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-2019-03625

November 21, 2023

Todd Tillinger
Chief Regulatory Branch
Seattle District, U.S. Army Corps of Engineers
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 shoreline refurbishment at Boeing's Developmental Center and Thompson sites along the Lower Duwamish Waterway Seattle, Washington (NWS-2018-1001)

Dear Mr. Tillinger:

Thank you for your letter of December 13, 2022, 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 Boeing's Developmental Center and Thompson site shoreline refurbishment project (NWS-2018-1001).

Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855(b)) for this action.

The enclosed document contains a biological opinion prepared by NMFS pursuant to section 7(a)(2) of the Endangered Species (ESA) on the effects of the shoreline stabilization project along the Lower Duwamish Waterway (LDW). We have determined that the United States Army Corps of Engineers' (Corps') proposed action, to permit a shoreline stabilization project along the LDW, would not jeopardize the continued existence of listed Puget Sound (PS) Chinook salmon, PS steelhead, PS/Georgia Basin (PS/GB) yelloweye rockfish, PS/GB bocaccio, or Southern Resident killer whales (SRKW). NMFS also concluded that the proposed action is likely to adversely affect, but is not likely to result in the destruction or adverse modification of critical habitat for PS Chinook salmon, PS steelhead, and SRKW.

We also reviewed the likely effects of the proposed action on essential fish habitat (EFH), pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855(b)). We concluded that the action would adversely affect the EFH of Pacific Coast salmon, Pacific Coast groundfish, and West Coast coastal pelagic species. We have included conservation recommendations to avoid, minimize, or otherwise offset potential adverse effects on EFH. Section 305(b)(4)(B) of the MSA requires federal agencies to provide a detailed written response to the Nation Marine Fisheries Service within 30 days of after receiving recommendations.

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

Please contact Dr. Jeff Vanderpham in the Oregon Washington Coastal Office (jeff.vanderpham@noaa.gov) if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

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

cc: Evan Carnes, COE
Jacalen Printz, COE

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

Boeing Developmental Center and Thompson Shoreline Infrastructure Stabilization Project
King County, Washington (COE Number: NWS-2018-1001)

NMFS Consultation Number: WCRO-2019-03265

Action Agency: United States Army Corps of Engineers, Seattle District

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely to Destroy or Adversely Modify Critical Habitat?
Puget Sound Steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	Yes	No
Puget Sound Chinook Salmon (*O. tshawytscha*)	Threatened	Yes	No	Yes	No
Puget Sound/Georgia Basin Yelloweye Rockfish (*Sebastes. ruberrimus*)	Threatened	Yes	No	Yes	No
Puget Sound/Georgia Basin Boccacio Rockfish (*Sebastes paucispinis*)	Endangered	Yes	No	Yes	No
Southern Resident Killer Whales (*Orcinus orca*)	Endangered	Yes	No	Yes	No
Humpback Whale (*Megaptera novaeangliae*) (Central America DPS and Mexico DPS)	CAM (Endangered) MEX (Threatened)	No	No	N/A	N/A

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

Consultation Conducted By: National Marine Fisheries Service
West Coast Region

Issued By:

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

Date: November 21, 2023

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 NMFS Oregon Washington Coastal Office in Lacey, Washington.

1.2. Consultation History

Formal ESA consultation was requested by the Corps on December 13, 2019, for a bank stabilization project at Boeing's Developmental Center (DC) and Thompson properties along the LDW. The Corps determined that the 2019 proposed action was likely to adversely affect listed species.

On November 23, 2020, the Corps resubmitted their consultation request because the applicant, Boeing, had substantially modified the design of the project. Consequently, the Corps effect determination changed to 'may affect, but not likely to adversely affect' (NLAA) listed Puget Sound (PS) Chinook salmon (*Oncorhynchus tshawytscha*; 6/28/05; 70 FR 37160) and PS steelhead (*O. mykiss*; 5/11/07, 72 FR 26722) or their critical habitat (09/02/05; 70 FR 52530, 2/24/16, 81 FR 9252, respectively). Similarly, the Corps determined that the proposed action resulted in No Adverse Effects for Pacific Coast Salmon essential fish habitat (EFH).

On May 25, 2021, NMFS contacted the Corps project manager to begin the consultation process. The Corps provided NMFS with an updated 2020 project design report and detailed project design drawings.

On June 3, 2021, NMFS requested additional information since the provided BA was no longer applicable to the modified proposed action and numerous details were missing to fully analyze the associated effects of the project. The Corps and Boeing provided a written response to NMFS's request via email on June 15, 2021.

On July 28, 2021, the Corps provided NMFS with additional details regarding the project designs and construction schedule. On August 2, 2021, NMFS provided a draft description of the proposed action to the Corps for review. The Corps and Boeing provided edits to the draft proposed action description to NMFS on August 10, 2021.

On November 16, 2021, NMFS requested more information from the Corps regarding stormwater treatment at the project site. The August 13, 2021, proposed action draft did not include stormwater treatment measures despite the inclusion of pollution generating impervious surfaces (PGIS) installation and repair in the areas upland of the sheet pile wall. This aspect of the project without treatment would expose ESA-listed fish and marine mammals to potentially toxic pollutants through environmental and ecological accumulation. As such, NMFS informed the Corps that our effects analysis would utilize an action area that extended to Elliott Bay because of recent findings documenting the fate and transport of pollutants in stormwater and the sensitivities of marine fishes and SRKW to newly identified toxins. Additionally, by increasing the action area, the effects of the project would extend to additional species and/or their habitats including SRKW (*Orcinus orca*), humpback whales (Central America and Mexico DPSs) (*Megaptera novaeangliae*), Puget Sound Georgia Basin (PS/GB) yelloweye rockfish (*S. ruberrimus*), and PS/GB bocaccio (*S. paucispinis*). NMFS requested the Corps to reconsider including these additional species in its effects determinations and provide an analysis of the effects of contaminants in stormwater on ESA-listed species, critical habitat, and EFH. NMFS paused consultation on November 16, 2021, until the Corps provided the additional information on stormwater treatment. On February 15, 2022, NMFS and the Corps met to discuss the information needs in more detail. On August 31, 2022, the Corps provided written responses from Boeing to NMFS's questions on stormwater treatment and discharge. The response also included a revised species determination of NLAA for PS/GB yelloweye rockfish, PS/GB bocaccio, SRKW and Central America DPS and Mexico DPS humpback whale.

On October 19, 2022, NMFS provided a revised description of the proposed action to the Corps for their review, and requested additional information about stormwater treatment and effects. On February 10, 2023, NMFS also described to the Corps likely adverse effects of the proposed action on ESA-listed species and critical habitats. On March 2, 2023, The Corps provided a response to this request, clarifying details about the proposed action, and additional descriptions of stormwater treatment at the site and anticipated site conditions. At this same time, based on likely adverse effects of the proposed action on ESA-listed species and their critical habitat, the Corps requested formal consultation. We determined that we had all the information necessary to complete ESA Section 7 and MSA consultation and initiated formal consultation on March 2, 2023.

On July 5, 2023, NMFS provided a draft revised proposed action to the Corps for review, also requesting clarification on proposed conservation measures and dimensions of overwater structures. On July 25, 2023, the Corps provided these clarifying details and a further revised proposed project description.

On July 5, 2022, the United States District Court for the Northern District of California issued an order vacating the 2019 regulations adopting changes to 50 CFR part 402 (84 FR 44976, August 27, 2019). As reflected in this document, we are now applying the section 7 regulations that governed prior to adoption of the 2019 regulations. For purposes of this consultation, we considered whether the substantive analysis and its conclusions articulated in the biological opinion and incidental take statement would be any different under the 2019 regulations. We have determined that our analysis and conclusions would not be any different.

1.3. Proposed Federal Action

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

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

The Corps is proposing to permit, under Section 10 of the Rivers and Harbors Act, and Section 404 of the Clean Water Act, the installation of 1 linear foot (lf) of sheet pile wall below the high tide line within the footprint of existing shoreline revetment, removal of Range Track Docks 2, 3 and 4, and pile wrapping at Range Track Dock 1 (Figure 1). There are several additional associated project components that the Corps is not including in their permit because the Corps has determined that they are in upland areas and do not require Corps authorization or permits. However, since these additional actions are part of the same overall project, they are associated with, and thus considered an effect of, the proposed action in this Biological Opinion.

The additional project components include installation of 1,405 linear feet (lf) of sheet pile wall at the following locations: Thompson Site (Area 1): 356 lf; DC Slip 6 (Area 2), 248 lf; and DC West of the North Oxbow Bridge (Area 3), 801 lf (Figure 1). The sheet pile wall would be installed within the existing revetment footprint. Boeing would also replace asphalt pavement and associated features along the LDW at the DC and Thompson sites, between river mile (RM) 5 and 6.

