, below.

Table 3. 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.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
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.
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.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
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.
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.

2.3. 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 Proposed Action element that limits of the extent of the action area is underwater noise levels from impact pile installation.

The action area includes the 300 feet laterally above the MHHW of the LCR and an area up and downstream of the project site where elevated sound levels will spread from impact pile driving. The area affected by underwater noise will be comprised of an approximately 14.2-mile reach of the LCR extending from approximately 51,747 feet (9.8 miles) downstream of the dock (near RM 56) to 23,110 feet (4.4 miles) upstream of the dock (near RM 70.5) (Figure 3).

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 impacts to listed species or designated critical habitat from federal agency activities or existing federal agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

Baseline of the Habitat
The action area is influenced by water quality and prey community impacts associated with all upstream uses, and is part of the LCR estuary. The Weyerhaeuser complex is approximately 220 acres in size and is located within a large area (more than 3,000 acres) zoned for heavy industrial use. Westrock Company is located just upstream of the dock at 300 Fibre Way, near RM 67.5 with a dock on the Old Mouth of the Cowlitz River used to load and offload timber products. The confluence of the Cowlitz and CR occurs two miles upstream from the dock and to the North near RM 68. A BNSF Railway extends mainly east-west along the north edge of the industrial area, approximately 3,000 feet from the dock. State Routes 432 and 433, which include the Lewis and Clark Bridge over the LCR, are also located in proximity to the site. At its closest point, the bridge is approximately 200 feet from the upstream edge of the dock. The submerged lands under the LCR are owned by the State of Washington Department of Natural Resources, which supports commercial and industrial activity via leasing and regulation. More than 56 million tons of foreign trade valued at over $21 billion is conveyed on the river each year (CRSOA 2022). The river is a primary export gate in the United States for wood products, wheat, barley, and other goods.

The ordinary high-water elevation of the LCR in the action area is estimated at 11.1 feet relative to the LCR Datum, which is equal to 13.6 feet relative to the North American Vertical Datum of 1988 (USACE 1978). The river at the dock is tidally influenced, and the typical daily tidal range is approximately 3 to 4 feet (NOAA 2022b). Although influenced by the tides, the saltwater wedge at the mouth of the river does not extend to the project site; the uppermost extent of the saltwater wedge is Cathlamet Bay, located roughly 25 miles downstream of the dock (McConnell et al. 1981). In addition to the influence of the tides, water elevation is also affected by seasonal runoff and by releases from Bonneville Dam, about 78 miles upstream of the dock. The typical seasonal fluctuation in water level is 5 to 6 feet, with lowest levels occurring in September and highest levels in May (NOAA 2022b). Water depth at the face of the dock is typically 38 to 50 feet.

More broadly, fish and wildlife habitat in the LCR has been and continues to be degraded by hydropower projects, water withdrawals, dredging, contamination by petrochemicals, heavy metals and radioactive waste, high water temperatures, and industrial, commercial, and residential development along the shoreline as well as logging and agricultural development within the watershed (Bottom et al. 2005; Fresh et al. 2005; LCREP 2007; NMFS 2013). Along stretches of the CR, the Cowlitz and their confluence, water and sediment are impaired for phthalates, pH, dissolved oxygen, poly-chlorinated biphenyls (PCBs), methyl mercury, temperature and dioxins (WDOE 303d). Fish habitat in the action area has been adversely affected by a variety of in-water and upland human activities, including habitat losses from all causes (urbanization, roads, diking, etc.), flood control, irrigation and hydroelectric dams, pollution, municipal and industrial water use, introduced/invasive species, hatchery production (NMFS 2013), and climate change (Section 2.2). On the mainstem of the CR, numerous hydropower projects including the Federal Columbia River Hydropower System have created a series of dams that have greatly altered the flow regime and created substantial barriers to in-river migration and dispersal for fish and other organisms.

The environmental baseline includes the impacts from deep-water dredging to accommodate safe vessel traffic and shallow water dredging to maintain vessel traffic. Therefore, dredging activities occur across numerous areas and microhabitats within the LCR including sloughs, secondary channels, and floodplain wetlands. All of these habitat areas provide rearing for ESA-listed fish, and all have been degraded by shore-based development and construction and maintenance of boat moorage facilities. Floodplain and off-channel sloughs have been cut off by dikes and flood control levees, limiting potential refuge areas and forage sites for juvenile salmonids. The dredge sediment disposal in the LCR has had adverse effects, including displacement of seasonally-flooded wetlands, regular disruption of shallow water benthic prey communities, and most significantly creation of attractive nesting habitat for avian predators feeding on juvenile salmonids (Evans et al. 2012; Sebring et al. 2013).

Collectively, these actions have degraded Pacific salmon and steelhead rearing, migration, and spawning habitats (Fresh et al. 2005; NMFS 2005a) in the action area. The riverbed below the dock consists primarily of alluvial sands with variable amounts of silt (GRI 2022). Combined with the depth of substrates at the dock, the area is not suitable for salmonid spawning and provides limited, if any, salmonid juvenile rearing habitat. Shoreline modifications and extensive armoring along the dock and the adjacent industrial area have decreased the extent of shallow water habitat, which is critical for juvenile salmonids and the organisms on which they feed (Bottom et al. 2005).

The river shoreline adjacent to the dock on the upstream and downstream ends is fairly steep, heavily armored with riprap, and moderately vegetated with Himalayan blackberry (*Rubus armeniacus*) and butterfly bush (*Buddleja davidii*), both of which are noxious weeds. The shoreline beneath the dock is steep, armored with riprap, and mostly unvegetated. These areas provide limited habitat value for fish and other aquatic life. However, just downstream of the riprap slope near the dock is a riparian area that includes approximately 20 acres of mudflat surrounding an approximately 7-acre island densely vegetated by low-stature willows; this area may support a diversity of wetland-dependent and aquatic organisms. Intact riparian habitat in the action area also occurs at Dibblee Point (Oregon side of CR along the shoreline of Lord Island (approximately 2 miles downstream of the dock), and at the confluence of the Cowlitz and CR. Although the waters near the dock may support fish, there is no suitable salmonid spawning habitat in proximity to the action area.

Anthropogenic underwater noise in the LCR is caused by dredging, ship traffic, and construction. As described above, the dock is within an actively used industrial area that supports storage, loading, unloading, and transport of river-borne cargo. Background underwater noise levels at the dock are not available. However, ambient noise levels measuring 136 decibels (dB) peak were measured at RM 45 where the river is tidally influenced, dredging occurs regularly, and shipping traffic includes large ocean-going transports, barges, and recreational vessels of varying size (Carlson et al. 2001; NMFS 2010a). Subtracting 15 dB from the peak sound measurement yields a crude estimate of root mean square (rms) value of 121 dB rms (NMFS 2010a). The river within the action area is also tidally influenced, is regularly dredged, and supports a variety of industrial and recreational ship traffic. In addition, the action area is adjacent to a heavily used industrial shoreline, including the Port of Longview, which is nearly 4 miles long. As a result, underwater noise levels are likely similar to those at RM 45. As a conservative measure, ambient underwater sound was assumed to be 120 dB rms for the purposes of this assessment.

The Cowlitz River drainage includes mixed land uses in Longview and Kelso, portions of the I-5 corridor, and large expanses of forested and agricultural lands. On the Oregon side is the shoreline of the community of Rainier, which is similarly developed with uses including the Teevens Log dock directly across from Port and upstream of the SR 433 Bridge, and the Gypsum Plant immediately just downstream of the SR 433 Bridge. At approximately the same location as the mouth of the Cowlitz entering on the Washington side, development thins out on the Oregon side and the shoreline becomes much more natural, although the river is separated from its floodplain as a result of significant diking. Downstream from the Project site, the Action Area is also heavily industrialized on the Washington side, until approximately the upper end of Lord Island. Willow Grove Park is a 75-acre public park located between the CR and Willow Grove Road. The boat launch is located within a boat basin that comprises several floating docks and is protected by a pile-supported concrete plank wall breakwater, which is designed to allow for fish passage. Willow Grove Park uplands are characterized by short grass on previously placed dredge sands, and naturally occurring beach sands. The shorelines on both the Oregon and Washington side of the river include a mix of residential and agricultural upland land use, shoreline roadways, and undeveloped areas. Habitat elements, including shallow water areas and vegetation, become increasingly more common moving downstream from the Port. Agriculture is the predominant land use on the Washington side in this reach, interspersed among natural areas. Walker Island, Fisher Island, Hump Island, and Crims Island are located between RMs 62 and 56; most of the sites are located in the river between Crims Island and Hump Island. These islands are predominantly wildlife areas, with the exception of Hump island which is used by USACE as a dredged material placement site.

These multiple watersheds, like the action area, are characterized by loss of connectivity with floodplains and feeding and resting habitat for juvenile salmonids in the form of low-velocity marshland and tidal channel habitats (Bottom et al. 2005). Each of the upland conditions influence habitat characteristics in the action area such as water quality and amount and composition of prey base. Habitat degradation has generally reduced the quality, complexity, and amount of this important rearing and migration habitat for salmon and steelhead.

The hydrology and hydrograph of the CR is significantly altered from historical conditions, shifting natural cues that salmonids rely on for spawning and outmigration behavior. River flow is less dynamic (Sherwood et al. 1990), sediment transport has decreased by as much as 50 percent (Simenstad et al. 1992). Other actions such as the depredation and relocation of large colonial nesting waterbird colonies have reduced the numbers of avian predators that prey upon salmonids in the CR estuary that may improve progress in reaching recovery goals by up to 6 percent (NMFS 2011). Degraded water quality in the action area results from load of increased fine sediments, elevated water temperatures especially during the winter (Weitkamp 1994), and a host of municipal and industrial discharges, permitted or otherwise (LCREP 2007). These conditions are a result of upstream land uses, all of which influence the LCR and its recovery potential (Fresh et al. 2005).

The baseline also includes the effects of projects that have proceeded subsequent to section 7 consultation. During the last several years, NMFS has engaged in multiple section 7 consultations on Federal projects adversely affecting ESA-listed fish and their habitats in or near the action area. These include vicinity (Multnomah County, Oregon; Clark County, Washington) adjacent to or within the action area (WCRO-2022-01443, WCRO-2020-03117, WCRO-2020-01523, WCRO-2020-03569, WCR-2019-11648, WCR-2018-10138, WCR-2017-7450, WCR-2017-6622, WCR-2016-5516), including the effects of actions addressed in programmatic consultations (the SLOPES IV programmatic consultation; NMFS number WCR-2011-00002). In general, those actions caused temporary, construction-related effects (increased noise and turbidity), and longer-term effects like increasing overwater coverage.

Baseline of the species in the area

Salmonids

The level of exposure of juvenile salmonids would vary depending on the species present, life history, location, migration timing, and water depth occupied. Juvenile salmonids migrate in the vicinity of and might rear in the action area during different times of the year, although the dock provides limited, if any, juvenile rearing habitat. In general, juvenile salmonids are present in the action area year-round, being most abundant from late winter through summer, becoming less abundant in the fall (NMFS, 2017b). Juvenile Chinook salmon are present year-round with timing ranging from spring to early fall, although sub-yearlings are present later into the fall (Dawley et al., 1986; NMFS, 2017b). Juvenile chum salmon are present from winter to spring. Juvenile coho salmon and steelhead are present year-round with their primary timing ranging from spring to mid-summer. Juvenile sockeye salmon are present during mid-spring to late summer. The SR fall Chinook ESU is comprised of a single extant natural-origin population (Lower Snake River) and one extirpated population (Middle Snake River).

Over-winter rearing is expected only among five species with a sub-yearling life history stage in the lower Columbia River:

1. Lower Columbia River Chinook,
2. Snake River Fall Chinook,
3. Lower Columbia coho,
4. Lower Columbia Steelhead, and
5. Snake River Fall Chinook.

All ESA-listed Columbia basin salmon and steelhead rear and/or migrate through the action area, affecting the rearing and migration habitat PBFs for these species. Juvenile salmonids are likely to rear in shallow waters consisting primarily of sand/silt substrate near shorelines. Upstream and downstream migration of adult salmonids and smolts are likely to occur in the mainstem LCR. The survival of migrating fish has been reduced, due to the loss of multiple life-history stages as a result of habitat alteration (Bottom et al. 2005).

The ESA-listed species considered in this opinion must migrate through the action area, thus 100% are exposed to the degraded baseline conditions both as juveniles and as adults. Some of the species considered in this consultation rear in the action area, and thus are exposed to the degraded baseline for a significant portion of this sensitive life stage. Exposure to degraded habitat conditions may negatively affect the condition of individual fishes that will also be exposed to the effects of the proposed action, and may in turn influence the nature and degree of their response.