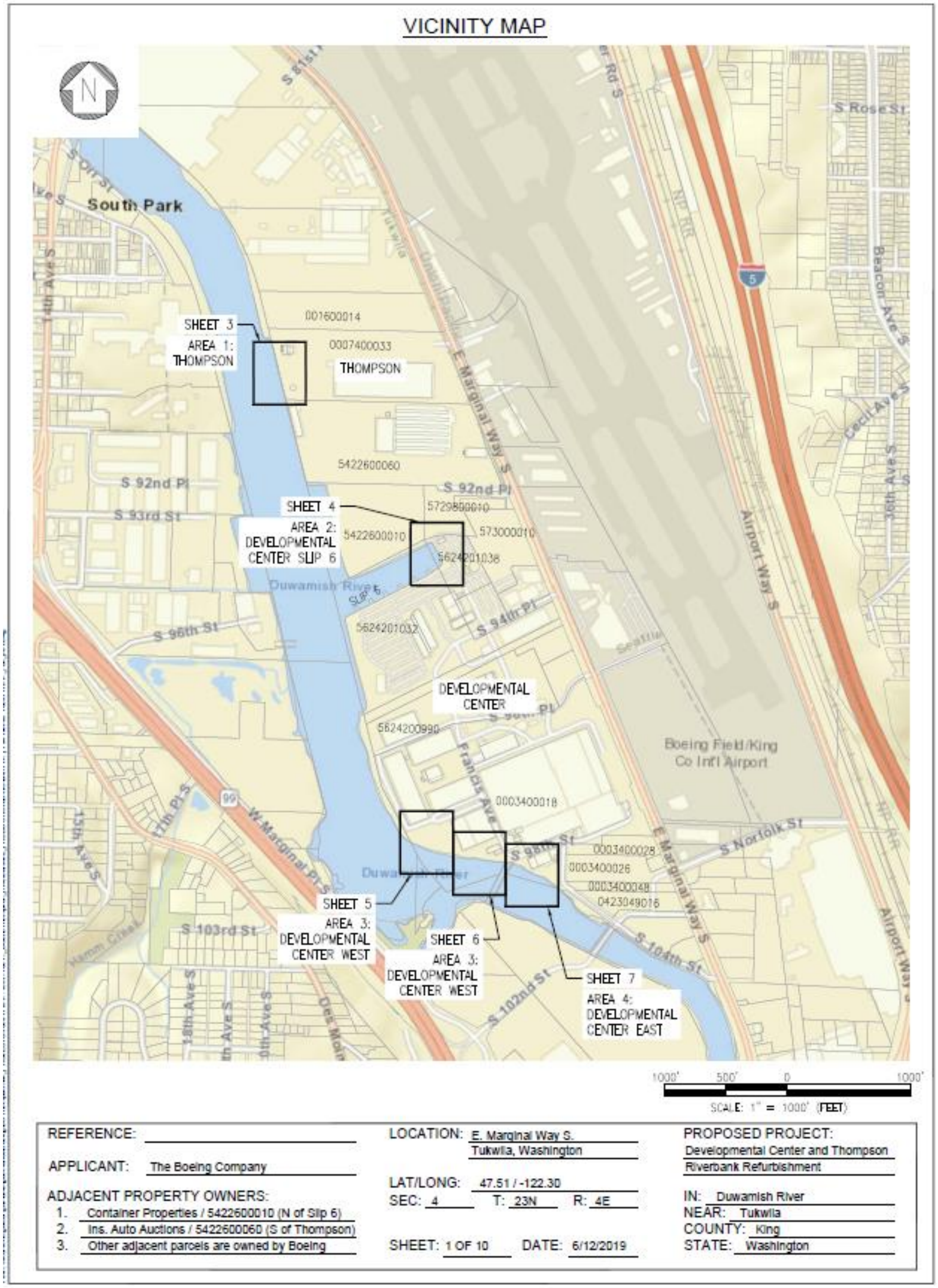

Figure 1. Planned construction locations along the LDW.

The LDW, bordering the western edge of the DC and Thompson sites, is an industrial setting and much of the existing bank stabilization infrastructure is aging and has fallen into disrepair. The proposed sheet pile work is designed to stabilize the shoreline along Boeing's facilities and protect against settlement resulting from riverbank instability. Upland infrastructure is currently exhibiting cracking pavement, sloughing, and leaning fence posts, which Boeing attributes to riverbank erosion.

Whenever possible, work occurring waterward of the high tide line (HTL) would be completed in the dry (not in the water) when tides and river levels are lower than the construction areas. Work that would occur in the dry (not in the water) is being proposed outside of the approved in-water work window of October 1 – February 15. If work is to occur in the water, the approved in-water work window would apply. Work that would occur outside of the approved in-water work window (October 1 – February 15) would occur during low tide or “dry” (not in water) conditions. In-water work would occur within the approved in-water work window. All access for construction activities would be land-based. No materials or equipment would be delivered or operated from the Duwamish River side of the riverbank. In addition, all work below the HTL would be within the footprint of existing bank stabilization measures. All work would be completed within a 3-month period

Only 1 lf of the proposed sheet pile wall would be installed below the OHWM or HTL. The remaining 1,405 lf would be above both the highest astronomical tide (HAT[1]) designation and Federal Emergency Management Agency (FEMA) 100-year base flood level. Vibratory and impact hammers would be used during the sheet pile wall installation process. The sheet pile walls at range track dock 1 would be installed behind the existing timber bulkhead and integrated into the existing dock structure. Following installation of the wall, excavators would be used to excavate and remove material between the sheet pile wall and the existing timber pile wall. The existing timber pile wall would be removed with vibratory hammers or by direct pull. After the timber pile wall is removed, the site will be graded and filter rock and riprap will be placed using an excavator.

The new sheet pile wall would intersect active stormwater drains that discharge stormwater from surfaces landward of the wall. All work on the stormwater drains would occur in the dry above the OHWM/HTL. Boeing would also replace asphalt pavement and associated features along the LDW at the DC and Thompson sites, between river mile (RM) 5 and 6. Range track docks 2, 3, and 4 are proposed to be removed (550 square feet), including the existing creosote-treated support pilings (9 in total). Removal of creosote-treated pilings would require excavation two feet below the existing ground surface to cut existing piles. Excavated areas would then be backfilled with clean sand and the excavated materials would be removed and disposed of at an offsite location. The areas where the docks are removed above OHWM/HTL would be replanted using native vegetation.

Range track dock 1 would not be removed. Repairs are planned for range track dock 1 under the proposed action, including wrapping 13 damaged piles near the mudline with reinforced plastic material, installing steel collars, and replacing cross braces. The over-water area of range track

[1] The elevation of the highest predicted astronomical tide expected to occur at a specific tide station over the National Tidal Datum Epoch, or TDE. The TDE is the specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (e.g., mean lower low water, etc.) for tidal datums (https://tidesandcurrents.noaa.gov/datum_options.html).

dock 1 is approximately 900 square feet. Table 1 summarizes the areas of project impacts below the OHWM/HTL.

Table 1. Summary of project impacts below the OHWM/HTL.

Activity	Duration	Excavation (cubic yards)	Fill (cubic yards)	Area Directly Affected (square feet)	Length Directly Affected (linear feet)
Connection of the proposed sheet pile wall at the north end of the Thompson site	Permanent	<1	<1	30	1
Range Track Docks 2, 3 and 4 removal (decking and 9 pilings)	Permanent	5	5	900[a]	80
Repair of Range Track Dock 1	~ 3 months	7	7	2,300	120
Stormwater pipe related to wall penetration (TS1 and DC5 only)	~ 3 months	6	6	100	20

[a] overwater surface area of structure removed

Asphalt at Areas 1, 2, and 3 would be removed and replaced at a width of 20-feet along the sheet pile walls to allow for construction access and provide a transition to the existing pavement with drainage to the existing catch basins. In total 27,600 square feet of existing impervious surfaces would be repaved, 500 additional square feet would be added, and 3,200 square feet would be removed from the project area (Table 2). There would be a 2,700 square-foot net reduction in the area of impervious surfaces. The existing asphalt would be removed and replaced with 8-inch base course and 4-inch hot mix asphalt. The material used to repair and/or replace existing impervious surface would be cement concrete and asphalt. Prior to any subsurface activity or asphalt/concrete removal, Boeing Environmental Health Services (EHS) would work with Washington Department of Ecology (Ecology) to ensure appropriate removal and disposal methods are used. The parking lots would be supported by the new sheet pile wall and stormwater would drain into the LDW via stormwater outfalls/drains, as described above.

Table 2. Land disturbance, impervious surfaces and earthworks of project areas.

		Impervious areas			Earthworks	
Location	Area of land disturbing activity (sf)	Replaced impervious surface (sf)	New impervious surface (sf)	Removed impervious surface (sf)	Excavation (cy)	Fill (cy)
Thompson (Area 1)	8,200	6,200	100	200	300	300
DC Slip 6 (Area 2)	7,000	5,800	100	700	400	400
DC West (Area 3)	22,800	15,600	300	2,300	700	1,000
Total	**38,000**	**27,600**	**500**	**3,200**	**1,400**	**1,700**

Note: sf = square feet, cy = cubic yards

Installation of the sheet pile wall requires removal of three quaking aspen trees which were determined to be in poor health. The three removed trees would be replaced. Construction is expected to affect the roots and canopy of nine additional trees. Revegetation and restoration is also planned for the areas where Range Track Docks 2, 3, and 4 would be removed.

Minimization Measures

The proposed project includes a number of minimization measures intended to reduce the impacts of the project on listed species and critical habitat. Specific measures include:

- Implementing a stormwater pollution prevention plan intended to reduce delivery of pollutants, sediments, and contaminated runoff to the LDW during construction.
- Placing temporary cover (plastic sheeting, mulching, nets, or blankets), silt fencing and compost socks, sediment retention ponds or traps, stormwater treatment, and dust control.
- Replanting of native vegetation in the footprint of removed track docks.
- Removing the invasive species vegetation at all work sites.
- Working waterward of the HTL only in the "dry," when tides are lower than the construction activities.
- Performing all in-water work would occur in the approved in-water work window.
- Removing existing intertidally located structures and debris, including concrete rubble, two range track structures at the DC, and an existing timber pile wall at the Thompson Site.
- Accessing the site all for construction activities from land.
- Allowing no materials or equipment to be delivered or operated from the Duwamish River side of the riverbank.
- Ensuring all work within the HTL (as described above) would be within the footprint of existing bank stabilization measures.
- Completing project construction in compliance with Washington State Water Quality Standards (Washington Administrative Code [WAC] 173-201A), including:
    - Petroleum products, fresh cement, lime, concrete, chemicals, or other toxic or deleterious materials would not be allowed to enter surface waters.
    - There would be no discharge of oil, fuels, or chemicals to surface waters, or onto land where there is a potential for reentry into surface waters.
    - Fuel hoses, oil drums, oil or fuel transfer valves, fittings, etc., would be checked regularly for leaks, and materials will be maintained and stored properly to prevent spills.
    - The Contractor would prepare a spill prevention, control, and countermeasures (SPCC) plan and use this plan during all demolition and construction operations. A copy of the plan with any updates would be maintained at the work site.
    - The SPCC plan would outline BMPs, responsive actions in the event of a spill or release, and notification and reporting procedures. The plan would also outline management elements such as personnel responsibilities, project site security, site inspections, and training.
    - The SPCC plan would outline the measures to prevent the release or spread of hazardous materials found on site or encountered during construction but not identified in contract documents, including any hazardous materials that are stored, used, or generated on site during construction activities. These items include, but are not limited to, gasoline, diesel fuel, oils, and chemicals.

- Applicable spill response equipment and material designated in the SPCC plan would be maintained at the job site.

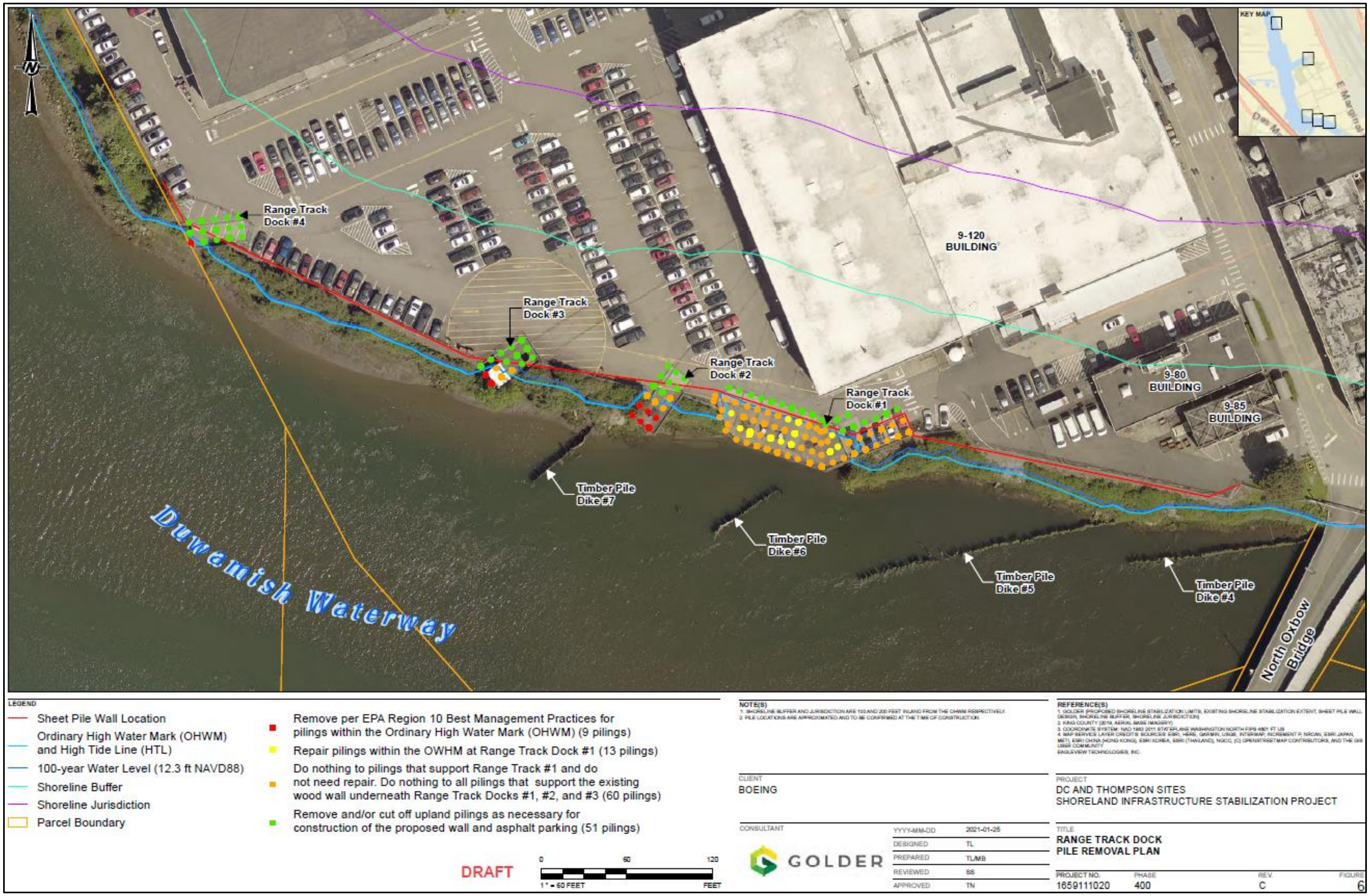

Figure 2. Location and method of pile removal or repair associated with range track docks 1-4.

We considered, under the ESA, whether or not the proposed action would cause any other activities and determined that it would cause the continued presence, repair and use of the impervious surfaces landward of the sheet pile wall, and stormwater treatment and discharge associated with water and contaminants generated by those surfaces (pollution generating impervious surfaces; PGIS) and discharged through the sheet-pile wall.

Stormwater at the Development Center (DC) currently receives treatment via oil-water separators, hydrodynamic separators, roof downspout filtration totes, and catch basin filter inserts, in addition to sweeping, source control, spill kits and housekeeping measures in accordance with National Pollution Discharge Elimination System (NPDES) Industrial Stormwater General Permit (ISGP) #WAR000146, as administered by Ecology. Site management practices are documented under a Site Specific Storm Water Pollution and Prevention Plan (SWPPP) available on Ecology's PARIS website[2]. Table 2 below presents the various stormwater treatments for the existing outfalls at the site, also identifying the contributing basins (areas), and the proposed redirection to two outfalls (DC2 and DC 5) when the others are capped. As reported by the applicant, as of July 2023 the applicant has substantially completed the stormwater portions of the project, with eight outfalls severed, plugged with grout and abandoned, and the previous connections re-routed and collected in the treatment basins, then routed through the remaining functional outfalls. None of the stormwater outfalls discharge wastewater effluent. Only stormwater runoff is discharged from the Development Center and Thompson sites.

The ISGP and associated regulations require quarterly monitoring for standard benchmark pollutants, which include copper, zinc, pH, turbidity, and oil sheen. Ecology includes numeric effluent limits in the ISGP based on a determination that a pollutant in the receiving waterbody is at levels that may be toxic to aquatic life. The segments of the LDW adjacent to the Isaacson/Thompson and Developmental Center sites are not listed as impaired (category 5) for aquatic toxicity for any pollutant. Ecology has included a numeric effluent limit for total suspended solids (TSS) based on Washington Sediment Management Standards.

At both the Isaacson/Thompson site and Developmental Center site, Boeing implements best management practices to address pollutants detected in stormwater. At the Isaacson/Thompson site, Boeing reports that monitoring has shown that these best management practices are effective at maintaining stormwater pollutant levels below ISGP benchmark levels and the TSS numeric effluent limit (stormwater at the Isaacson/Thompson site is not monitored for PCBs). At the Developmental Center site, Boeing is constructing four new stormwater treatment systems (installation of 2 of the 4 treatment systems is complete, with the remaining two to be completed in 2024). These stormwater treatment systems are designed to ensure pollutant levels remain below ISGP benchmark levels and the numeric effluent limit for TSS, and to reduce levels of PCBs to non-detect. Although these stormwater treatment systems are not part of the Boeing shoreline stabilization project, the stormwater would be discharged through the outfalls being replaced. Stormwater discharged through these outfalls is also generated by the PGIS located landward of, and stabilized by, the proposed sheet pile wall.

[2] Ecology. 2023. Water Quality Permitting and Reporting Information System (PARIS), Boeing A & M Development Center. https://apps.ecology.wa.gov/paris/FacilitySummary.aspx?FacilityId=2101. Accessed April 11, 2023.

Ecology's ISGP and associated regulations require that treatment systems be designed to handle: (1) a design storm such as a 25-year storm event or (2) 91 percent of total runoff volume based on modeling. The Developmental Center treatment systems are designed to treat a minimum of 91 percent of the total runoff volume. While Ecology allows compliance with either design standard, indicating they are roughly equivalent in terms of protecting water quality, it is not possible to specify a storm event interval for percent runoff capture. Boeing considers the discharge of untreated stormwater to be unlikely due to the treatment system design.

Table 3. Project site conditions prior to and following the proposed project, describing the existing and anticipated outfall and treatment methods for stormwater.

Site Condition as of January 2021					Current/Anticipated Site Condition			
Outfall name[1]	**Size (in.)**[2]	**Basin name**[1]	**Trib. area (acres)**[1]	**Treatment Best Management Practices**[1]	**Status (active) (inactive-date)**	**Revised basin name**[3]	**Trib. area (acres)**[3]	**Treatment Best Management Practices**[3]
DC2[4]	24	Area 2	12.6	Oil control, filter vault, hydrodynamic separator, cleanway, filter units	Active	WQ Drainage Area 2N	15.03	Engineered media, filtration system, oil control, filter vault, hydrodynamic separator, cleanway filter units
DC3	6	Area 3	0.9	Pilot treatment system, infiltration	Inactive 3/29/2018[1]	Redirected – Tributary to DC2[3]		
DC4	8	Area 4	1.4	Cleanway filter units, spill control	Inactive 8/1/2024	Redirected – Tributary to DC2[3]		
DC5	36	Area 5	2.1	Cleanway filter units, oil control	Active	WQ Drainage Area 5N	21.55	Engineered media filtration system, oil control, cleanway filter units
DC6	12	Area 6	0.1	Non-industrial area	Inactive 1/10/2022	Redirected – Tributary to DC5[3]		
DC7	12	Area 7	0.3	Non-industrial area	Inactive 1/10/2022	Redirected – Tributary to DC5[3]		
DC8	12	Area 8	1.4	Non-industrial area	Inactive 1/10/2022	Redirected – Tributary to DC5[3]		
DC16	6	Area 16	0.1	Cleanway filter units	Inactive 8/1/2024	Redirected – Tributary to DC2[3]		
DC17	18	Area 17	0.3	Non-industrial area	Inactive 8/1/2024	Redirected – Tributary to DC2[3]		
DC19	6	Area 19	0.3	Cleanway filter units	Inactive 1/10/2022	Redirected – Tributary to DC5[3]		

[*] Note: as of July 2023, the applicant substantially completed the stormwater portions of the project, with eight outfalls severed, plugged with grout and abandoned, and the previous connections re-routed and collected in the treatment basins, then routed through the remaining functional outfalls; Trib. = Tributary.