Salmonids in the action area will generally exhibit either a stream-maturing or ocean-maturing life history type. A stream-type life history is exemplified by juvenile salmon and steelhead that typically rear in upstream tributary habitats for over a year. Salmonids exhibiting this life history 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 juvenile fish migrate through the action area as smolts (approximately 100 to 200 mm in size) move quickly downstream, and pass by the action area within one to two days (Dawley et al. 1986).

An ocean-type life history is exemplified by juvenile salmon that move out of spawning streams and migrate towards the LCR estuary as sub-yearlings and are actively rearing within the LCR estuary. Fish that exhibit these life histories include LCR Chinook salmon (fall runs), CR chum salmon, and to a lesser extent, SR fall-run Chinook salmon. These fish are generally smaller in size (less than 100 mm) and more likely to spend days to weeks residing in tidal freshwater habitats characterized by the action area, with peak abundances occurring March through May (Hering et al. 2010; McNatt et al. 2016).

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. Generally speaking, 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. Juvenile salmon occupy different locations within the CR, and are typically in shallower water during the day, avoiding predation by larger fish that are more likely to be in deeper water. These juveniles will venture into the deeper areas of the river away from the shoreline, towards the navigation channel and along the bathymetric break – or channel margin – and will be closer to the bottom of the channel (Carter et al. 2009). The smaller sub-yearling 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 higher potential sub-yearling use in areas of 20 to 30 feet deep.

The consequence of systematic habitat loss is a reduction of habitat varieties, and corollary loss of species variety that relied on that complex of diverse conditions. According to Rich's (1920) survey results, salmon present in the estuary during September-December 1916 consisted of a diversity of life history types, including recent migrants from upriver, as well as individuals that had spent a significant period rearing in the estuary (Burke 2005; Bottom et al. 2005). However, beach-seining surveys since 2002 indicated that proportionally fewer juvenile salmon now utilize the estuary throughout the late summer and fall, and the population curve is now skewed toward the period March through July and peaks sharply in spring or early summer (Bottom et al 2008). Analyzing historical data (Rich 1920), there were at least six Chinook life history types in the CR, including five variants of sub yearling life history, prior to extensive development in the basin. These strategies were distinguished by length of time spent in each freshwater environment, time spent in the estuary, and time and size at ocean entrance.

Many early life history strategies of CR salmonids have been lost due to past management actions discussed under the environmental baseline (Bottom et al., 2005). Chinook salmon with estuarine rearing life histories are now substantially reduced in abundance, leaving three principal life history types in the basin: fry migrants, sub-yearling migrants that rear in natal streams (including hatchery-reared juveniles) and/or main rivers and yearling migrants (Burke 2005). LCR steelhead has lost 4 historical populations, and LCR Chinook salmon diversity has declined by 8-10 historical populations. The NWFSC determined 28 of the 32 extant populations of LCR Chinook salmon were extirpated or at very high risk of extirpation and similarly, 21 of 24 historical populations of LCR coho were at very high risk of being extirpated, though modest improvements were noted in the 2015 review (Ford 2022). CR chum have 17 historical populations, 14 of which are extirpated or nearly so. Further construction and habitat modification will result in the loss of more populations of ESA-listed fish, and these trends will continue.

Adult Chinook salmon presence in the lower CR occurs from late spring through late fall. Adult coho salmon are likely to be present from late summer through early winter. Adult chum salmon primarily occur during the fall. Adult sockeye salmon presence most likely ranges from late spring to late summer. Adult steelhead presence ranges from February to December, although majority of upstream passage through the LCR occurs during the spring and summer (Columbia Basin Research, n.d.). Based on the broad timing of these species, and the proposed work period of September 1 to December 31 for pile removal and installation, exposure for adult LCR Chinook, SR spring/summer Chinook, SR fall Chinook, LCR Coho and CR Chum salmonids is highly likely.

Eulachon

Pacific eulachon are anadromous smelt that spawn within the mainstem LCR and its tributaries. Previous studies have documented the highest densities of out-migrating larvae in the CR downstream of the confluence of the Cowlitz River and CR, however eulachon spawn upriver in the mainstem channel and in Sandy River (WDFW 2020). The eulachon spawning migration typically begins when river temperatures are between 0°C and 10°C, which usually occurs between January and April in the CR. Spring freshets carry larvae to the CR Estuary, and juveniles will disperse onto the continental shelf within the first year of life (Gustafson 2015). Migration of adults into the CR and its tributaries occurs from December through May, with peak abundances and spawning during February and March over sandy substrates in LCR tributaries. Eggs and larvae are present from February until early June, as they drift in currents downstream to the LCR Estuary.

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 but that are not part of the 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 402.02).

Temporary effects of the proposed action are reasonably certain to include; 1) water quality impairment (increased turbidity and resuspended contaminants) 2) increase of underwater noise due to vibratory and impact pile driving and 3) localized benthic impacts due to pile driving.

Enduring effects of the proposed action are reasonably certain to include; 1) removal of the existing creosote treated timber and associated piles, and 2) perpetuation of the existing over-water structure (shade, predation).

2.5.1. Effects on Critical Habitat

As mentioned in Section 2.2, portions of the action area include designated critical habitat for each of the 13 ESA-listed ESUs/DPSs of salmonids within the LCR and the southern DPS of eulachon. Critical habitat includes Physical and Biological Features (PBFs) necessary to support various life stages of salmonid and non-salmonid listed species (i.e., rearing, migration). NMFS reviews effects on critical habitat affected by a proposed action by examining how the PBFs of critical habitat would be altered, and the duration of such changes.

Two of the six PBFs established for salmonid critical habitat are likely to be present in the action area. Those PBFs are:

1. Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and 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.

2. Freshwater migration corridors free of obstruction 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. These features are essential to conservation because without them juveniles cannot use the variety of habitats that allow them to avoid high flows, avoid predators, successfully compete, begin the behavioral and physiological changes needed for life in the ocean, and reach the ocean in a timely manner.

Two of the three of the PBFs established for the southern DPS of eulachon are likely to be present within the action area. Those PBFs are:

1. Freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, and with migratory access for adults and juveniles.

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

Salmonids

Shading and Predation

During construction, the dock and moored vessels may attract juvenile salmonid predators to shallow water areas due to shading they may produce. Juvenile salmonids are usually reluctant to enter shaded zones created by over-water structures, piles, and moored vessels. These areas create favorable ambush habitat for predators such as smallmouth bass, largemouth bass, and pike minnows. The overwater shade and the slower stream velocity caused by these structures can be easily exploited by these piscivores. Additionally, migrating smolts that swim near the dock would be more vulnerable to avian predators. These birds may perch on dock structures or moored vessels. Piscivorous birds present in the CR that feed on juvenile salmonids include Double-crested cormorants, California and Ring-billed gulls, and Caspian terns.

After the construction period, all juvenile salmonids could occur near the dock while migrating downriver, and be vulnerable to fish predators using the piles for ambushing migrating juveniles. Adult migration will not be affected by the proposed dock reconstruction. The proposed action extends the duration of possible shading impacts into the future (i.e., extending the lifespan of the existing structure). The presence of the dock will likely adversely affect juvenile salmonids and the safe migration value of designated critical habitat in the action area.

Shading and predation will have a small effect on adult eulachon migration because adult eulachon are large enough to avoid piscine predators and are likely to swim around the structure. Larval eulachon which drift passively to the estuary are likely to be consumed by juvenile piscine predators where they drift under or adjacent to the replacement dock. However, the relatively small area occupied by the physical presence of the dock will limit mortality to a very small portion of the eulachon run. Therefore, shading and predation will have negligible effects on designated eulachon critical habitat.

Cover

The proposed action would have no effect on existing natural cover. As described in the environmental baseline, the project area has no existing shoreline vegetation and contains no submerged aquatic vegetation (SAV). The replacement of filter rock and riprap extends the duration of the degraded condition of this habitat, and prevents the formation of natural cover from undercut banks, side channels, or aquatic vegetation. Flood-control levee systems have isolated the CR within the project footprint, altering sediment transport regimes and severely degrading the quality of this PBF for ESA-listed species (Cannon 2015). While the shoreline armoring replacement would not extend these impacts to new areas, the proposed action would perpetuate the degraded condition and function of this habitat within the project footprint.

Benthic prey

Shading from the dock structures and moored vessels also has the potential to impact forage opportunities by perpetuating disturbances to benthic communities. Overwater shade can disrupt the growth of aquatic vegetation, reducing forage availability for juvenile salmonids and other small fish that comprise the adult salmonid prey base (Sagerman et al. 2009). The proposed action extends the duration of shading impacts on benthic communities; however, it is expected to be relatively minor.

Underwater Noise

Fish can detect and respond to sound from pile driving and from vessels in a manner that delays their migratory behavior and makes them more susceptible to predators. For the period of time that vibratory driving, impact driving, or vessel noise occurs, the migration value of the action area is diminished, but these are each temporary occurrences that do not prevent the action area from serving its migration role. Elevated noise from pile driving will temporarily adversely affect the rearing PBF for juvenile salmonid critical habitat, but is expected to cause no enduring effects to critical habitat in the area. Once pile driving is completed, rearing and migration values will be affected only by the perpetual presence of the structure.

Water Quality

Water quality of the critical habitat in the action area would be temporarily affected by increased TSS during pile removal and installation, and all additional in-water work. Once in the water column, the CR would transport suspended sediments downstream. The sediment at the dock is mainly composed of alluvial sand and silt which would be expected to settle out of the water column quickly (Newcombe & Jensen, 1996). While pile removal and installation and in-water work increase TSS, any impact on rearing and migration PBFs would be localized and temporary. Increased TSS would return to baseline levels as soon as construction activities are completed.

Resuspended sediments
Effects to critical habitat from an increase in resuspended contaminants is not expected to be permanent. Migration is unlikely to be appreciably diminished by these sources of water quality reduction, however rearing could be incrementally and chronically diminished by the chemical contaminants reducing prey communities or creating a source for bioaccumulation. Also, growth and fitness values of rearing could be diminished. This effect is discussed in effects on listed fish, below. The sole permanent impact to water quality conditions in critical habitat is the removal of creosote treated timber from the environment and is expected to be beneficial.

Benthic Impacts
The installation of new steel piles will eliminate a small amount of benthic habitat (296 square feet) which supports forage for migrating and rearing juvenile salmonids. Although the addition of the steel piles and dock structure will prolong the degraded state of benthic habitat for the life of the new dock, the reduction of this PBF is small relative to existing conditions.

Eulachon
Increased turbidity will temporarily impair water quality and impair freshwater spawning and incubation habitat in the action area. Elevated underwater noise will also degrade freshwater spawning and incubation habitat in the action area during pile installation. Although spawning has not been documented within the action area, substrates suitable for egg adhesion may occur in the action area. The proposed action is not expected to obstruct adult Eulachon migration through the river or larval downstream drift. In the event that early runs spawn in the action area during the pile installation work windows, the potential to encounter drifting larval fish is low considering that 30 days are typically required for egg incubation (PBF 2). The effects described above will only impact areas in proximity to the dock and will be temporary in nature, returning to pre-project levels once construction activities cease. Barges and tugs will be limited to the area immediately surrounding the dock, with most of the channel remaining unaffected.

2.5.2. Effects on ESA-listed species

Short-term Effects
Water quality impairment
During pile removal and installation and any in-water work, there will be an increase in total suspended solids (TSS) in the action area. Some salmonids may experience temporary effects as a result of these activities during the work window. According to Newcombe and Jensen (1996), the effects of increased TSS on exposed fish can range from beneficial (improved survival by reduced predation) to detrimental (physiological stress and reduced growth). Constant exposure to turbid conditions by fish may cause physiological stress responses that increase an individual’s maintenance energy needs, and reduce feeding and growth (Lloyd et al., 1987; Redding et al., 1987; Servizi & Martens, 1991). These responses may include gill flaring, coughing, and a temporary reduced feeding rate. A study by Bisson and Bilby (1982) found that salmonids are able to detect and distinguish turbidity and other water quality gradients.

Larger adult salmon quickly respond to turbidity by avoiding the areas. Other studies show that larger salmonids are more able to tolerate elevated TSS than smaller juveniles (Servizi & Martens, 1991, 1992). As salmonids grow and their swimming ability improves, they depend less on shallow, nearshore habitats (Groot & Margolis, 1991). Consequently, we expect any adults exposed to elevated TSS to traverse or swim around the action area without experiencing adverse effects. Additionally, yearling juveniles migrate quickly to the LCR Estuary and Pacific Ocean in spring and are not likely to be present in the action area long enough to experience any beneficial or adverse effects caused by turbid conditions, which are proposed for fall and early winter.