[1] See Stormwater Pollution Prevention Plan (SWPPP) Boeing Developmental Center (DC), January 2021

[2] See Shoreline Infrastructure Stabilization Project 90% Draft Plans prepared by WSP USA, Inc. and Golder Member of WSP, April 26, 2021

[3] See Engineering Report Advanced Stormwater Treatment Boing Development Center prepared by Geosyntec Consultants, Inc., September 28, 2018

[4] Outfall DC2 would not be impacted by the improvements proposed by the Shoreline Infrastructure Stabilization Project. Outfall DC2 would accept combined drainage from Outfalls DC3, DC4, DC16 and DC17.

In accordance with Ecology First Amendment Agreed Order (Docket #19427) and Second Amendment Agreed Order (Docket #20873), a separate upland project to add engineered media filtration treatment systems is currently under construction. The project is being constructed in phases with a final completion of August 1, 2024. The Site Specific SWPPP will be updated as each phase is completed. Stormwater from two areas at the Developmental Center site - areas DC5N and DC9N - are currently routed to the DC5N advanced stormwater engineered media filtration treatment system. Table 2 details the treatment associated with each outfall affected by the proposed action.

Stormwater at the Thompson Site currently receives treatment via oil water separators and cleanway filters in addition to sweeping, source control, spill kits and housekeeping measures in accordance with National Pollution Discharge Elimination System (NPDES) Industrial Stormwater General Permit (ISGP) #WAR000148, as administered by Ecology and documented under a Site Specific Storm Water Pollution and Prevention Plan (SWPPP) (Table 3).

Stormwater from all proposed existing, replaced and new PGIS would be treated (Table 4). All industrial PGIS areas are designed to sheetflow to the individual stormwater collection system for treatment as described above.

Table 4. Surface area of existing, replaced and new PGIS at the project areas, and the surface area of PGIS treated.

Location	Project Pollution Generating Impervious Areas (PGIS)		
	Existing/Replaced PGIS (square feet)	**New PGIS (square feet)**	**Treated PGIS (square feet)**
Thompson (Area 1)	6,200	100	6,300
DC Slip 6 (Area 2)	5,800	100	5,900
DC West (Area 3)	15,600	300	15,900

2. ENDANGERED SPECIES ACT BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

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

The Corps determined that the proposed action is not likely to adversely affect either DPS of humpback whales or their critical habitat. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.12).

2.1. Analytical Approach

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

This biological opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214, February 11, 2016).

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

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 for the conservation of a listed species.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

NMFS relied on the best available science on stormwater contaminants, stormwater treatment methods, the dispersal of contaminants in freshwater and marine water, the associated contamination of sediments from certain stormwater contaminants, and the responses of fishes to exposed to stormwater contaminants. As described in n Section 2.3 (Action Area), despite treatment activities on site, we expect some stormwater contaminants to be carried by currents from the stormwater discharge outlets in the LDW at the project site upstream during high tides to the upper extent of tidal influence within the Duwamish/Green River (approximately to the confluence with the Black River at RM 11), and downstream into Elliot Bay at the outlet of the river into the Puget Sound. We also expect contaminants to be carried from the outlet out into Elliot Bay. Where data was not specific to Puget Sound, NMFS relied on studies on the stormwater contaminants in other nearshore and deep marine waters. NMFS has based its action area on the effects of stormwater. Relying on the larger action area at 1 km waterward radially from the mouth of the LDW, NMFS expects likely adverse effects to PS Chinook salmon, PS steelhead, PS/GB bocaccio, PS/GB yelloweye rockfish and SRKW due to exposure of these species to stormwater runoff. The NMFS also expects likely adverse effects to the critical habitats of PS Chinook salmon, PS steelhead, PS/GB bocaccio, PS/GB yelloweye rockfish, and SRKW. Our analysis includes these species and designated critical habitats that are present in the action area.

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 2015, 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 5, 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 5 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
Puget Sound Chinook salmon	Threatened 6/28/05 (70 FR 37159)	Shared Strategy for Puget Sound 2007 NMFS 2006	NMFS 2016; Ford 2022	This ESU comprises 22 populations distributed over five geographic areas. All Puget Sound Chinook salmon populations continue to remain well below the TRT planning ranges for recovery escapement levels. Most populations also remain consistently below the spawner–recruit levels identified by the TRT as necessary for recovery. Across the ESU, most populations have increased somewhat in abundance since the last status review in 2016, but have small negative trends over the past 15 years. Productivity remains low in most populations. Overall, the Puget Sound Chinook salmon ESU remains at “moderate” risk of extinction.	• Degraded floodplain and in-river channel structure • Degraded estuarine conditions and loss of estuarine habitat • Degraded riparian areas and loss of in-river large woody debris • Excessive fine-grained sediment in spawning gravel • Degraded water quality and temperature • Degraded nearshore conditions • Impaired passage for migrating fish • Severely altered flow regime
Puget Sound steelhead	Threatened 5/11/07	NMFS 2019	NMFS 2016; Ford 2022	This DPS comprises 32 populations. Viability of has improved somewhat since the PSTRT concluded that the DPS was at very low viability, as were all three of its constituent MPGs, and many of its 32 DIPs (Hard et al. 2015). Increases in spawner abundance were observed in a number of populations over the last five years within the Central & South Puget Sound and the Hood Canal & Strait of Juan de Fuca MPGs, primarily among smaller populations. There were also declines for summer- and winter-run populations in the Snohomish River basin. In fact, all summer-run steelhead populations in the Northern Cascades MPG are likely at a very high demographic risk.	• Continued destruction and modification of habitat • Widespread declines in adult abundance despite significant reductions in harvest • Threats to diversity posed by use of two hatchery steelhead stocks • Declining diversity in the DPS, including the uncertain but weak status of summer-run fish • A reduction in spatial structure • Reduced habitat quality • Urbanization • Dikes, hardening of banks with riprap, and channelization
Puget Sound/ Georgia Basin DPS of yelloweye Rockfish	Threatened 04/28/10	NMFS 2017d	NMFS 2016d	Yelloweye rockfish within the Puget Sound/Georgia Basin (in U.S. waters) are very likely the most abundant within the San Juan Basin of the DPS. Yelloweye rockfish spatial structure and connectivity is threatened by the apparent reduction of fish within each of the basins of the DPS. This reduction is probably	• Over harvest • Water pollution • Climate-induced changes to rockfish habitat • Small population dynamics

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				most acute within the basins of Puget Sound proper. The severe reduction of fish in these basins may eventually result in a contraction of the DPS' range.	
Puget Sound/ Georgia Basin DPS of Bocaccio	Endangered 04/28/10	NMFS 2017d	NMFS 2016d	Though bocaccio were never a predominant segment of the multi-species rockfish population within the Puget Sound/Georgia Basin, their present-day abundance is likely a fraction of their pre-contemporary fishery abundance. Most bocaccio within the DPS may have been historically spatially limited to several basins within the DPS. They were apparently historically most abundant in the Central and South Sound with no documented occurrences in the San Juan Basin until 2008. The apparent reduction of populations of bocaccio in the Main Basin and South Sound represents a further reduction in the historically spatially limited distribution of bocaccio, and adds significant risk to the viability of the DPS.	• Over harvest • Water pollution • Climate-induced changes to rockfish habitat • Small population dynamics
Southern resident killer whale	Endangered 11/18/05	NMFS 2008	NMFS 2022k	The Southern Resident killer whale DPS is composed of a single population that ranges as far south as central California and as far north as southeast Alaska. While some of the downlisting and delisting criteria have been met, the biological downlisting and delisting 63 criteria, including sustained growth over 14 and 28 years, respectively, have not been met. The SRKW DPS has not grown; the overall status of the population is not consistent with a healthy, recovered population. Considering the status and continuing threats, the Southern Resident killer whales remain in danger of extinction.	• Quantity and quality of prey • Exposure to toxic chemicals • Disturbance from sound and vessels • Risk from oil spills

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. A summary of the status of critical habitats, considered in this opinion, is provided in Table 6, below.