Juvenile salmonids exposed to elevated TSS would experience similar physiological responses to adult salmonids (mentioned above). The risk of exposure to turbidity is greater for sub-yearling salmonids than yearling salmonids and adults. Sub-yearling salmonids are known to reside (over-winter) in the lower Columbia River up to a year before emigrating to the ocean (Johnson et al. 2015). However, the temporary duration of the proposed action and CR flow dynamics make the possibility of prolonged exposure to turbid conditions very unlikely. It is possible that behavioral alteration might make juveniles more susceptible to predation as they relocate to other areas. These effects will be further limited by the IWWW, when the density of juvenile salmon in the action area is lower. Although a small number of sub-yearling juvenile salmonids may be harmed by increased TSS, we expect effects among the juveniles exposed to be minor and predominantly a behavioral avoidance response.

During pile removal, contaminants (PAHs) concentrated within the creosote treated timber piles and surrounding sediment are likely to be mobilized and resuspended in the water column (Smith et al. 2008; Parametrix 2011). Creosote-treated piles contaminate the surrounding sediment up to two meters away with PAHs (Evans et al. 2009). Projects can release PAHs directly from creosote-treated timber during the demolition of structural elements and if any of the piles break during removal (Parametrix 2011). Smith et al. (2008) reported concentrations of total PAHs of 101.8 μg/l 30 seconds after creosote-pile removal and 22.7 μg/l 60 seconds after. Given the high flows of the CR, we expect contaminant concentrations to dilute quickly. However, PAH levels in the sediment after pile removal can remain high for six months or more (Smith et al. 2008). Romberg (2005) found a major reduction in sediment PAH levels three years after pile removal contaminated an adjacent sediment cap. The action is likely to result in a temporary increase of exposure for ESA-listed species that encounter the action area during the action and for the period of time after, where elevated sediment concentration of PAHs has yet to return to baseline. Juvenile salmonids have a higher likelihood of exposure, due to their use of surrounding nearshore habitat than adults, which as discussed above, will likely be migrating through the area and do not forage in the area. This exposure could contribute to sub-lethal effects, such as impaired fitness and decreased reproductive success. However, as the action and effects are temporary, we expect any harm to be limited to individuals and will not contribute to population level effects. Additionally, the removal of creosote-treated timber will be beneficial to ESA-species that utilize the action area over time.

Eulachon are not expected to be present in the action area during the in-water construction window. If eulachon unexpectedly arrive in the action area early, we anticipate that they would have a similar response to the turbidity and contaminant effects caused by the proposed action as adult salmonids. Adult eulachon are highly mobile and would likely avoid areas with elevated TSS. Also, adult eulachon would not be harmed by resuspended sediments as they are semelparous and usually die shortly after spawning. We expect effects to be limited to a few individuals that might be present during the IWWW and these effects will not result in population level consequences.

Underwater noise

The planned work would create a varied and complicated in-water soundscape around the project site. The proposed action includes up to two pile drivers at the same time, with a combination of vibratory and impact, impact and impact or vibratory and vibratory installation. A multi-agency work group determined that to protect ESA-listed species, sound pressure waves should be within a single strike threshold of 206 decibels (dB), and for cumulative strikes either 187 dB sound exposure level (SEL) where fish are larger than 2 grams or 183 dB SEL where fish are smaller than 2 grams. Figures 3 and 4 contrast the cumulative SEL at measured distance. The SEL measurement is a cumulative measurement, based on the number of consecutive strikes, where the SEL increases as pile strikes increase in number. When many consecutive pile strikes are needed, John Stadler (NMFS Biologist, retired, pers comm 5-18-19) states that cessation of pile driving for 10-12 hours after multiple strikes before resuming pile driving reduces SELs to baseline and can provide fish an opportunity to move through the area and away from the impacted pile, reducing effects of SELs on fish. Figures 5 and 6 display the approximate range of injury and behavioral responses to fish, respectively, at the project site.

RESULTANT ISOPLETHS	FISHES				
(Range to Effects)	ONSET OF PHYSICAL INJURY			BEHAVIOR	
	Peak Isopleth	SEL_{cum} Isopleth		RMS Isopleth	
		Fish ≥ 2 g	Fish < 2 g		
ISOPLETHS (meters)	8.6	292.9	292.9	2,154.4	Fishes present
Isopleth (feet)	28.1	960.8	960.8	7,068.4	
Cumulative SEL at measured distance	211				

Figure 3. NMFS Multi Species Pile Driving Calculator; Impact Report (assumptions are one hammer, up to 8 piles daily, 1000 strikes per pile)

RESULTANT ISOPLETHS	FISHES				
(Range to Effects)	ONSET OF PHYSICAL INJURY			BEHAVIOR	
	Peak Isopleth	SEL_{cum} Isopleth		RMS Isopleth	
		Fish ≥ 2 g	Fish < 2 g		
ISOPLETHS (meters)	8.6	292.9	292.9	2,154.4	Fishes present
Isopleth (feet)	28.1	960.8	960.8	7,068.4	
Cumulative SEL at measured distance	214				

Figure 4. NMFS Multi Species Pile Driving Calculator; Impact Report (assumptions are two hammers, up to 8 piles daily, 1000 strikes per pile)

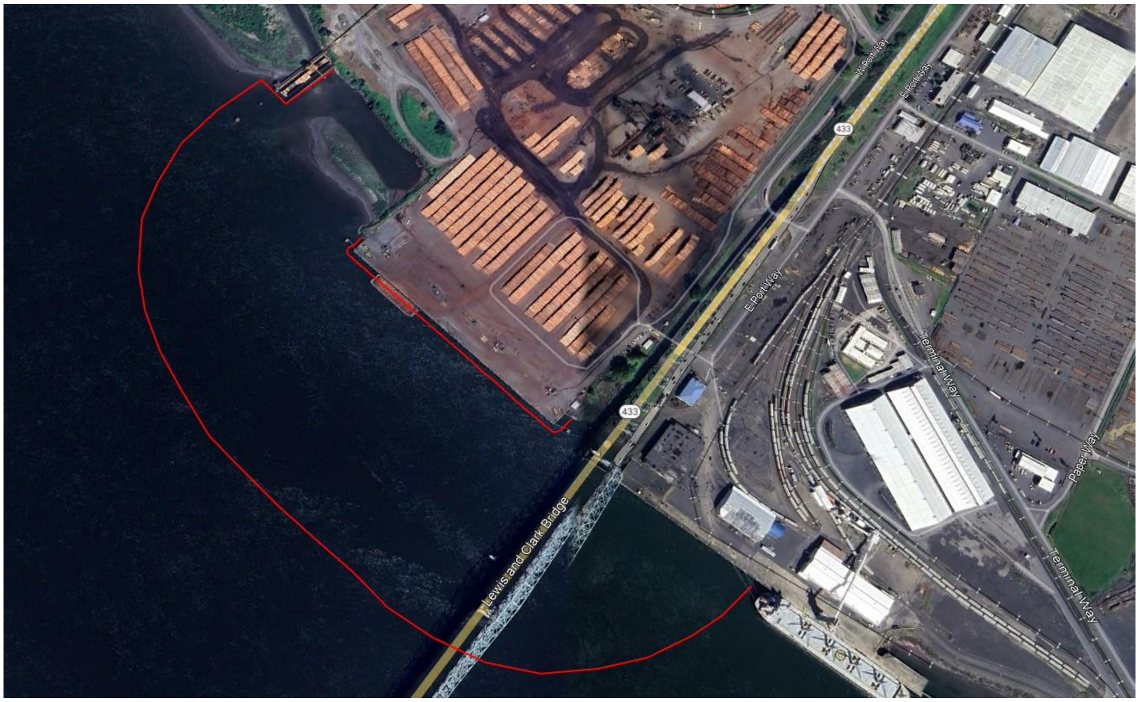

Figure 5. Underwater noise spread, cumulative physical injury threshold SELcum (outer boundary) and peak single strike (inner boundary)

Figure 6. Underwater noise spread, behavioral effects threshold (outer boundary)

The best available information indicates that impact driving 30-inch diameter steel piles would be the project-related noise source most likely to be injurious or lethal to fish, followed by the temporary installation of 24-inch steel piles. The rest of the project's sound sources (localized vessel uses and vibratory hammer use) are unlikely to cause harmful effects, but are assumed to be present in the water, in some combination of sources, over the entire duration of the project. Sound waves transmitted through the water column from vibratory hammer use will almost certainly result in behavioral responses from individual fish. Sound pressure waves from vibratory pile driving are much shallower than waves produced from impact driving and do not result in physical injury to fishes. When activated, vibratory hammers produce sound pressure levels approximately 17 dB lower than those produced by an impact hammer (Nedwell & Edwards, 2002). No empirical studies have reported any physically injurious effects from vibratory driving as far as NMFS is aware. Based on the best available information we do not expect sound pressure waves from vibratory installation alone to result in injury to fish present.

Impact pile driving, despite the use of a bubble curtain, is likely to injure or kill fish. Impact hammers produce short, intense, pulse-type sounds that are typically considered isolated events or are repeated in succession. Such sounds have the potential to physically injure fish due to their relatively rapid rise in ambient pressure, followed by a period of diminishing oscillating maximal and minimal pressures. The responses of fish exposed to elevated sound pressure levels (SPLs) can range from no effect to a brief acoustic annoyance, temporary or permanent loss of hearing, behavioral changes and stress, or tissue injuries and barotraumas (Hastings and Popper 2005; Hedges 2011; Ruggerone et al. 2008; WSDOT 2020). Typical barotrauma injuries include hemorrhage, hematoma, burst capillaries, and a deflated or ruptured swim bladder (Halvorsen et al. 2011). Despite attenuation from the use of a bubble curtain, impact driving 30-inch diameter steel piles would cause in-water noise levels above the 206 dBpeak single-strike threshold for the onset of injury in fish out to approximately 28 feet (8.6 m) around each pile (Figures 3-6). At the expected maximum of 8,000 daily pile strikes, any fish that remain at 960.8 feet (292.9 m) from the pile driving for a full day's work are likely to be injured by accumulated sound energy. The likelihood of injury, and the intensity of injury for individual fish in would increase with increased proximity to the on-going pile driving.

Adult salmonids are likely to be in the action area during in-water construction. Adult salmon are not typically as susceptible to barotrauma as juveniles due to their larger size. Also, these fish are highly mobile and are capable of evading areas with excessive noise. Therefore, LCR chum, Chinook, and coho salmon, which migrate through the action area during the IWWW are likely to be exposed as adults, but are unlikely to be harmed, although behavioral disturbance will occur.

Juvenile steelhead and yearling coho, Chinook, and sockeye salmon from MCR, UCR, UWR, and SR species are expected to be larger as outmigrants when they reach the action area, based on their typical 1-2-year freshwater rearing behaviors, and thus they are also less susceptible to injury from pile driving sound, however despite their larger size, if they are present in the approximate 25-foot radius (peak single strike) or 960-foot radius (SELcum) area where sound levels are highest during pile driving, they can also be severely injured or killed. We anticipate that a few individual yearling juveniles will be harmed by impact pile driving despite their typical migration period being outside the in-water work windows. However, population effects are insignificant.

In contrast to impact pile driving, vibratory pile driving will likely only modify the behavior of salmonids. We expect adult salmonids that do encounter underwater noise created during vibratory pile installation to move upstream or laterally at a rate that would limit their exposure to a few minutes. Minor behavioral disturbances would include some combination of acoustic masking, startle responses, altered swimming patterns, and area avoidance. The intensity of those effects would increase with increased proximity to the source and or duration of exposure. We do not expect harm to adult salmonids, and population effects are discountable.

Juvenile salmonids present in the action area would most likely respond to underwater noise caused by vibratory pile driving similarly to adult salmonids. However, the behavioral responses of juveniles may slightly increase their risk of being preyed upon.

Some individual fish from each of the 14 species described in this opinion are likely to be exposed to the effects of the proposed action, but only sound from pile driving is likely to be at a scale, intensity, or duration that will cause significant adverse response. We identified probable population-specific presence and their status by reviewing the most recent status of those populations. Some will experience sublethal effects, such as temporary threshold shifts, some merely behavior responses such as startle. Physical injury from barotrauma, and death are also possible. Furthermore, not all exposed individuals will experience adverse effects. We cannot estimate the number of individuals from any species that will experience adverse effects from underwater sound, nor predict the specific responses among the fish exposed. We expect that juvenile salmon will be exposed to harmful noise, which may include mortality and behavioral changes associated with pile driving. These effects will be limited by the in-water work window when the density of juvenile salmon in the action area will expose very few fish to noise effects. Similarly, whereas adult salmonids are more likely to be in the action area, they are far more likely to evade and avoid the work area. Adult and juvenile salmonids are likely to modify their behavior to minimize exposure to noise, but pile driving noise is spatially extensive and is likely to affect adult and juvenile salmonids. A small number of individual juvenile salmonids may be harmed or killed during pile driving activities, but the in-water work windows will prevent population level effects.

We expect that any adult eulachon present in the action area would be affected similarly to the salmonids, as described above. Eulachon do not have swim bladders and are less susceptible to barotrauma (Caltrans, 2020). We do not anticipate eulachon would be present during the IWWW of October 1–December 31.

Benthic disturbance
Adult salmonids do not consume benthic invertebrates as a prey base. Adult salmon also usually cease prey consumption during their upstream migration (Quinn, 2018). Consequently, the reduction in invertebrate forage related to benthic disturbance or existing and temporarily increased shade (construction vessel staging) would not have a significant effect on adult ESA-listed species considered in this opinion.

The benthic prey of juvenile salmonids are likely to be diminished due to the elevated TSS caused by the proposed action. Effects on the prey are likely to be minor among juveniles, affecting those, if any, rearing in the action area more than those migrating through the action area. Rearing juveniles with less available prey in the action area are expected to find suitable areas in nearby unaffected areas, but may experience increased competition for those prey resources. Additionally, in-water structures in the action area may provide foraging habitat and may compensate for the loss of some benthic prey. According to Carrasquero (2001), juvenile salmonids may prey on periphyton, insects, and macroinvertebrates that adhere to in-water structures (such as steel piles) in the CR. Additionally, juveniles present will likely be avoiding the action area due to increased underwater noise and TSS, therefore we expect benthic prey disturbance to have a minor and temporary effect on juvenile salmonids.

We expect that any adult eulachon present in the action area would have a similar response to the benthic effects caused by the proposed action as the salmonids would. Adult eulachon are likely to respond to permanent habitat effects similarly to adult salmonids, by a slight adjustment in their migration pathway.

Enduring Effects

Removal of Creosote

Ultimately, the removal of 3,882.52 tons of creosote timber from the dock structure would result in a beneficial impact on ESA-listed species long term, by decreasing chronic exposure and subsequent contaminant loading into the critical habitat, which has been documented to impair fitness and predicate a myriad of sublethal effects in fish. The benefit from the removal of a large tonnage of creosote would be realized for all ESA-listed species present. For example, all life history stages of salmon are typically exposed to complex environmental mixtures of other toxic compounds (e.g., other metals, pesticides, weathered PAHs) in conjunction with other stressors (e.g., elevated temperatures, low dissolved oxygen) through a variety of exposure routes other than the water column, including consumption of contaminated prey items (dietary) or direct contact with contaminated sediments (NMFS SSNP 2022). Removal of creosote timber piles will reduce leaching of chemical compounds into surrounding sediments, which can cause toxic conditions for organisms that use these areas (DNR 2014). The applicant referenced the NMFS conservation calculator for the Puget Sound Nearshore Programmatic consultation (NMFS 2022) to estimate habitat loss and benefit resulting from the proposed action. While NMFS and the applicant acknowledge that the calculator is not directly applicable to the CR, their analysis suggests a measurable habitat benefit in the action area from the removal of creosote treated timber piles. The removal of creosote would result in a benefit to water quality regardless of biophysical setting.

Shading and Predation

Adult salmonids are too large to be consumed by piscivorous fish that may use in-water and over-water structures as ambush habitat in the CR. Adult salmonids tend to travel through the middle of the river channel and in deeper water. Therefore, the adults traversing the CR are least likely to experience adverse benthic disturbance effects. We expect that the few adults that may encounter the dock would swim around and/or underneath the structures with little to no variation in their migration trajectory.

Juveniles would respond to the structure by swimming around or through, which could slightly lengthen their migratory pathway. Such adjustments to their migration route can potentially be an adverse effect. These route alterations may increase individual energy expenditure, increase opportunities for predators to prey on juveniles, and has been shown to be correlated with mortality (Anderson et al., 2005). Rearing juveniles may also experience degraded habitat conditions due to the dock shade produced. Shade reduces forage opportunities for juveniles and displaces smaller juveniles from shallow water rearing habitat. The dock may create some shade and reduce water velocity that could likely make existing habitat conditions more attractive to predators. Studies found that pikeminnow and smallmouth bass actively search for low-velocity habitats, prefer shaded areas, and utilize overwater structures such as docks (Faler et al., 1988; Isaak & Bjornn, 1996; Martinelli & Shively, 1997). The dock replacement would extend the use of shaded and lower velocity areas preferred by piscivorous fish. Consequently, to the extent the dock will remain in the habitat, the structure would continue contributing to a reduction in the quality of the migratory corridor and rearing habitat. As a consequence, a few juvenile salmonids, especially sub-yearlings, are likely to be consumed by piscine predators. However, population scale effects are very unlikely.

Adult eulachon are typically 6–8 inches in length, and is usually beyond the gape limit of all piscivorous fish except for the largest fish found in the LCR. Thus, we do not anticipate this species to be subjected to increased predation risk because of the proposed action.

Exposure to ship wake stranding

A consequence of the proposed action is the continuation of ocean-going vessel (OGV) traffic on the CR to and from the dock into the future. OGVs (specifically deep draft vessels) produce long period wake waves that can erode shoreline habitats and strand juvenile fishes. The fishes can be carried onto beaches by these waves above the point where waves can return them the river. Ship wake stranding is a primary contributor to a low-priority limiting factor of CR salmonids (NMFS, 2011). A few studies have indicated that under certain conditions, these vessels can produce wakes that strand juvenile salmon in the CR. In 1975, it was estimated that 14,500 juvenile Chinook, 1,359 juvenile coho, and 4,771 juvenile chum salmon were stranded due to ship wakes from 180 OGVs (Bauersfeld, 1977).

Pearson et al. (2006) examined fish wake stranding at three beaches in the LCR in the summer of 2004, winter of 2005, and spring of 2005. In this study, 126 deep-draft vessels were monitored and juvenile stranding occurred at all three sites during the three seasons observed. The percentage of vessels that caused stranding varied among the three sample sites. The authors found that multiple factors were involved in the probability of wake stranding. The factors observed in this study include proximity to the shipping lane, tidal stage, tidal height, river flow, flow velocity, vessel type, vessel transit route, vessel load (i.e., loaded/unloaded), vessel speed, vessel size, fish abundance, beach characteristics (e.g., slope, shielding factors), and total wave excursion. In this study, a proxy for ship kinetic energy (accounting for ship size and speed), and fish abundance were found to have the greatest association with stranding occurrences, but the authors noted expressly that no single factor could be constructed to govern the likelihood of stranding.

The Columbia River Estuary ESA Recovery Plan Module states that there are limited options in terms of reducing the incidence of juvenile wake stranding (NMFS 2011). This is mainly due to the loss of revenue that would result from slower ship travel. Ship traffic through the estuary would continue, and the speed of the ships traversing the CR may be difficult to alter because of safety concerns. Approximately 50 to 55 mid-range vessels are loaded annually at the existing dock and the level of vessel traffic is expected to be maintained following reconstruction of the dock. The U.S. Coast Guard regulates traffic and speed within the LCR navigation channel.

Exposure to noise from boat/vessel traffic
As discussed above, recreational boat/commercial vessel activity is known to cause physiological stress to fish (Nicholes et al., 2015). However, the effect is only expected intermittently for a few minutes at a time. The fishes that encounter noise would likely move away from the area. Due to the intermittent nature of the disturbance and the ability for fish to move away, we do not expect this effect to be meaningful to the survival of adult or juvenile fish that encounter noise disturbance from boats/vessels.

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

Approximately six million people live in the CR basin, concentrated largely in urban centers. The effect of that population is expressed as changes to physical habitat and loadings of pollutants contributed to the CR over time. These changes are caused by residential, commercial, industrial, agricultural, and other land uses for economic development, and are also described in the environmental baseline (Section 2.4). The collective effects of these activities tend to be expressed most strongly in lower river systems where the impacts of numerous upstream land management actions aggregate to influence natural habitat processes and water quality. As such, these effects accrue within this action area, though most are generated from actions upstream of the action area. As human population grows, the range of effects described here are likely to intensify.

Resource-based industries (e.g., agriculture, hydropower facilities, timber harvest, fishing, and metals and gravel mining) caused many long-lasting environmental changes that harmed ESA-listed species and their critical habitats, such as basin-wide loss or degradation of stream channel morphology, spawning substrates, instream roughness and cover, estuarine rearing habitats, wetlands, floodplains, riparian areas, water quality (e.g., temperature, sediment, dissolved oxygen, contaminants), fish passage, and habitat refugia. Those changes reduced the ability of populations of ESA-listed species to sustain themselves in the natural environment by altering or interfering with their behavior in ways that reduce their survival throughout their life cycle. The environmental changes also reduced the quality and function of critical habitat PBFs that are necessary for successful spawning, production of offspring, and migratory access necessary for adult fish to swim upstream to reach spawning areas and for juvenile fish to proceed downstream and reach the ocean. Without those features, the species cannot successfully spawn and produce offspring.

While widespread degradation of aquatic habitat associated with intense natural resource extraction is no longer common, ongoing and future land management actions are likely to continue to have a depressive effect on aquatic habitat quality in the CR basin and within the action area. Additionally, as human population grows, other non-federal uses of the river are likely to increase and intensify, such as recreational boating and fishing, and nonpoint stormwater inputs from upland areas. With increased water-based recreation comes increased frequency of point-source pollution events such as oil and fuel spills, and increased presence of polycyclic aromatic hydrocarbons (PAH) in the aquatic environment. PAHs are long-lasting, have toxic effects on humans and other organisms, and are associated with cancer. In fishes, PAHs are carcinogenic and linked with a diverse suite of negative effects including reproductive, behavioral, and growth problems (Logan 2007). Tire particles contain 6PPD-quinone, which is acutely toxic to juvenile coho and Chinook salmon (Lo et al. 2023). Exposure to this toxin through stormwater runoff is likely to increase with increasing traffic along Washington roads adjacent or with ultimate drainage to the CR. This is particularly concerning as the CR produces several Chinook salmon stocks that are priority prey species for the Southern Resident Killer Whale and toxins often have the potential to bioaccumulate. Increased water-based recreation may also be associated with increased fishing pressure and increased risk of invasive species transmission into the action areas and to/from the LCR. Ongoing use of the CR navigation channel and increases in vessel traffic may increase ship wake stranding of juvenile salmonids and Eulachon and exacerbate nearshore habitat erosion and degradation. Ongoing maintenance and presence of shoreline armoring has degraded natural shoreline and floodplain function. As a result, recovery of aquatic habitat is likely to be slow in most areas, and contemporaneous cumulative effects from basin-wide activities are likely to have a slightly negative impact on population abundance trends and the quality of critical habitat PBFs into the future.

2.7. Integration and Synthesis

The Integration and Synthesis section is the final step in assessing the risk that the proposed action poses to species and critical habitat. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.7.1. ESA-Listed Species

Considering the status of the ESA-listed species, all but two of the species considered in this opinion are threatened. Those two species are the UCR spring-run Chinook salmon, and SR sockeye salmon which are endangered. Most of the component populations of LCR Chinook salmon, UCR spring-run 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, and the Southern DPS of Pacific eulachon are at a low level of persistence. All individuals from populations of these listed species are likely to move through the action area at some point during their life history.

Factoring the current environmental baseline, fish from the component populations that travel through the action area encounter degraded habitat conditions: restricted natural flows, reduced water quality from substantial chemical pollution, loss of functioning floodplains and secondary channels, and loss of vegetated riparian areas and associated shoreline cover. The significance of the degradation is reflected in the limiting factors identified above including habitat access to floodplain and secondary channels, degraded habitat, loss of spawning and rearing habitat, pollution, wake stranding of juveniles, and increased predation. Highlighting the importance of protecting current functioning habitat and limiting water quality degradation, minimizing entrainment, and reducing potential predation of ESA-listed fish.