Table 6. 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
Puget Sound Chinook salmon	9/02/05 70 FR 52630	Critical habitat for Puget Sound Chinook salmon includes 1,683 miles of streams, 41 square mile of lakes, and 2,182 miles of nearshore marine habitat in Puget Sounds. The Puget Sound Chinook salmon ESU has 61 freshwater and 19 marine areas within its range. Of the freshwater watersheds, 41 are rated high conservation value, 12 low conservation value, and eight received a medium rating. Of the marine areas, all 19 are ranked with high conservation value.
Puget Sound steelhead	2/24/16 81 FR 9252	Critical habitat for Puget Sound steelhead includes 2,031 stream miles. Nearshore and offshore marine waters were not designated for this species. There are 66 watersheds within the range of this DPS. Nine watersheds received a low conservation value rating, 16 received a medium rating, and 41 received a high rating to the DPS.
Puget Sound/Georgia Basin DPS of yelloweye rockfish	11/13/2014 79 FR68042	Critical habitat for yelloweye rockfish includes 414.1 square miles of deepwater marine habitat in Puget Sound, all of which overlaps with areas designated for canary rockfish and bocaccio. No nearshore component was included in the CH listing for juvenile yelloweye rockfish as they, different from bocaccio and canary rockfish, typically are not found in intertidal waters (Love et al., 1991). Yelloweye rockfish are most frequently observed in waters deeper than 30 meters (98 ft) near the upper depth range of adults (Yamanaka et al., 2006). Habitat threats include degradation of rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality as specific threats to rockfish habitat in the Georgia Basin.
Puget Sound/Georgia Basin DPS of bocaccio	11/13/2014 79 FR68042	Critical habitat for bocaccio includes 590.4 square miles of nearshore habitat and 414.1 square miles of deepwater habitat. Critical habitat is not designated in areas outside of United States jurisdiction; therefore, although waters in Canada are part of the DPSs' ranges for all three species, critical habitat was not designated in that area. Based on the natural history of bocaccio and their habitat needs, NMFS identified two physical or biological features, essential for their conservation: 1) Deepwater sites (>30 meters) that support growth, survival, reproduction, and feeding opportunities; 2) Nearshore juvenile rearing sites with sand, rock and/or cobbles to support forage and refuge. Habitat threats include degradation of rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality as specific threats to rockfish habitat in the Georgia Basin.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Southern resident killer whale	08/02/21 86 FR 41668	Critical habitat includes approximately 2,560 square miles of marine inland waters of Washington: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. Six additional areas include 15,910 square miles of marine waters between the 20-feet (ft) (6.1-meter (m)) depth contour and the 656.2-ft (200-m) depth contour from the U.S. international border with Canada south to Point Sur, California. We have excluded the Quinault Range Site. Based on the natural history of the Southern Residents and their habitat needs, NMFS identified three PCEs, or physical or biological features, essential for the conservation of Southern Residents: 1) Water quality to support growth and development; 2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and 3) passage conditions to allow for migration, resting, and foraging Water quality in Puget Sound, in general, is degraded. Some pollutants in Puget Sound persist and build up in marine organisms including Southern Residents and their prey resources, despite bans in the 1970s of some harmful substances and cleanup efforts. The primary concern for direct effects on whales from water quality is oil spills, although oil spills can also have long-lasting impacts on other habitat features In regards to passage, human activities can interfere with movements of the whales and impact their passage. In particular, vessels may present obstacles to whales' passage, causing the whales to swim further and change direction more often, which can increase energy expenditure for whales and impacts foraging behavior. Reduced prey abundance, particularly Chinook salmon, is also a concern for critical habitat.

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

We define the action area for this proposed action based on the movement of stormwater contaminates from the project site, as we expect that to result in the greatest extent of physical, chemical or biological effects. Stormwater contaminants would be carried by currents from the stormwater discharge outlets or other surface runoff into the LDW to the upper extent of tidal influence within the Duwamish/Green River (approximately to the confluence with the Black River at RM 11) during high tides, and downstream to outlet of the river at the Puget Sound. We also expect contaminants to be carried from the river mouth into Elliot Bay. As described in Section 2.1 (Analytical Approach), we anticipate stormwater contaminant effects to extend 1 km waterward radially from the mouth of the Duwamish/Green River (the downstream end of the LDW).

2.4. Environmental Baseline

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 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

The LDW is the downstream portion of the Duwamish River and is located along a major shipping route for bulk and containerized cargo. This portion of the Duwamish River is estuarine, where freshwater from the river mixes with the salt water of the Puget Sound Estuary. Habitat conditions for listed salmonids in the action area are degraded. In the early 1900s, the waterway was filled to create uplands that were subsequently developed for industrial and commercial operations, including the dredging and straightening of the original watercourse (Ecology 2011). The shoreline of the LDW has been altered from its natural condition over the past more than 100 years. The shoreline is almost entirely artificially hardened. Riprap, bulkheads, and pile-supported structures are common along much of the shoreline, and as a result it lacks natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, or side channels.

For more than a century, the LDW has facilitated industrial and commercial operations such as shipping and handling of bulk materials, concrete manufacturing, paper and metals fabrication, marine construction, boat manufacturing, marina operations, food processing, and airplane parts manufacturing. The LDW was added to the U.S. Environmental Protection Agency's (EPA) National Priorities List in 2001 and to the Washington State Hazardous Sites List in 2002. The LDW Waterway Group is conducting an ongoing Remedial Investigation and Feasibility Study of the LDW to assess risks to human health and the environment and to evaluate cleanup alternatives.

The LDW receives contaminant inputs from industrial activities and other sources, much of which has ended up in the sediments. Discharges and releases of oil and hazardous substances into the waterway resulted from current and historical industrial and municipal activities and processes since the early 1900s. Facilities released materials through permitted and nonpermitted discharges, spills during cargo transfer and refueling, stormwater runoff through contaminated soils at upland facilities, and discharge of contaminated groundwater. The primary exposure pathways of a contaminant from media to receptors are via contaminants that accumulate in the sediments. The sediments in the estuary are contaminated with metals, petroleum products, and other organic materials (ACOE 2000). The organisms that live in and on the sediments, and that are exposed to sediment contamination, form the base of the food web upon which most of the fish, birds, and other wildlife that use the LDW environment depend. Contamination of the sediments affects nearly all aspects of the LDW ecosystem. Contaminants have been found in tissues of benthic invertebrates and fish in the LDW, indicating that contamination from the sediments is being accumulated by organisms. This suggests that juvenile and adult forage, including aquatic invertebrates and fishes, may inadequately support growth and maturation of juvenile Chinook salmon.

Terrestrial and riparian habitat quality is generally low within the action area, which is dominated by industrial and commercial development along the LWD and along the shoreline of Elliot Bay. Terrestrial habitat, defined as areas landward of the top of bank, within the action area consist largely of industrial and landscaped areas, and patches of vegetation growing toward the top of the bank along riprapped areas. Impervious surfaces cover much of the upland portion of the action area.

Riparian habitat, defined as the zone between the OHWM and the top of bank, within the project area contains patches of riparian vegetation. Fringe areas between the OHWM mark and the top of bank that are adjacent to impervious surfaces include scattered patches of trees, grasses, and weedy forbs. The majority of the shoreline of the action area is hardened with riprap or bulkheads. In several areas, riprap and other miscellaneous debris extends below the OHWM elevations, affecting habitat quality.

The DC and Thompson sites are located along the east bank of the Duwamish Waterway. The Duwamish Waterway begins at Turning Basin 3 adjacent to the DC sites and extends five miles north to Harbor Island. Harbor Island is situated in south Elliot Bay in Puget Sound. The Duwamish Waterway is split into two waterways by Harbor Island and drains to Elliot Bay, the central basin region of Puget Sound (Port of Seattle 2009). The northern bound of the Lower Duwamish Waterway begins south of Turning Basin 3 and extends south 12 miles where it becomes the Green River.

The Duwamish Waterway was heavily dredged in 1913 to transform the river into an industrial waterway. Benthic sediments have been contaminated from past industrial activities. Cleanup of the LDW is an ongoing effort [Port of Seattle and City of Seattle 2010, Lower Duwamish Waterway Group (LDWG) 2004]. Aquatic vegetation in the LDW is sparse. Water quality within the project areas is generally degraded because of associated stormwater runoff from the surrounding developed area. Several small tributaries drain into the waterway, but historical development has rendered these streams inaccessible to salmonids and off- and side-channel habitats are not present (King County 2000).

Within Elliot Bay, aquatic habitat is also degraded. The nearshore is almost entirely armored resulting in minimal riparian vegetation and little nutrient input from riparian sources. The armoring has also resulted in minimal shallow water habitat along the shoreline, coarse substrate, and minimal submerged aquatic vegetation. Overwater structures (piers, docks and floats) also cover much of the nearshore, further reducing the growth of submerged aquatic vegetation and the suitability of habitat for fish. Elliot Bay includes some portions of shoreline with fringe (patchy) kelp, and fringe (patchy) eelgrass at the most westerly portion of Elliot Bay (Ecology 2023), and limited herring spawning may occur at the northern end of Elliot Bay (WDFW 2023)

Water quality in Elliot Bay is also degraded. Some areas are identified as Category 5 waters (places where water quality standards have been violated for one or more pollutants, requiring a water quality improvement project) for PCBs, bacteria, dioxins, PAHs, low dissolved oxygen and other contaminants (Ecology 2023).

ESA-listed species that occur within the action area include PS Chinook salmon and PS steelhead in Elliot Bay and the LDW, and PS/GB bocaccio, PS/GB yelloweye rockfish and SRKW within Elliot Bay. Both species of salmon spawn upstream of the project site in the Duwamish/Green River or tributaries and juveniles rear within the Duwamish/Green River, including the LDW, before migrating through Elliot Bay to the wider Puget Sound and Pacific Ocean. Critical habitat is designated within the LDW portion of the action area for both species, and for PS Chinook salmon within Elliot Bay.

Bocaccio rockfish adults stay in deep waters (98 feet or deeper) but juveniles use shallow areas within their designated critical habitat, and larval lifestages float in the water column. Larvae are born with limited abilities to swim, maintain buoyancy in the water column, and feed. These larvae are pelagic for approximately 2 months and occur in the water column from near the surface to depths of 328 feet or more. Larval presence in Puget Sound peaks in spring and again in summer, and larvae commonly associated with kelp beds. Similar to bocaccio, yelloweye rockfish larvae are produced 2 times per year in Puget Sound, and float within the water column for approximately 2 months. Unlike bocaccio, yelloweye juveniles ‘settle’ in deeper water, and thus critical habitat and juvenile and adult lifestages are expected only in the deep-water portion of the action area. Critical habitat is designated for both species of rockfish throughout much of Elliot Bay.

Southern Resident killer whale may occur in Elliot Bay. Areas with water less than 20 feet deep are not designated as critical habitat for SRKW, but most of the bay is deeper than 20 feet and is designated as critical habitat.

2.5. Effects of the Action

Under the ESA, “effects of the action” are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action (see 50 CFR 402.02). A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered the factors set forth in 50 CFR 402.17(a) and (b).