Within this context, the proposed action would create a temporary physical disturbance in the water column (via noise and turbidity), along with extending the life of the dock that may modify fish migration, provide ambush habitat for piscivorous fish, and reduce the abundance of benthic prey for juveniles. These habitat alterations would displace a small number of adult and juvenile fish as they migrate around the dock. Due to the lack of shoreline vegetation and industrial nature of the dock footprint, it does not provide a suitable habitat for juveniles. Rearing conditions are impaired due to shoreline armoring however, the presence of nearby shoreline vegetation may provide off-channel refugia for juvenile salmonids.

The last element in the integration of effects includes a consideration of the cumulative effects anticipated in the action area. The recovery of aquatic habitat from the degraded baseline conditions is likely to be slow in most of the action area, and the cumulative effects (from continued or increasing uses of the action area) are likely to have a negative impact on habitat conditions. This in turn may cause negative pressure on population abundance trends in the future.

However, even when we consider the status of the threatened and endangered fish populations and degraded environmental baseline within the action area, the proposed action itself is not expected to affect the distribution, diversity, or productivity of any of the populations of ESA-listed species at a measurable level. The effects of the action would be minor to have a measurable impact on the affected populations since no population is expected to experience a greater proportion of the negative effects on abundance. Because the proposed action would not reduce the productivity, spatial structure, or diversity of the affected populations, when combined with a degraded environmental baseline and additional pressure from cumulative effects, the action would not appreciably affect the listed species considered in this opinion.

2.7.2. <u>Critical Habitat</u>

Critical habitat throughout the range of these species is ranked at the watershed scale. Most watersheds (or hydraulic units) have had degradation to some or all PBFs in varying degrees, but many watersheds are still ranked as having medium to high conservation value due to the importance of the role those watersheds serve for the species' life cycle.

In the context of the status of critical habitat and the specific baseline conditions of PBFs in the action area, the proposed action perpetuates a slight obstruction to the passage of juvenile fishes, but would not reduce or change existing natural cover, alter water temperature, or substantially reduce available forage. The replacement of the dock will prevent the establishment of undercut banks, side channels, or other essential habitat features for juvenile salmonids. When considering the cumulative effects of non-federal actions, recovery of aquatic habitat is likely to be slow in most of the action area and cumulative effects from basin-wide activities are likely to have a neutral to negative impact on the quality of critical habitat PBFs.

The critical habitat for migration and rearing is functioning moderately under the current environmental baseline in the action area. Given that the proposed action would have a temporary, localized, low-level effect on the PBFs for migration, rearing, and spawning habitat is not present, even when considered as an addition to the baseline conditions, the proposed action is not likely to reduce the quality or conservation value of critical habitat for any species considered in the consultation.

2.8. Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and the cumulative effects, it is NMFS's biological opinion that the proposed action is not likely to jeopardize the continued existence of LCR Chinook salmon, UWR Chinook salmon, UCR spring-run Chinook salmon, SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, LCR coho salmon, SR sockeye salmon, CR chum salmon, LCR steelhead, UWR steelhead, MCR steelhead, UCR steelhead, SR steelhead, or the Southern DPS of Pacific eulachon or destroy or adversely modify designated critical habitat of any of the ESA-listed species considered in this opinion.

2.9. Incidental Take Statement

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

Portions of this proposed action are likely to result in take of Southern DPS Pacific eulachon adults, larvae, and/or eggs. Take for Southern DPS Pacific eulachon is not currently prohibited under a section 4(d) rule.

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 associated with elevated underwater noise
- Death of juvenile salmonids from predacious fish utilizing shade cast by the overwater structures and vessels utilizing the dock.

Take in the form of harm is often impossible to quantify as a number of individuals, because the presence of the individuals (exposure to the harmful conditions) is highly variable over time, and is influenced by factors that cannot be easily predicted. Additionally, the duration of exposure is highly variable based on species behavior patterns, and the wide variability in numbers exposed and duration of exposure create a range of responses, many of which cannot be observed without research and rigorous monitoring. These biotic and environmental processes interact in ways that may be random or directional, and may operate across far broader temporal and spatial scales than are affected by the proposed action. Thus, the distribution and abundance of fish within the action area cannot be attributed entirely to habitat conditions, nor can the NMFS precisely predict the number of fish that are reasonably certain to be injured or killed if their habitat is modified or degraded by the proposed action. Additionally, the NMFS knows of no device or practicable technique that would yield reliable counts of individuals that may experience these impacts. In these circumstances, we describe an “extent” of take which is a measure of the harming condition spatially, temporally, or both. The extent of take is causally related to the amount of harm that will result, and each extent of take provided below is an observable metric for monitoring, compliance, and re-initiation purposes. In summary, the extent of take for this action is defined as:

- Harm associated with elevated underwater noise impacts to salmon and steelhead from driving piles with an impact hammer: The installation of up to 624 30-inch steel pipe piles (Approximately 325 piles will be installed during Phase 1, and 299 piles will be installed during Phase 2). The extent of take is the installation of 624 30-inch steel piles. This surrogate is causally linked to incidental take by underwater noise because the amount of take increases incrementally with each pile strike.

- Harm from shade and predation effects is the completed size of the dock, 117,000 sf. Juvenile salmonids present in the at the dock may be harmed, injured or die during the construction and operation of the overwater dock facility. Benthic prey community abundance would be reduced by the action, reducing the available prey to fishes in the area affected. In this case, the surrogate is the total area of the constructed dock, 117,000 sf. The square footage of the replaced dock surface corelates to the area of turbidity and benthic disturbance. If the square footage of the replaced dock surface exceeds 117,000 sf, the take limit is exceeded and the opinion must be re-initiated. This surrogate serves as an effective re-initiation trigger because, the area can be tracked on a continuous basis.

Exceedance of any of the exposure limits described above would constitute an exceedance of authorized take that would trigger the need to reinitiate consultation.

2.9.2. Effect of the Take

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

2.9.3. Reasonable and Prudent Measures

"Reasonable and prudent measures" refer to those actions the Director considers necessary or appropriate to minimize the impact of the incidental take on the species (50 CFR 402.02).

The Corps or the applicant shall apply the following reasonable and prudent measures to ensure that take is minimized.

1. Complete riprap placement and restoration of the slope under the dock.
2. Regularly observe the surrounding area for fish presence before and during impact pile driving.
3. Minimize incidental take caused by underwater noise.
4. Ensure completion of a monitoring and reporting program to confirm that the take exemption for the proposed action is not exceeded, and that the terms and conditions in this incidental take statement are effective in minimizing incidental take.

2.9.4. Terms and Conditions

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

1. The following terms and conditions implement reasonable and prudent measure 1:
   a. As required by the Corps of the applicant regarding the WDFW HPA authorized and issued for this proposed action: Placement of armor rock along the shoreline may occur at any time when the work area is in the dry (low tide, seasonally low water,

etc.). Placement of armor rock along the shoreline at times when the work area is NOT in the dry: October 1 – December 31.

b. If the contractor is unable to perform the above work when the area is in the dry, identify a specific work period to complete riprap replacement and restoration of the slope during the IWWW that minimizes overlap with ESA-listed species to the maximum extent feasible.

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

a. The Corps shall require that the applicant, using a trained biologist, visually monitor between 200 and 500 feet downstream of the piles during impact pile driving to observe and report numbers of juvenile and adult salmonid presence, in distress, or apparent mortality.

   i. Monitoring will begin 15 minutes prior to the initiation of impact pile driving and continue continuously for 2 hours.

   ii. Monitoring will occur at the beginning of the day, and once again during the day after impact driving is reinitiated after stopping for not less than 30 minutes if impact driving stops for 30 minutes or longer during the day.

   iii. Documented observations will include time, date, whether bubble curtains were employed within 15 minutes of observed fish, numbers of fish observed by species and life stage (if possible), signs of distress or mortality, whether one or two impact drivers are operating, and approximate distance from impact driving operations.

   iv. Observations will be documented with field notes and photographs which are numerically cross-referenced.

b. If dead and/or injured fish are observed, an effort will be made to collect a sample of these fish.

3. The following terms and conditions implement reasonable and prudent measure 3:

a. The Corps shall require that the applicant conduct a performance test of the sound attenuation device (bubble curtain) prior to any impact pile driving or proofing. The performance test shall confirm calculated pressures and flow rates at each manifold ring.

b. The Corps shall require that the applicant monitor sound levels from impact pile driving throughout the course of pile installation and implement the following measures:

   i. If the biologist observes that fish seen from vantage points from the dock or shoreline are present in at least small-sized juvenile salmonid schools or individual adult salmonids, the biologist will immediately notify the contractor and the applicant, to implement up to a one-day delay in pile driving or until 30 minutes have passed without observations of fish.

   ii. Continuously monitor underwater sound at a distance of 30 ft and 90 ft and report observed peak decibels with notations included for concurrent strikes from multiple impact drivers where known.

4. The following terms and conditions implement reasonable and prudent measure 4:
   a. The Corps shall require that the applicant report all monitoring items, to include at minimum, the following:
      i. Report the mean number of strikes per pile, the number of piles installed, the type of piles installed, the time between pile installation sessions, the periods of concurrent pile driving and the methods (i.e. impact and impact) the total days of pile driving, the type and use of sound attenuation device, and type of driving hammer used.
      ii. Report the volume of slope and riprap restoration placed under the dock to ensure it does not exceed approximately 2,000 cubic yards of filter rock and 2,667 cubic yards of Class II riprap.
      iii. Report completed dimensions of the structure to ensure it does not exceed 117,000 sf of overwater coverage.
      iv. A report based on these observation, collection, and monitoring efforts should be provided to: projectreports.wcr@noaa.gov and should be labeled with the NMFS tracking number WCRO-2023-02346 with attention to David Price, Washington Coast Lower Columbia Branch.

2.10. Conservation Recommendations

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

1. NMFS recommends to the Corps and Applicant to assess and document the feasibility of incorporating stormwater improvements such as advanced treatment of PGIS stormwater runoff prior to discharge to the Columbia River. Stormwater runoff is highly likely to contain several contaminants that have proven damaging to fish, including PAHs and microplastics such as 6PPD/6PPD-q (linked to urban runoff coho mortality syndrome) from vehicles regularly operating on the deck. Fortunately, recent literature has also shown that mortality can be prevented by infiltrating road runoff through soil media containing organic matter, which removes 6PPD-q and other contaminants (Fardel et al. 2020; Spromberg et al. 2016; McIntrye et al. 2015).

2.11. Reinitiation of Consultation

This concludes formal consultation for the Weyerhaeuser log export dock replacement.

Under 50 CFR 402.16(a): "Reinitiation of consultation is required and shall be requested by the federal agency, where discretionary federal involvement or control over the action has been retained or is authorized by law and: (1) If the amount or extent of taking specified in the incidental take statement is exceeded; (2) If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or written concurrence; or (4) If a new species is listed or critical habitat designated that may be affected by the identified action."

2.12. "Not Likely to Adversely Affect" Determinations

Southern DPS Green Sturgeon

The only known spawning population of southern DPS green sturgeon occurs in the Sacramento River. Adults migrate into the river to spawn between April and July. Juveniles spend 1 to 4 years in freshwater before migrating to the ocean. Green Sturgeon could occur, but are unlikely to be present, in the action area during pile installation. During late summer and early fall, adults and subadult Green Sturgeon are known to congregate in large concentrations in the LCR estuary (NMFS 2021); however, most adults and subadults typically exit the LCR prior to the start of the pile installation work windows. Acoustic telemetry in the CR in 2010 and 2011 detected one individual at the uppermost receiver station (located at RM 23.5, approximately 42 miles downstream of the Dock); however, the number of fish decreased rapidly with distance from the mouth of the LCR estuary (Hansel et al. 2017). Adults and subadults are strong swimmers with the speed and power to escape and avoid noise and disturbance from pile driving activities. Green Sturgeon may be affected by turbidity and suspended sediments and/or elevated sound levels. Sturgeon are typically found in turbid conditions and forage in the benthos by stirring up the sediment to access benthic prey such as burrowing shrimp and are thus relatively tolerant of higher suspended sediment concentrations. Consequently, the proposed action will have no impact on green sturgeon spawning or juvenile rearing. Additionally, the project action area does not overlap with green sturgeon critical habitat. The only impact on green sturgeon would be a slight decrease in prey resources. However, this decrease is not expected to result in harm on any individual green sturgeon as any benthic effects will be temporary and restricted to the immediate dock footprint. Therefore, the project is not likely to adversely affect green sturgeon.

Southern Resident Killer Whale

Southern Resident killer whales (SRKW) could be indirectly affected by reducing availability of their primary prey species, Chinook salmon. The proposed activities are not expected to produce a measurable effect on the abundance, distribution, diversity, or productivity of Chinook salmon at either the population or species level. Given the total quantity of prey available to SRKWs throughout their range, this reduction in prey is extremely small. This conclusion is based on NMFS's previous analyses of the effects of in-river salmon harvest on SRKWs (e.g. WCRO-2017-7164). Due to the estimated reduction being small, there is a low probability that any juvenile Chinook salmon killed by the proposed maintenance activities would have later (3–5 years) been intercepted by the killer whales across their vast range in the absence of the proposed activities. Therefore, the anticipated reduction of salmonids associated with the proposed action would result in an insignificant reduction in adult equivalent prey resources for SRKWs and an insignificant effect on their proposed critical habitat.

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

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

3.1 EFH Affected by the Proposed Action

The proposed project occurs within EFH for federally managed fish species within the Pacific Coast Salmon (Chinook and coho salmon) fishery management plan (Pacific Fishery Management Council (PFMC 2024).

3.2 Adverse Effects on EFH

NMFS determined the proposed action would adversely affect EFH as follows;

1. Temporary decrease in water quality due to increased suspended sediment and resuspended contaminants caused by pile removal and installation.
2. Temporary increase of underwater noise from pile removal and installation activities.
3. Perpetuation of obstruction to migratory corridors and habitat for piscine predators due to the presence of the dock.

The effects listed above may affect foraging opportunity or temporarily alter migratory behaviors. A small amount of low-quality freshwater benthic habitat will be replaced by the installation of the steel pilings (Section 1.3). Although the footprint of the dock does not expand, the proposed action increases the longevity of the structure facilitating a continuation of freshwater habitat and migratory passage that is permanently degraded along the right bank of the CR, adjacent to the dock.

3.3 EFH Conservation Recommendations

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

1. NMFS recommends the Corps and applicant assess the feasibility of incorporating additional structural/procedural best management practices for the prevention and/or reduction of predation by piscivorous birds onsite.

Fully implementing the EFH conservation recommendation would protect, by avoiding or minimizing the adverse effects described in section 3.2, above, Pacific Coast salmon.

3.4 Statutory Response Requirement

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

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

If the response is inconsistent with the EFH conservation recommendations, the USACE must explain why the recommendations will not be followed, including the scientific justification for any disagreements over the effects of the action and the recommendations.

3.5 Supplemental Consultation

The Corps 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 Corps. Other interested users could include the Port of Longview, Weyerhaeuser, citizens of Cowlitz, Wahkiakum, and Clark WA counties, citizens of Columbia and Multnomah OR counties and local recovery and conservation groups or organizations. Individual copies of this opinion were provided to the Corps. The document will be available at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

4.2 Integrity

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

4.3 Objectivity

Information Product Category: Natural Resource Plan

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

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion [*and EFH consultation, if applicable*] 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, if applicable*], and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5 REFERENCES

Agne, M.C., P.A. Beedlow, D.C. Shaw, D.R. Woodruff, E.H. Lee, S.P. Cline, and R.L. Comeleo. 2018. Interactions of predominant insects and diseases with climate change in Douglas-fir forests of western Oregon and Washington, U.S.A. Forest Ecology and Management 409(1). https://doi.org/10.1016/j.foreco.2017.11.004

Alizedeh, M.R., J.T. Abatzoglou, C.H. Luce, J.F. Adamowski, A. Farid, and M. Sadegh. 2021. Warming enabled upslope advance in western US forest fires. PNAS 118(22) e2009717118. https://doi.org/10.1073/pnas.2009717118

Anderson, S. C., J. W. Moore, M. M. McClure, N. K. Dulvy, and A. B. Cooper. 2015. Portfolio conservation of metapopulations under climate change. Ecological Applications 25:559-572.

Barnett, H.K., T.P. Quinn, M. Bhuthimethee, and J.R. Winton. 2020. Increased prespawning mortality threatens an integrated natural- and hatchery-origin sockeye salmon population in the Lake Washington Basin. Fisheries Research 227. https://doi.org/10.1016/j.fishres.2020.105527

Beechie, T., E. Buhle, M. Ruckelshaus, A. Fullerton, and L. Holsinger. 2006. Hydrologic regime and the conservation of salmon life history diversity. Biological Conservation, 130(4), pp.560-572.

Bisson, P. A., & Bilby, R. E. 1982. Avoidance of suspended sediment by juvenile coho salmon. North American Journal of Fisheries Management, 2(4), 371-374.

Black, B.A., P. van der Sleen, E. Di Lorenzo, D. Griffin, W.J. Sydeman, J.B. Dunham, R.R. Rykaczewski, M. García-Reyes, M. Safeeq, I. Arismendi, and S.J. Bograd. 2018. Rising synchrony controls western North American ecosystems. Global change biology, 24(6), pp. 2305-2314.

Bottom, D. L., Baptista, A., Burke, J., Campbell, L., Casillas, E., Hinton, S., . . . Zamon, J. E. 2011. Estuarine Habitat and Juvenile Salmon: Current and Historical Linkages in the Lower Columbia River and Estuary, Final Report 2002-2008. In (pp. 216): Report of Research to US Army Corps of Engineers, Portland District, Contract W66QKZ20374382.

Bottom, D.L., C.A. Simenstad, J. Burke, A.M. Baptista, D.A. Jay, K.K. Jones, E. Casillas, and 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 NMFS-NWFSC-68. 246 p.

Braun, D.C., J.W. Moore, J. Candy, and R.E. Bailey. 2016. Population diversity in salmon: linkages among response, genetic and life history diversity. Ecography, 39(3), pp.317-328.

Burke, B.J., W.T. Peterson, B.R. Beckman, C. Morgan, E.A. Daly, M. Litz. 2013. Multivariate Models of Adult Pacific Salmon Returns. PLoS ONE 8(1): e54134. https://doi.org/10.1371/journal.pone.0054134

Burke, J. L. 2005. Life histories of juvenile Chinook salmon in the Columbia River estuary: 1916 to the present. M.S. Thesis. Oregon State University, Corvallis.

Cannon, C. M. 2015. Landforms along the Lower Columbia River and the Influence of Humans. Portland State University. Pp. 133.

Carr-Harris, C.N., J.W. Moore, A.S. Gottesfeld, J.A. Gordon, W.M. Shepert, J.D. Henry Jr, H.J. Russell, W.N. Helin, D.J. Doolan, and T.D. Beacham. 2018. Phenological diversity of salmon smolt migration timing within a large watershed. Transactions of the American Fisheries Society, 147(5), pp.775-790.

Carrasquero, J. 2001. Over-water structures: freshwater issues: Washington Department of Fish and Wildlife.

Carlson, T. J., Ploskey, G. R., Johnson, R., Mueller, R. P., Weiland, M. A., & Johnson, P. 2001. Observations of the behavior and distribution of fish in relation to the Columbia River navigation channel and channel maintenance activities. Pacific Northwest National Lab (PNNL), Richland, WA (United States).

Caltrans. 2020. Technical Guidance for the Assessment of Hydroacoustic Effects of Pile Driving on Fish. Division of Environmental Analysis. Sacramento, California. October 2020.

Carter, J. A., McMichael, G. A., Welch, I. D., Harnish, R. A., & Bellgraph, B. J. 2009. Seasonal juvenile salmonid presence and migratory behavior in the lower Columbia River. PNNL-18246. Pacific Northwest National Laboratory, Richland, Washington.

Chasco, B., I. C. Kaplan, A. Thomas, A. Acevedo-Gutiérrez, D. Noren, M. J. Ford, M. B. Hanson, J. Scordino, S. Jeffries, S. Pearson, K. N. Marshall, and E. J. Ward. 2017. Estimates of Chinook salmon consumption in Washington State inland waters by four marine mammal predators from 1970 to 2015. Canadian Journal of Fisheries and Aquatic Sciences. 74(8): 1173–1194.

Cooper, M.G., J. R. Schaperow, S. W. Cooley,S. Alam,L. C. Smith, D. P. Lettenmaier. 2018. Climate Elasticity of Low Flows in the Maritime Western U.S. Mountains. Water Resources Research. https://doi.org/10.1029/2018WR022816

CRSOA (Columbia River Steamship Operators Association). 2022. https://www.crsoa.net/. Accessed May 2022.

Crozier, L.G., B.J. Burke, B.E. Chasco, D.L. Widener, and R.W. Zabel. 2021. Climate change threatens Chinook salmon throughout their life cycle. Communications biology, 4(1), pp.1-14.

Crozier L.G., M.M. McClure, T. Beechie, S.J. Bograd, D.A. Boughton, M. Carr, T. D. Cooney, J.B. Dunham, C.M. Greene, M.A. Haltuch, E.L. Hazen, D.M. Holzer, D.D. Huff, R.C. Johnson, C.E. Jordan, I.C. Kaplan, S.T. Lindley, N.Z. Mantua, P.B. Moyle, J.M. Myers, M.W. Nelson, B.C. Spence, L.A. Weitkamp, T.H. Williams, and E. Willis-Norton. 2019. Climate vulnerability assessment for Pacific salmon and steelhead in the California Current Large Marine Ecosystem. PLoS ONE 14(7): e0217711. https://doi.org/10.1371/journal.pone.0217711

Crozier, L. G., and J. Siegel. 2018. Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2017. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. U.S. National Marine Fisheries Service, Northwest Region.

Crozier, L. 2017. Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2016. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. U.S. National Marine Fisheries Service, Northwest Region.

Crozier, L. 2016. Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2015. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. U.S. National Marine Fisheries Service, Northwest Region.

Crozier, L. 2015. Impacts of Climate Change on Columbia River Salmon: A review of the scientific literature published in 2014. Pages D1-D50 in Endangered Species Act Section 7(a)(2) supplemental biological opinion: consultation on remand for operation of the Federal Columbia River Power System. U.S. National Marine Fisheries Service, Northwest Region.

Crozier, L., R.W. Zabel, S. Achord, and E.E. Hockersmith. 2010. Interacting effects of density and temperature on body size in multiple populations of Chinook salmon. Journal of Animal Ecology. 79:342-349.

Crozier, L.G. and R.W. Zabel. 2006. Climate impacts at multiple scales: evidence for differential population responses in juvenile Chinook salmon. Journal of Animal Ecology. 75:1100-1109.

Dawley, E. M., Ledgerwood, R. D., Blahm, T. H., Sims, C. W., Durkin, J. T., Kirn, R. A., . . . Ossiander, F. J. (1986). Migrational characteristics, biological observations, and relative survival of juvenile salmonids entering the Columbia River estuary, 1966-1983. US Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife Portland, OR.

Dorner, B., M.J. Catalano, and R.M. Peterman. 2018. Spatial and temporal patterns of covariation in productivity of Chinook salmon populations of the northeastern Pacific Ocean. Canadian Journal of Fisheries and Aquatic Sciences, 75(7), pp.1082-1095.

Evans, A. F., N. J. Hostetter, D. D. Roby, K. Collis, D. E. Lyons, B. P. Sandford, R. D. Ledgerwood, and S. Sebring. 2012. System-wide evaluation of avian predation on juvenile salmonids from the Columbia River based on recoveries of Passive Integrated Transponder Tags. Transactions of the American Fisheries Society 141:975-989.

Fardel. A., P-E. Peyneau, B. Bechet, A. Lakel, F. Rodriguez. 2020. Performance of two contrasting pilot swale designs for treating zinc, polycyclic aromatic hydrocarbons and glyphosate from stormwater runoff. Science Total Env. 743:140503

Faler, M. P., Miller, L. M., & Welke, K. I. 1988. Effects of variation in flow on distributions of northern squawfish in the Columbia River below McNary Dam. North American Journal of Fisheries Management, 8(1), 30-35.

Feist, B.E., J.J. Anderson, and R. Miyamoto. 1996. Potential impacts of pile driving on juvenile pink (Oncorhynchus gorbuscha) and chum (O. keta) salmon behavior and distribution. Fisheries Research Institute Report No. FRI-UW-9603:66 pp.

FitzGerald, A.M., S.N. John, T.M. Apgar, N.J. Mantua, and B.T. Martin. 2020. Quantifying thermal exposure for migratory riverine species: Phenology of Chinook salmon populations predicts thermal stress. Global Change Biology 27(3).

Ford, M. J. (editor). 2022. Biological Viability Assessment Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Pacific Northwest. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-171.

Fresh, K.L., E. Casillas, L.L. Johnson, and D.L. Bottom. 2005. Role of the estuary in the recovery of Columbia River Basin salmon and steelhead: An evaluation of the effects of selected factors on salmonid population viability. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-69. 105 p.