Effects of the proposed action include temporary, intermittent and long-term (enduring) effects. Temporary effects are associated with construction activities (completed within three months), whereas long-term effects are associated with the presence and operation of proposed structures. For this proposed action and activities caused by it, temporary effects on habitat and species result from turbid conditions and noise during in-water construction activities. Long-term effects would result from the presence of the proposed sheet pile wall, the removal or maintenance of structures, and discharge of stormwater

As a result, we identified temporary, intermittent, and enduring effects on aquatic habitat availability, water quality, benthic communities, forage base, predator/prey dynamics, migration areas, shoreline processes, and riparian function. These effects on habitat conditions, including critical habitat, would have indirect effects on species occurring within the action area. We also anticipate direct lethal and sub-lethal effects on species by contaminants in stormwater discharge.

2.5.1 Effects on Critical Habitat

Critical habitat designations in the action area that would be adversely affected by the action include PS Chinook salmon, PS steelhead, PS/GB bocaccio, PS/GB yelloweye rockfish, and SRKW. 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, and the influence of these changes on the potential for the habitat to serve the conservation values for which it was designated. Critical habitat in the estuarine, nearshore, and marine environments include:

- PS Chinook salmon and PS steelhead:
  - Freshwater migration – free of artificial obstruction, natural cover, water quality and quantity.
  - Estuarine areas – forage, free of artificial obstruction, natural cover, salinity, water quality and quantity.
  - Nearshore marine areas – forage, free of artificial obstruction, natural cover, water quantity and quality

- PS/GB bocaccio:
  - Deepwater sites (>30 m) that support growth, survival, reproduction, and feeding opportunities.
  - Nearshore juvenile rearing sites with sand, rock and/or cobbles to support forage and refuge.

- PS/GB yelloweye rockfish:
  - Deepwater sites (>30 m) that support feeding opportunities and predator avoidance.

- Southern Resident killer whale:
  - Water quality to support growth and development.

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

Temporary Effects

Benthic Conditions/Forage

Areas where sediment is disturbed by proposed pile repair or removal, excavation, and sheet pile wall installation, would disturb and diminish benthic and forage prey communities. In areas where suspended sediment settles on the bottom smothering can occur and disrupt benthic and some forage communities. The speed of recovery is determined by the intensity of the disturbance; the greater the disturbance the longer the recovery time (Dernie et al., 2003). Additionally, the ability of a disturbed site to recolonize is affected by whether or not adjacent communities can re-seed the affected area. Thus, recovery can range from several weeks to many months. Diminishment of benthic communities can also impact important juvenile salmonid forage species such as Pacific herring, sand lance, surf smelt, and salmonids. The project site is located near the extent of the intertidal zone and contains important habitat for a variety of invertebrates and fishes.

We anticipate the disturbance of benthic conditions by construction activities to be short-term (period of in-water work) and highly localized to the immediate area of disturbance and established mixing zone for turbidity (within 300 feet of in-water work). Any reduction to the quality or quantity of forage, as a PB of critical habitat for PS Chinook salmon or PS steelhead, would be minor.

Water Quality

Temporary, intermittent, and enduring declines in water quality would result from the proposed action. Water quality would be temporarily degraded during construction work associated with repair and removal of in-water structures (piles), shoreline armoring (sheet pile wall installation), and stormwater pipe drain modifications. Effects include increased turbidity, reduced dissolved oxygen, re-suspension of contaminants, and accumulation of contaminants and toxins in aquatic environment.

Temporary degradation to water quality as a result of project construction would occur within the vicinity of the construction site, but are unlikely to persist downstream into Elliott Bay. Turbidity may increase during excavation to repair (wrap) or remove wooden piles, install the sheet pile wall, and reroute stormwater drains to accommodate installation of the sheet pile wall. Turbidity would be most likely to increase during these activities if work was conducted in-water. Work is proposed to occur, except in a few instances, above MHHW and during low tide or “dry” conditions. In estuaries, state water quality regulations establish a mixing zone of 300 feet plus the depth of water over the discharge port as measured during mean lower low water[3]. Elevated turbidity is not expected to persist past the mixing zone and would return to baseline conditions shortly after in-water work is completed. Outside of in-water work, elevated turbidity

[3] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-400

is likely when tidal water re-inundates excavated areas. Modification to stormwater drains may result in slightly increased runoff during construction as stormwater may be rerouted until construction is completed, which may result in a slight increase in turbidity.

Suspension of sediments during in-water work can result in reduced dissolved oxygen (DO) within the mixing zone. Based on a review of six studies on the effects of dredging on DO levels, LaSalle (1988) concluded that, when relatively low levels of suspended material are generated and counterbalancing factors such as flushing exist, anticipated DO depletion around in-water work activities would be minimal. High levels of turbidity could cause a contemporaneous reduction in DO within the same affected area. Reduced DO is not expected to exceed the established mixing zone of 300 feet plus the depth of water over the discharge port(s) as measured during mean lower low water. Because most work would occur above MHHW it is unlikely that DO would be significantly impacted by the proposed action. Similarly, given the expected insignificant increases in turbidity it is unlikely that DO would be reduced to levels that would compromise the existing habitat, reduce conservation value, or impair species growth or reproduction.

Re-suspension of contaminants may occur during the proposed range track dock and pile removal and repair. Creosote-treated piles can contaminate surrounding sediment up to two meters away with PAHs (Evans et al. 2009) and removing creosote-treated piles would mobilize PAHs that have settled into surrounding sediments (Smith et al. 2008; Parametrix 2011). Projects can also release PAHs directly from creosote-treated timber during the demolition of overwater timber and if piles break during removal (Parametrix 2011). However, studies have shown that the concentration of creosote derived PAHs released into surface water rapidly dilutes. 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. 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. Removal of creosote timber piles would reduce leaching of chemical compounds into nearshore and marine sediments, which can create toxic conditions for organisms that use these areas (e.g. West et al. 2016). This would incrementally improve habitat conditions in the LDW for PS Chinook salmon and PS steelhead.

As with suspended sediments, re-suspended contaminants resulting from the proposed work are not expected to be detectable above background levels beyond the established mixing zone of 300 feet plus the depth of water over the discharge port(s) as measured during MLLW. Negative effects to water quality are expected to abate as the contaminated materials settles out, at which point they would become persistent in the substrate. Accumulation of contaminants in benthic sediments can cause chronic or sublethal effects to prey and forage species and is discussed later. Re-suspension of contaminants is unlikely to reduce the conservation value of critical habitat in the action area.

Given the temporary nature of the effects to water quality described above and that most construction would occur during low tide or “dry” conditions we expect temporary construction-related activities to have only a minor effect on water quality as a PBF of critical habitat for PS Chinook salmon or PS steelhead.

Intermittent Effects

Water Quality

In total, 27,600 square feet of existing PGIS would be replaced, 500 square feet would be added, and 3,200 square feet would be removed as part of the proposed action resulting in a net decrease of PGIS area. However, repaving/replacing paved areas would ensure that PGIS remains at the Boeing site for the foreseeable future providing a vector for contaminated stormwater to the Lower Duwamish Waterway and Elliot Bay. As described in the Environmental Baseline section (2.3) numerous harmful compounds such as heavy metals, PCBs, PAHs, 6PPD-quinone and VOCs are currently found at the Boeing sites and in stormwater discharges. As such, we expect stormwater discharge to adversely affect listed salmonids, rockfish, and SRKW, and their critical habitats.

Stormwater runoff is a major contributing factor to water quality impairments throughout Washington State (EPA 2020). Impervious surfaces, such as roads and parking lots, alter the natural infiltration of vegetation and soil, and accumulate many diverse pollutants. During heavy rainfall or snowmelt events, accumulated pollutants are mobilized and transported in runoff from roads and other impervious surfaces. Individual stormwater outfalls ultimately discharge to streams, rivers, lakes, and marine waters. In chemical terms, runoff from roadways, parking lots, and other hardscaped elements of the transportation grid represents an extraordinarily complex mixture, consisting of thousands of distinct compounds, the vast majority of which have not been identified or characterized in terms of adverse environmental effects (Du et al. 2017, Peter et al. 2018). The proposed project intends to capture and treat stormwater prior to discharge into Puget Sound. Stormwater from all proposed existing, replaced and new PGIS would be treated, as described above. All industrial PGIS areas are designed to sheetflow to the individual stormwater collection system for treatment. However, we anticipate some contaminants will not be fully removed by the treatments systems, and stormwater may also discharge directly to the LDW during storm events that exceed the capacity of the treatment systems.

Despite water quality standards and treatment, environmental monitoring has documented pollution-driven degradation in nearly all aquatic habitats (freshwater, estuarine, and marine) for NOAA trust resources, including those presently listed for protection under the U.S. Endangered Species Act (ESA). In Puget Sound, for example, this includes habitat supporting several species of Pacific salmon and steelhead, rockfish, SRKW and humpback whales. The agency must consider potential direct and indirect (and/or delayed in time) impacts of toxics on species and their habitats, including critical habitat (under the ESA) and essential fish habitat (under the MSA, considered in Section 3 of this document). The physical, biological, and chemical dimensions of habitat quality, including aquatic food webs, encompass the abundance and productivity of freshwater macroinvertebrates (as prey for juvenile salmon), the health of shoreline macroalgal communities (e.g., sheltering eelgrass habitats), and the survival and abundance of shore-spawning herring and other marine forage fish (keystone species for marine food webs).

Recent research by NMFS' science team (Northwest Fisheries Science Center, Ecotoxicology and Environmental Chemistry Programs) has shown that untreated stormwater is highly toxic to aquatic species, including Pacific salmon and marine forage fish. Conversely, parallel studies have shown that clean water/green infrastructure treatment methods can remove pollutants from stormwater. We expect that despite treatment to be performed at the proposed regional facility, effluent will still contain some contaminants, such as PAHs and 6PPD/6PPD-quinone (6PPD-q). Water quality will improve, but discharges will still adversely affect water quality due to uncaptured contaminants. Stormwater may also include an array of contaminants depending on the surrounding land use and proximity to industrial facilities (Table 7).

Stormwater can discharge at any time of year. However, first-flush rain events after long dry periods typically occur in September in western Washington. As with stormwater runoff globally, the leading edge of hydrographs (the first flush) in Puget Sound have proportionally higher contractions of contaminants, including those long known to resource managers (as evidenced by existing aquatic life criteria under the Clean Water Act), as well as many chemicals of emerging concern, so-called because they were largely unknown a decade ago (Peter et al. 2020). Higher concentrations of pollutants occur less frequently between March and October as longer dry periods exist between storm events. In western Washington, most stormwater discharge occurs between October and March, when the region receives the most rain.

Table *7*. Pollutants commonly found in stormwater runoff in Washington state

Pollutant Class	Examples	Urban Sources
Petroleum hydrocarbons	PAHs (poly aromatic hydrocarbons)	Roads (vehicles, tires), industrial, consumer products
Metals	Mercury, copper, chromium, nickel, titanium, zinc, arsenic, lead	Roads, electronics, pesticides, paint, waste treatment
Microplastics	6PPD/6PPD-q	Vehicle tires
Common use pesticides, surfactants	Herbicides (glyphosate, diquat), insecticides, fungicides, adjuvants, surfactants (detergents, soaps)	Roads, railways, lawns, levees, golf courses, parks
Nutrients and sediment	Nitrogen, phosphorus fertilizers, fine-grained inorganic sediment	Fertilizer, soil erosion
Persistent bio-accumulative toxicants (PBT)	POPs (persistent organic pollutants) PCBs (polychlorinated biphenyls) PBDEs (polybrominated diphenyl ethers) PFCs (poly- and per-fluorinated compounds) Pharmaceuticals (estrogen, antidepressant)	Eroding soils, solids, development, redevelopment, vehicles, emissions, industrial, consumer products
Temperature and dissolved oxygen	Warm water, unvegetated exposed surfaces (soil, water, sediments)	Impervious surfaces, rock, soils (roads, parking lots, railways, roofs)
Bacteria	*Escherichia coli*	Livestock waste, organic solids, pet waste, septic tanks

Stormwater negatively impacts critical habitat of the ESA listed fishes and SRKW by degrading water quality, (water quality is also a feature of essential fish habitat, see the EFH analysis presented in section 3 of this document). Contaminants in stormwater can be transported far downstream to estuaries and the ocean dissolved in surface waters, attached to suspended sediments, or via aquatic food webs (e.g., bioaccumulation). Aquatic organisms including ESA-listed fish and marine mammals may take up contaminants from their surrounding environments by direct contact with water and sediments, or ingestion of contaminated plankton, invertebrates, detritus, or sediment, indicating that prey and substrate are also adversely affected features of critical habitat.

For SRKW, stormwater discharge events would reduce quality and quantity of prey including juvenile Chinook salmon. As PS Chinook salmon are a PBF of SRKW critical habitat, their repeated/chronic exposure to contaminants in successive cohorts, directly through diminished water quality, and via contaminated prey, both described above, results in a diminishment of the forage PBF of SRKW critical habitat. Both quantity and quality of prey would slightly decline as a result of impacts to water quality, as these effects are likely to cause latent health effects on

fish that slightly reduce adult abundance, and also reduce the quality of adult fish that do return and serve as SRKW prey, due to bioaccumulated contaminants.
We anticipate water quality to be degraded by the discharge of stormwater effluent generated by PGIS at the project site. Although treatment systems would provide treatment to achieve state standards, significantly reducing toxins in stormwater effluent, we expect some degradation of the water quality PBF of critical habitat for PS Chinook salmon, PS/GB bocaccio, PS/GB yelloweye rockfish, and SRKW. However, given the existing and proposed treatment of all discharges from the PGIS at the project areas, we believe that water quality, sediment quality, and prey communities would continue to support the conservation role for each of the designated species.

<u>Enduring Effects</u>

Water Quality

The enduring effects on water quality include the chronic and system-wide introduction and extended existence of pollutants from stormwater generated in the uplands of the site. Episodic effects would occur during use and maintenance of the repaired dock structure and via stormwater runoff from new and replaced pollution generating impervious surfaces (PGIS). Enduring effects include accumulation of toxic contaminants and pollutants in the downstream nearshore, estuarine, and marine environments. Increased levels of PAHs, oils, and other contaminants would be widely dispersed, and can have detrimental effects at very low levels of exposure either directly or indirectly through the consumption of prey contaminated by their own exposure in the water column. This would impair the value of critical habitat for growth and maturation of listed species. Over time, the proposed action would cause toxic contaminants (described in the previous section) to accumulate in the action area, in solution and biological tissues, and degrade water quality and prey base quality (discussed in more detail in the next sections) in the Lower Duwamish Water and Elliott Bay degrading the water quality PBF of critical habitat for PS Chinook salmon, PS steelhead, PS/GB bocaccio, PS/GB yelloweye rockfish, and SRKW. This adverse effect would remain until stormwater originating from Boeing facilities is treated to remove toxic compounds before discharging into the LDW.

Prey communities of PS Chinook salmon and PS steelhead would be affected by contaminants in stormwater. Juvenile Chinook salmon from the Lower Columbia and Willamette Rivers, which have similar urban sources of pollution, were noted to have PCBs and PAHs in the stomach contents of all fish evaluated, indicating that prey is a source of exposure contributing to body burden in salmonids (Johnson et al 2007). Similar consumption/stomach content would be expected at this site. Salmonids that consume those prey would also carry those contaminants themselves

Benthic organisms within the action area may also be exposed to PAHs through their diet and through direct contact with contaminated water and sediments. This includes the areas adjacent to construction as well the estuarine, nearshore, and marine environments further downstream in Elliott Bay and the greater Puget Sound. PAHs may bioaccumulate in aquatic invertebrates within these benthic communities (Varanasi et al. 1989, Meador et al. 2006).

Additionally, bank hardening, like the sheet pile wall, even when incorporating vegetation into the design, impedes geomorphic adjustment processes like channel migration and leads to more damaging erosion events locally or in downstream reaches (see Florsheim et al. 2008). This may result in increased chronic erosion of the LDW, leading to the elevated levels of suspended sediments. The sheet pile wall also prevents the LDW from re-establishing connection to its historic floodplain, which is currently where Boeing facilities and other industrial developments reside. This ensures the inability of the historic floodplain to provide an expanded area for depositing and storing excess sediment, particularly fine sediment. This diminished capability may result in further elevated levels of suspended sediment, compared to an environment with better floodplain connectivity and natural hydrologic functions. The proposed sheet pile wall is, therefore, expected to result in adverse changes in water quality from long-term increases in suspended sediments, reducing the function of the rearing PBFs in the action area.

Hyporheic processes that provide cold water refuge for adult and juvenile anadromous fishes during low-flow periods are also lost when impervious surfaces, such as the PGIS upland of the sheet pile wall, intercept stormwater and reduce summer groundwater elevations. Bank hardening, like the sheet pile wall, that prevents lateral channel movement and sediment sorting processes results in the loss of habitat forming processes that create and maintain hyporheic connections that provide summer cold-water refuge in alcoves (Poole and Berman 2001). The proposed sheet pile wall, by preventing re-establishment of floodplain connectivity and natural channel processes, therefore, prevents the formation of cold water refugia in off-channel habitats, thereby reducing the function of rearing and migrating PBFs in the action area.

Habitat Complexity/Natural Cover

The proposed project would result in the armoring/stabilization of 1,790 feet the bank of the LDW with a new sheet pile wall. Common bank hardening/armoring/stabilization (e.g. sheet pile walls) reduces habitat quality and habitat connectivity. Although all but 1 lf would be below the OHWM, the entire wall is intended to prevent or slow bank erosion to stabilize the bank and protect existing infrastructure, which would result in degraded habitat quantity, quality and function. Specifically, bank armoring can perpetuate channelization, eliminate cover, and reduce forage and prey opportunities for juvenile salmonids. Although the project site is within the downstream reaches of the Duwamish River, it is an estuarine area, with both riverine and estuarine habitat functions important to rearing and migrating salmonids. Shoreline stabilization has been identified as a primary limiting factor or threat to the recovery of most salmon and steelhead populations (NWFSC 2015, NMFS 2017).

Streambank and nearshore armoring create a simplified habitat interface ill-suited for rearing juvenile salmonids when compared to a natural bank. This structural stabilization resists lateral scour and natural bank function, resulting in a loss of aquatic and riparian habitat volume, function, and complexity for the life of the structure. Shoreline armoring is extensive in urban areas worldwide, but the ecological consequences are poorly documented. The presence of bank stabilizing structures has been found to result in reduced large woody debris, fewer pools, less sediment storage, and a higher channel incision potential (Segura and Booth 2010). A study by Morley et al. (2012) mapped armoring along the Duwamish River estuary and evaluated differences in temperature, invertebrates, and juvenile salmon diet between armored and unarmored intertidal habitats. Epibenthic invertebrate densities were over tenfold greater on unarmored shorelines and taxa richness double that of armored locations. Over 66 percent of the Duwamish shoreline is armored, similar to much of south and central Puget Sound, the impacts from armoring, and denying access to potential food sources, can affect overall fish health, growth, and survival.

Bank armoring generally reduces the sediment available for transport by preventing delivery of sediments from upland areas. Finer material like gravel and sand provide important spawning substrate for sand lance and surf smelt. Therefore, a reduction of gravel and sand within the intertidal and nearshore zone as a result of the bulkhead would reduce potential spawning habitat availability and fecundity of both species (Rice 2006; Parks et al. 2013); both species are important prey of PS Chinook salmon. Although WDFW has not designated any of the areas in the immediate vicinity of the proposed armoring to support forage fish spawning[4], the armoring of the LDW reduces the transport of fines from upland areas downstream to Elliot Bay, where beach spawning occurs.