Freshwater, C., S. C. Anderson, K. R. Holt, A. M. Huang, and C. A. Holt. 2019. Weakened portfolio effects constrain management effectiveness for population aggregates. Ecological Applications 29:14.

Gliwicz, Z.M., E. Babkiewicz, R. Kumar, S. Kunjiappan, and K. Leniowski, 2018. Warming increases the number of apparent prey in reaction field volume of zooplanktivorous fish. Limnology and Oceanography, 63(S1), pp.S30-S43.

Gosselin, J. L., Buhle, E. R., Van Holmes, C., Beer, W. N., Iltis, S., & Anderson, J. J. 2021. Role of carryover effects in conservation of wild Pacific salmon migrating regulated rivers. Ecosphere, 12(7), e03618.

Gourtay, C., D. Chabot, C. Audet, H. Le Delliou, P. Quazuguel, G. Claireaux, and J.L. Zambonino-Infante. 2018. Will global warming affect the functional need for essential fatty acids in juvenile sea bass (Dicentrarchus labrax)? A first overview of the consequences of lower availability of nutritional fatty acids on growth performance. Marine Biology, 165(9), pp.1-15.

GRI. 2022. Geotechnical Investigation Weyerhaeuser Log Export Dock Rebuild. Prepared for Weyerhaeuser Company. Prepared by GRI. Vancouver, Washington.

Groot, C., & Margolis, L. 1991. Pacific salmon life histories. Vancouver, Canada: UBC press.

Gustafson, R.G., M.J. Ford, D. Teel, and J.S. Drake. 2022. Status review of eulachon (Thaleichthys pacificus) in Washington, Oregon, and California. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-105. 360 p.

Halofsky, J.E., Peterson, D.L. and B. J. Harvey. 2020. Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA. Fire Ecology 16(4). https://doi.org/10.1186/s42408-019-0062-8

Halofsky, J.S., D.R. Conklin, D.C. Donato, J.E. Halofsky, and J.B. Kim. 2018. Climate change, wildfire, and vegetation shifts in a high-inertia forest landscape: Western Washington, U.S.A. PLoS ONE 13(12): e0209490. https://doi.org/10.1371/journal.pone.0209490

Halvorsen, M.B., Casper, B.M., Woodley, C.M., Carlson, T.J., and Popper, A.N. 2011. Predicting and mitigating hydroacoustic impacts on fish from pile installations. NCHRP Research Results Digest 363, Project 25-28, National Cooperative Highway Research Program, Transportation Research Board, National Academy of Sciences, Washington, D.C. http://www.trb.org/Publications/Blurbs/166159.aspx

Hansel, H.C., Romine, J.G., and Perry, R.W., 2017, Acoustic tag detections of green sturgeon in the Columbia River and Coos Bay estuaries, Washington and Oregon, 2010–11: U.S. Geological Survey Open-File Report 2017-1144, 30 p., https://doi.org/10.3133/ofr20171144.

Hastings, M.C., and A. N. Popper. 2005. Effects of sound on fish. Final Report # CA05-0537 – Project P476 Noise Thresholds for Endangered Fish. For: California Department of Transportation, Sacramento, CA. January 28, 2005, August 23, 2005 (Revised Appendix B). 85 pp.

Healey, M., 2011. The cumulative impacts of climate change on Fraser River sockeye salmon (Oncorhynchus nerka) and implications for management. Canadian Journal of Fisheries and Aquatic Sciences, 68(4), pp.718-737.

Hedges, C.J., 2011. “Hydroacoustic Impacts on Fish from Pile Installation.” National Cooperative Highway Research Program, Research Results Digest 363.

Hering, D. K., Bottom, D. L., Prentice, E. F., Jones, K. K., & Fleming, I. A. 2010. Tidal movements and residency of subyearling Chinook salmon (Oncorhynchus tshawytscha) in an Oregon salt marsh channel. Canadian Journal of Fisheries and Aquatic Sciences, 67(3), 524-533.

Herring, S. C., N. Christidis, A. Hoell, J. P. Kossin, C. J. Schreck III, and P. A. Stott, Eds., 2018: Explaining Extreme Events of 2016 from a Climate Perspective. Bull. Amer. Meteor. Soc., 99 (1), S1–S157.

Holden, Z.A., A. Swanson, C.H. Luce, W.M. Jolly, M. Maneta, J.W. Oyler, D.A. Warren, R. Parsons and D. Affleck. 2018. Decreasing fire season precipitation increased recent western US forest wildfire activity. PNAS 115(36). https://doi.org/10.1073/pnas.1802316115

Holsman, K.K., M.D. Scheuerell, E. Buhle, and R. Emmett. 2012. Interacting effects of translocation, artificial propagation, and environmental conditions on the marine survival of Chinook Salmon from the Columbia River, Washington, USA. Conservation Biology, 26(5), pp.912-922.

HDR 2024. Biological Assessment and Essential Fish Habitat Assessment. Weyerhaeuser Log Export Dock Replacement. Longview, WA: HDR, Inc.

ICTRT (Interior Columbia Basin Technical Recovery Team). 2007. Interior Columbia Basin TRT: Viability criteria for application to Interior Columbia Basin Salmonid ESUs. Available at http://www.nwfsc.noaa.gov/trt/trt_viability.cfm.

ICTRT. 2003. Independent populations of Chinook, steelhead, and sockeye for listed evolutionarily significant units within the Interior Columbia River domain. Working draft. July.

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.

IPCC Working Group I (WGI). 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou editor. Cambridge University Press (https://www.ipcc.ch/report/ar6/wg1/#FullReport).

IPCC Working Group II (WGII). 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. H.O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, and B. Rama (eds.) Cambridge University Press (https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_FinalDraft_FullReport.pdf)

Isaak, D. J., & Bjornn, T. C. 1996. Movement of northern squawfish in the tailrace of a lower Snake River dam relative to the migration of juvenile anadromous salmonids. Transactions of the American Fisheries Society, 125(5), 780-793.

Isaak, D.J., C.H. Luce, D.L. Horan, G. Chandler, S. Wollrab, and D.E. Nagel. 2018. Global warming of salmon and trout rivers in the northwestern U.S.: Road to ruin or path through purgatory? Transactions of the American Fisheries Society. 147: 566-587. https://doi.org/10.1002/tafs.10059

Jacox, M. G., Alexander, M. A., Mantua, N. J., Scott, J. D., Hervieux, G., Webb, R. S., & Werner, F. E. 2018. Forcing of multi-year extreme ocean temperatures that impacted California Current living marine resources in 2016. Bull. Amer. Meteor. Soc, 99(1).

Johnson, M., T. Friesen, D. Van Doornik, D. Teel, and J. Myers. 2018. Genetic influence from hatchery stocks on upper Willamette River steelhead Oncorhynchus mykiss. Oregon Department of Fish and Wildlife. ODFW Information Report Series 2018-03.

Keefer M.L., T.S. Clabough, M.A. Jepson, E.L. Johnson, C.A. Peery, C.C. Caudill. 2018. Thermal exposure of adult Chinook salmon and steelhead: Diverse behavioral strategies in a large and warming river system. PLoS ONE 13(9): e0204274. https://doi.org/10.1371/journal.pone.0204274

Kilduff, D. P., L.W. Botsford, and S.L. Teo. 2014. Spatial and temporal covariability in early ocean survival of Chinook salmon (Oncorhynchus tshawytscha) along the west coast of North America. ICES Journal of Marine Science, 71(7), pp.1671-1682.

Koontz, E.D., E.A. Steel, and J.D. Olden. 2018. Stream thermal responses to wildfire in the Pacific Northwest. Freshwater Science, 37, 731 - 746.

Krosby, M. D.M. Theobald, R. Norheim, and B.H. McRae. 2018. Identifying riparian climate corridors to inform climate adaptation planning. PLoS ONE 13(11): e0205156. https://doi.org/10.1371/journal.pone.0205156

Lindley S.T., C.B. Grimes, M.S. Mohr, W. Peterson, J. Stein, J.T. Anderson, et al. 2009. What caused the Sacramento River fall Chinook stock collapse? NOAA Fisheries West Coast Region, Santa Cruz, CA. U.S. Department of Commerce NOAA-TM-NMFS-SWFSC-447.

Lloyd, D.S., J.P. Koenings, and J.D. LaPerriere. 1987. Effect of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management 7:18-33.

Lo BP, Marlatt VL, Liao X, Reger S, Gallilee C, Ross ARS, Brown TM. Acute Toxicity of 6PPD-Quinone to Early Life Stage Juvenile Chinook (Oncorhynchus tshawytscha) and Coho (Oncorhynchus kisutch) Salmon. Environ Toxicol Chem. 2023 Apr;42(4):815-822. doi: 10.1002/etc.5568. PMID: 36692118.

Logan, D. T. 2007. Perspective on Ecotoxicology of PAHs to Fish. Human and Ecological Risk Assessment: An International Journal, 13(2), 302–316. https://doi.org/10.1080/10807030701226749

Malek, K., J.C. Adam, C.O. Stockle, and R.T. Peters. 2018. Climate change reduces water availability for agriculture by decreasing non-evaporative irrigation losses. Journal of Hydrology 561:444-460.

Martinelli, T. L., & Shively, R. S. 1997. Seasonal distribution, movements and habitat associations of northern squawfish in two lower Columbia River reservoirs. Regulated Rivers: Research & Management: An International Journal Devoted to River Research and Management, 13(6), 543-556.

McNatt, R. A., Bottom, D. L., & Hinton, S. A. 2016. Residency and movement of juvenile Chinook salmon at multiple spatial scales in a tidal marsh of the Columbia River estuary. Transactions of the American Fisheries Society, 145(4), 774-785.

McConnell, R.J., G.R. Snyder, J.T. Durkin, and T.H. Blahm. 1981. Concentration, extent, and duration of salinity intrusion into the Columbia River estuary September – October, 1977-1978. In: Proceedings of the National Symposium on Freshwater Inflow to Estuaries, Volume II. USFWS. FWS/OBS-81/04.

McIntyre, J.K., J. Davis, C. Hinman, K.H. Macneale, B.F. Anulacion, N.L. Scholz, and J.D. Stark. 2015. Soil bioretention protects juvenile salmon and their prey from the toxic effects of urban stormwater runoff. Chemosphere, 132:213-219.

McNatt, R.A., D.L. Bottom, and S.A. Hinton. 2016. Residency and movement of Juvenile Chinook Salmon at Multiple Spatial Scale in a Tidal Marsh of the Columbia River Estuary. Transactions of the American Fisheries Society 145(4):774-785.

Munsch, S. H., C. M. Greene, N. J. Mantua, and W. H. Satterthwaite. 2022. One hundred-seventy years of stressors erode salmon fishery climate resilience in California's warming landscape. Global Change Biology.

Myers, J.M., J. Jorgensen, M. Sorel, M. Bond, T. Nodine, and R. Zabel. 2018. Upper Willamette River Life Cycle Modeling and the Potential Effects of Climate Change. Draft Report to the U.S. Army Corps of Engineers. Northwest Fisheries Science Center. 1 September 2018.

Newcombe, C.O. and J.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal Fisheries Management 16:693-727.

Nedwell, J.R. & Edwards, B. 2002. Measurements of underwater noise in the Arun River during piling at County Wharf, Littlehampton. Subacoustech Report Reference: 513 R 0104.

NMFS. 2024. 2024 5-year Review: Summary & Evaluation of Upper Willamette River Steelhead, Upper Willamette River Chinook. National Marine Fisheries Service West Coast Region, Portland, OR

NMFS. 2022a. 5-Year Review: Summary & Evaluation of Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, Lower Columbia River Coho Salmon, and Lower Columbia River Steelhead. United States. National Marine Fisheries Service. West Coast Region. DOI: https://doi.org/10.25923/431f-fc96

NMFS. 2022b 5-Year Review: Summary & Evaluation of Upper Columbia River Spring-run Chinook Salmon and Upper Columbia River Steelhead. United States. National Marine Fisheries Service. West Coast Region. DOI: https://doi.org/10.25923/p4w5-dp31

NMFS. 2022c 5-Year Review: Summary & Evaluation of Upper Columbia River Spring-run Chinook Salmon and Upper Columbia River Steelhead. United States. National Marine Fisheries Service. West Coast Region. DOI: https://doi.org/10.25923/p4w5-dp31

NMFS. 2022d. 5-Year Review: Summary & Evaluation of Snake River Fall-Run Chinook Salmon United States. National Marine Fisheries Service. West Coast Region DOI: https://doi.org/10.25923/vgh6-g225

NMFS. 2022e. 5-year Review: Summary and Evaluation of Snake River Sockeye Salmon. National Marine Fisheries Service, West Coast Region. DOI: https://doi.org/10.25923/q1s6-3g66

NMFS. 2022f. 5-Year Review: Summary & Evaluation of Middle Columbia River Steelhead. United States. National Marine Fisheries Service. West Coast Region. DOI: https://doi.org/10.25923/63dr-dw24

NMFS. 2022g. 2022 5-Year Review: Summary & Evaluation of Snake River Basin Steelhead United States. National Marine Fisheries Service. West Coast Region. DOI: https://doi.org/10.25923/pxax-h320

NMFS. 2022h. 2022 5-year Review: Summary and Evaluation of Eulachon, Southern DPS. National Marine Fisheries Service, West Coast Region.

NMFS SSNP. 2022. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation for the Salish Sea Nearshore Programmatic Consultation (SSNP) June 29, 2022. NMFS Consultation No.: WCRO-2019-04086. 359p.

NMFS. 2021. Southern Distinct Population Segment of the North American Green Sturgeon (Acipenser medirostris) 5-Year Review: Summary and Evaluation. West Coast Region, Long Beach, California.

NMFS. 2017a. ESA Recovery Plan for Snake River Spring/Summer Chinook Salmon (Oncorhynchus tshawytscha) & Snake River Basin Steelhead (Oncorhynchus mykiss). November 2017. Portland, OR.

NMFS. 2017b. ESA Recovery Plan for Snake River Fall Chinook Salmon (Oncorhynchus tshawytscha) November 2017. Portland, OR.

NMFS. 2017c. Recovery Plan for the Southern Distinct Population Segment of Eulachon (Thaleichthys pacificus). National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, OR, 97232.

NMFS. 2015. ESA Recovery Plan for Snake River Sockeye Salmon. West Coast Region, Protected Resources Division, Portland, OR.

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. Seattle.

NMFS. 2011a. ESA Recovery Plan for Upper Willamette River Chinook Salmon and Steelhead. West Coast Region. Protected Resources Division, Portland, OR.

NMFS. 2011b. Biennial report to Congress on the recovery program for threatened and endangered species October 1, 2008 – September 30, 2010. National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Washington, D.C.

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

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

NOAA. 2022. Tides and Currents –Longview, WA Station (Station ID 9440422). https://tidesandcurrents.noaa.gov/stationhome.html?id=9440422. Accessed March 2022.

NOAA National Centers for Environmental Information (NCEI), State of the Climate: Global Climate Report for Annual 2021, published online January 2022, retrieved on February 28, 2022 from https://www.ncdc.noaa.gov/sotc/global/202113.

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

Ohlberger, J., E.J. Ward, D.E. Schindler, and B. Lewis. 2018. Demographic changes in Chinook salmon across the Northeast Pacific Ocean. Fish and Fisheries, 19(3), pp.533-546.

Olmos M., M.R. Payne, M. Nevoux, E. Prévost, G. Chaput, H. Du Pontavice, J. Guitton, T. Sheehan, K. Mills, and E. Rivot. 2020. Spatial synchrony in the response of a long range migratory species (Salmo salar) to climate change in the North Atlantic Ocean. Glob Chang Biol. 26(3):1319-1337. doi: 10.1111/gcb.14913. Epub 2020 Jan 12. PMID: 31701595.

Ou, M., T. J. Hamilton, J. Eom, E. M. Lyall, J. Gallup, A. Jiang, J. Lee, D. A. Close, S. S. Yun, and C. J. Brauner. 2015. Responses of pink salmon to CO2-induced aquatic acidification. Nature Climate Change 5:950-955.

Parametrix. 2011. Creosote Release from Cut/Broken Piles. Washington Department of Natural Resources. Olympia, WA.

PFMC. 2024. Pacific Fishery Management Council. Pacific Coast Salmon Fishery Management Plan. Feb 2024. 94p.

Quinn, T. P. 2018. The Behavior and Ecology of Pacific Salmon and Trout (2nd ed.). University of Washington Press. http://www.jstor.org/stable/j.ctvcwnvv1

Rich, W. H. 1920. Early history and seaward migration of Chinook salmon in the Columbia and Sacramento rivers: US Government Printing Office.

Redding, J.M., C.B. Schreck, and F.H. Everest. 1987. Physiological effects on coho salmon and steelhead of exposure to suspended solids. Transactions American Fisheries Society. 116:737-744.

Romberg, P. 2005. Recontamination Sources at Three Sediment Caps in Seattle. Proceedings of the 2005 Puget Sound Georgia Basin Research Conference. 7 pp.

Schindler, D. E., J. B. Armstrong, and T. E. Reed. 2015. The portfolio concept in ecology and evolution. Frontiers in Ecology and the Environment 13:257-263.

Sebring, S. H., M. C. Carper, R. D. Ledgerwood, B. P. Sandford, G. M. Mathews, and A. F. Evans. 2013. Relative vulnerability of PIT-tagged subyearling fall Chinook salmon to predation by Caspian terns and double-crested cormorants in the Columbia River estuary. Transactions of American Fisheries Society 142:1321-1334.

Servizi, J. A. and Martens D. W. 1992. Sublethal Responses of Coho Salmon (Oncorhynchus kisutch) to Suspended Sediments. Canadian Journal of Fisheries and Aquatic Sciences. 49(7): 1389-1395. https://doi.org/10.1139/f92-154

Sherwood, C.R., D.A. Jay, R.B. Harvey, P. Hamilton, and C.A. Simenstad. 1990. Historical changes in the Columbia River estuary. Progress in Oceanography 25(1-4):299-352.

Siegel, J., and L. Crozier. 2020. Impacts of Climate Change on Salmon of the Pacific Northwest: A review of the scientific literature published in 2019. National Marine Fisheries Service, Northwest Fisheries Science Center, Fish Ecology Division. https://doi.org/10.25923/jke5-c307

Siegel, J., and L. Crozier. 2019. Impacts of Climate Change on Salmon of the Pacific Northwest. A review of the scientific literature published in 2018. Fish Ecology Division, NWFSC. December 2019.

Simenstad, C.A., D.A. Jay, and C.R. Sherwood. 1992. Impacts of watershed management on land-margin ecosystems: The Columbia River estuary. In Watershed Management, R.J. Naiman (editor). Pages 266-306.

Smith, P. 2008. Risks to human health and estuarine ecology posed by pulling out creosote treated timber on oyster farms. Aquatic Toxicology 86 (2008) 287-298. Smith, P. 2008. Risks to human health and estuarine ecology posed by pulling out creosote treated timber on oyster farms. Aquatic Toxicology 86 (2008) 287-298.

Spromberg JA, Baldwin DH, Damm SE, McIntyre JK, Huff M, Sloan CA, Anulacion BF, Davis JW, Scholz NL. 2015. Coho salmon spawner mortality in western US urban watersheds: bioinfiltration prevents lethal storm water impacts. J Appl Ecol. 2016 Apr;53(2):398-407. doi: 10.1111/1365-2664.12534. Epub 2015 Oct 8. PMID: 27667853; PMCID: PMC5019255.

Sridhar, V., M.M. Billah, J.W. Hildreth. 2018. Coupled Surface and Groundwater Hydrological Modeling in a Changing Climate. Groundwater Vol. 56, Issue 4. https://doi.org/10.1111/gwat.12610

Stachura, M.M., N.J. Mantua, and M.D. Scheuerell. 2014. Oceanographic influences on patterns in North Pacific salmon abundance. Canadian Journal of Fisheries and Aquatic Sciences, 71(2), pp.226-235.

Sturrock, A.M., S.M. Carlson, J.D. Wikert, T. Heyne, S. Nusslé, J.E. Merz, H.J. Sturrock and R.C. Johnson. 2020. Unnatural selection of salmon life histories in a modified riverscape. Global Change Biology, 26(3), pp.1235-1247.

Thorne, K., G. MacDonald, G. Guntenspergen, R. Ambrose, K. Buffington, B. Dugger, C. Freeman, C. Janousek, L. Brown, J. Rosencranz, J. Holmquist, J. Smol, K. Hargan, and J. Takekawa. 2018. U.S. Pacific coastal wetland resilience and vulnerability to sea-level rise. Science Advances 4(2). DOI: 10.1126/sciadv.aao3270

USACE (U.S. Army Corps of Engineers). 1978. Columbia River Datum Elevations. Flood Profiles. CL-03-116. 1973 Revision.

USOFR (U.S. Office of the Federal Register). 2011. 76 FR 65324. Endangered and Threatened Species; Designation of Critical Habitat for the Southern Distinct Population Segment of Eulachon. National Marine Fisheries Service, Department of Commerce. Final Rule. October 20, 2011. Federal Register: 76 (203): 65324-65352.

USOFR (U.S. Office of the Federal Register). 2013a. 78 FR 2893. Endangered and threatened species: Designation of a nonessential experimental population for Middle Columbia River Steelhead above the Pelton Round Butte Hydroelectric Project in the Deschutes River Basin, OR. Department of Commerce, National Oceanic and Atmospheric Administration. January 15, 2013. Federal Register 78(10):2893-2907.

USOFR (U.S. Office of the Federal Register). 2013b. 78 FR 2726. Endangered and threatened species; Designation of critical habitat for Lower Columbia River coho salmon and Puget Sound steelhead; Proposed rule. U.S Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. January 14, 2013. Federal Register 78(9):2726-2796.

USOFR (U.S. Office of the Federal Register). 2014. 79 FR 20802: Endangered and threatened wildlife; Final rule to revise the Code of Federal Regulations for species under the jurisdiction of the National Marine Fisheries Service. U.S Department of Commerce. Federal Register 79(71):20802-20817.

USOFR (U.S. Office of the Federal Register). 2019. 84 FR 53117. Notice of Initiation of 5-year reviews; request for information. National Marine Fisheries Service. U.S. Department of Commerce. October 4, 2019. Federal Register 84(193): 53117-53119.

USOFR (U.S. Office of the Federal Register). 2020a. 85 FR 16619: Endangered and Threatened Species; Extension of Public Comment Period. National Marine Fisheries Service, U.S. Department of Commerce. March 24, 2020. Federal Register 85(57):16619.

USOFR (U.S. Office of the Federal Register). 2020b. 85 FR 81822: Revisions to Hatchery Programs Included as Part of Pacific Salmon and Steelhead Species Listed Under the Endangered Species Act; final rule. National Marine Fisheries Service, U.S. Department of Commerce. 17 December 2020. Federal Register 85(243):81822–81837.

Veilleux, H.D., Donelson, J.M. and Munday, P.L., 2018. Reproductive gene expression in a coral reef fish exposed to increasing temperature across generations. Conservation physiology, 6(1), p.cox077.

Wainwright, T. C., and L. A. Weitkamp. 2013. Effects of climate change on Oregon Coast coho salmon: habitat and life-cycle interactions. Northwest Science 87(3): 219-242.

Ward, E.J., J.H. Anderson, T.J. Beechie, G.R. Pess, M.J. Ford. 2015. Increasing hydrologic variability threatens depleted anadromous fish populations. Glob Chang Biol. 21(7):2500–9. Epub 2015/02/04. pmid:25644185.

WDOE. Washington Department of Ecology. Washington State Water Quality Assessment: (303(d)/305(b)) List. Version 6.0.5. Accessed 2025.

WSDOT (Washington State Department of Transportation). 2020. Biological Assessment Preparation Manual. https://wsdot.wa.gov/engineering-standards/designtopics/ environment/environmental-disciplines/fish-wildlife/endangered-species-act-andessential-fish-habitat/biological-assessment-preparation-manual-template# BAmanual.

Williams, C. R., A. H. Dittman, P. McElhany, D. S. Busch, M. T. Maher, T. K. Bammler, J. W. MacDonald, and E. P. Gallagher. 2019. Elevated CO2 impairs olfactory-mediated neural and behavioral responses and gene expression in ocean-phase coho salmon (Oncorhynchus kisutch). 25:963-977.

Williams, T.H., B.C. Spence, D.A. Boughton, R.C. Johnson, L.G. Crozier, N.J. Mantua, M.R. O'Farrell, and S.T. Lindley. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. NOAA Fisheries Southwest Fisheries Science Center, Santa Cruz, CA: U.S. Dep Commerce NOAA Tech Memo NMFS SWFSC 564.

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. General Technical Report PNW-GTR-326, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, Oregon.

Yan, H., N. Sun, A. Fullerton, and M. Baerwalde. 2021. Greater vulnerability of snowmelt-fed river thermal regimes to a warming climate. Environmental Research Letters 16(5). https://doi.org/10.1088/1748-9326/abf39