As described above, the sheet pile wall prevents connectivity with the historic floodplain along the lower Duwamish River (the LDW), and prevents natural channel migration, braiding and formation of floodplain off channel areas, and further encourages channelization. This reduces the quality of river edge habitat and subsequently the survival, behavior, and distribution of juvenile salmonids that would otherwise rear near stream margins. Although the sheet pile wall would be placed within the footprint of the existing armoring, it would perpetuate degraded habitat conditions by maintaining and enhancing armoring of the bank for its entire length. Beamer and Henderson (1998) reported a reduction in juvenile rearing density of 5 to 10 times between natural forested banks and riprapped banks. Beechie et al. (2006) reported that modified banks lacked backwater areas, and pools created by eddies. Due to lower habitat diversity fish are found at much lower densities and diversity in riprap areas than in natural areas (Bolton and Shellberg 2001). In other words, higher species diversity and abundances are found in areas with natural banks due to the greater diversity of habitat features (Beamer and Henderson 1998). The installation of shoreline armoring limits the amount of channel habitat available for juvenile salmonids. Hayman et al. (1996) demonstrated that natural and unaltered floodplains have twice the amount of channel habitat than isolated floodplains. Indeed, floodplain habitats provide among the most productive juvenile salmon and steelhead rearing areas (Sommer et al. 2001; Sommer et al. 2004; Jeffres et al. 2008).

The sheet pile wall and impervious surfaces of upland development also reduce riparian vegetation establishment and growth. Changes to the quantity of riparian vegetation, woody debris and aquatic vegetation associated with the proposed project may have adverse effects on forage, an essential element of the critical habitat PBFs for PS Chinook salmon and steelhead rearing. Floodplain and streamside vegetation are important sources of energy for the maintenance of invertebrates and fish. Instream communities are highly dependent on leaf litter from streamside forests for maintaining metabolism and ecosystem structure. Robust vegetation along the water's edge dramatically increases the input of terrestrial invertebrates into aquatic

---

4
https://wdfw.maps.arcgis.com/home/webmap/viewer.html?webmap=19b8f74e2d41470cbd80b1af8dedd6b3&extent=-126.1368,45.6684,-119.6494,49.0781

systems (Fischenich 2001; Florsheim et al. 2008). Roots uptake elements from the soil and bedrock, then deliver them to the stream through the process of decay (Fischenich and Copeland 2001).

Roots, stems, logs, and organic debris such as leaves provide colonization sites through increased surface area, and velocity refuge for algae and macro invertebrates (Fischenich 2001; Florsheim et al. 2008). Aquatic macroinvertebrate diversity and density are higher in streams with wider riparian areas (Newbold et al. 1980; Florsheim et al. 2008). Organic matter delivered from site-level riparian areas, or accumulated within edge habitat from upstream sources, is a food source for macro-invertebrates (Fischenich 2001). In floodplain channels, which frequently have a high fluvial transport potential, floodplain forests are an important source of immobile wood that provide, among other functions, forage species colonization sites. Riparian vegetation is a vital source of energy for invertebrates and fish (Fischenich 2001). The abundance of aquatic invertebrate species that support Chinook salmon and steelhead growth and maturation, is expected to be reduced by the channel confinement and limiting of the establishment of riparian vegetation by the continued presence of bank armoring (sheet pile wall) and the upland development is supports.

The disconnectedness of floodplains also affects the aquatic food web (Winemiller 2004). The inundation of vegetated floodplains provides macrodetritus - a base-level food source. A reduction or elimination of floodplain inundation results in a corresponding reduction in macrodetrital inputs. This reduction in floodplain inundation and macrodetrital inputs has been associated with reductions in flow, the loss of floodplains (e.g. fill, revetments and levees), and habitat simplification (NMFS 2011). Junk et al. (1989) found that most vertebrates found in a mainstem channel greatly depend directly or indirectly on primary production in adjacent floodplains, when a regularly inundated floodplain is present. Developments have separated large temperate mainstem rivers from their floodplains (Junk et al. 1989). Therefore, the reduction in floodplain connectivity associated with the proposed project, through this pathway, may further reduce stream productivity and forage availability for rearing Chinook salmon and steelhead.

The lack of riparian vegetation in the project area also prevents future recruitment of large woody debris (LWD) from adjacent streambanks, and the channelization in the LDW further limits the potential for accumulation of LWD along the channel margins carried by flows from upstream areas. Instream LWD can increase habitat complexity, reduce sediment transport, trap gravel for spawning, stabilize stream channels, provide food for aquatic invertebrates, and provide stream nutrients, increasing overall stream productivity (Bisson et al. 1987). LWD provides important overhead cover for spawning, migrating and rearing salmonids, and creates flow refugia in higher velocity habitats (Shirvell 1990; Roni and Quinn 2001). Instream LWD can also create pools, which provide instream cover (by water depth) and low velocity habitats, particularly well-suited for juvenile salmonid rearing (Bisson et al. 1987; Shirvell 1990; Roni and Quinn 2001).

Replanting would occur in the revetment of removed range track docks 2, 3, and 4. Enhancing riparian function and quality through revegetation efforts would create additional shallow water habitats, naturally stabilize river banks and shorelines, and provide organic inputs that would enhance benthic communities and forage base. These enhancements would provide the greatest benefit to juvenile Chinook salmon given their extensive use of shallow water habitats for migration and rearing. Benefits from increased riparian habitat quantity and function would occur once new vegetation has established. Degraded riparian area and function was identified as one of the limiting factors for PS Chinook salmon in the 2007 recovery plan. Riparian function is especially degraded in the LDW and substantial riparian restoration efforts are required to create fully intact and functioning riparian habitat both within and surrounding the construction site. The riparian planting included in the proposed action slightly reduces the adverse effects of the shoreline/streambank armoring and results in minor incremental gains towards recovery needs for salmonids, particularly nearshore-oriented juvenile Chinook salmon. The proposed project includes the following conservation measures to minimize degradation of nearshore and riparian habitat conditions.

- Remove the invasive species vegetation at all work sites.
- All work waterward of the HTL would be conducted in the "dry", when tides are lower than the construction activities.
- All in-water work would occur in the approved in-water work window.
- Remove existing intertidally located structures and debris, including concrete rubble, and range track structures at the DC.
- All work within the HTL (as described above) would be within the footprint of existing bank stabilization measures.

Although revegetation of all disturbed areas is a component of the proposed project, the sheet pile wall, concrete and other such structures landward of the wall, will reduce or prevent the growth of riparian vegetation. While the proposed action only affects a relatively small area of floodplain connectivity and riparian habitat located landward of the structure, this incremental reduction is significant given that riparian and floodplain habitat is scarce in the LDW (TerraLogic and Landau 2004).

Passage Conditions

The proposed action includes repairing portions of range track dock 1 (900 square feet surface area) and removal of range track docks 2, 3, and 4 (550 square feet surface area), in effect reducing overwater structure area in the Lower Duwamish Waterway. Juvenile Chinook salmon migrate along shallow nearshore habitats, and OWS's disrupt their migration. In the marine nearshore, there is substantial evidence that OWS impede the nearshore movements of juvenile salmonids (Heiser and Finn 1970; Able et al. 1998; Simenstad 1999; Southard et al. 2006; Toft et al. 2007). In the Puget Sound nearshore, 35 to 45 millimeter juvenile chum and pink salmon were reluctant to pass under docks (Heiser and Finn 1970). Southard et al. (2006) snorkeled underneath ferry terminals and found that juvenile salmon were not underneath the terminals at high tides when the water was closer to the structure, but only moved underneath the terminals at low tides when there was more light penetrating the edges. These findings show that overwater-structures can disrupt juvenile salmon migration in the Puget Sound nearshore.

Overwater structures cause delays in migration for PS Chinook salmon from disorientation, fish school dispersal (resulting in a loss of refugia), and altered migration routes (Simenstad 1999).

Juvenile salmonids stop at the edge of the structures and avoid swimming into their shadow or underneath them (Heiser and Finn 1970; Able et al. 1998; Simenstad 1988; Southard et al. 2006; Toft et al. 2013). Juvenile salmon migrate along the edge of shadows rather than through them (Nightingale and Simenstad 2001; Southard et al. 2006; Celedonia et al. 2008a; Celedonia et al. 2008b; Moore et al. 2013; Munsch et al. 2014). In freshwater, about three-quarters of migrating Columbia River fall Chinook salmon smolts avoided a covered channel and selected an uncovered channel when presented with a choice in an experimental flume setup (Kemp et al. 2005). In Lake Washington, actively migrating juvenile Chinook salmon swam around structures through deeper water rather than swimming underneath a structure (Celedonia et al. 2008b). Structure width, light conditions, water depth, and presence of macrophytes influenced the degree of avoidance. Juvenile Chinook salmon were less hesitant to pass beneath narrower structures (Celedonia et al. 2008b).

An implication of juvenile salmon avoiding OWS is that some of them would swim around the structure (Nightingale and Simenstad 2001). Swimming around structures lengthens the migration distance and is correlated with increased mortality. Anderson et al. (2005) found migratory travel distance rather than travel time or migration velocity has the greatest influence on the survival of juvenile spring Chinook salmon migrating through the Snake River 2005. This behavioral modification would cause them to temporarily utilize deeper habitat, thereby exposing them to increased piscivorous predation. Hesitating upon first encountering the structure, as discussed, also exposes salmonids to avian predators that may use the floating structures as perches. Typical piscivorous juvenile salmonid predators, such as flatfish, sculpin, and larger juvenile salmonids generally avoid the shallowest nearshore waters that outmigrant juvenile salmonids prefer—especially in the earliest periods of their marine residency. When juvenile salmonids temporarily leave the relative safety of the shallow water, their risk to being preyed upon by other fish increases. This has been shown in the marine environment where juvenile salmonid consumption by piscivorous predators increased fivefold when juvenile pink salmon were forced to leave the shallow nearshore (Willette 2001). Juvenile steelhead are unlikely to be affected by the overwater structures included in the proposed action as they are less dependent on shallow areas for migration and typically use deeper habitats during outmigration.

The removal of the three range track docks may incrementally improve nearshore migration for PS Chinook salmon by reducing overwater coverage from structures. However, this benefit is small and is unlikely to affect habitat at a scale substantive enough to increase the conservation value of the habitat. Similarly, repair of range track dock 1 ensures overwater coverage would remain for the life of the structure further impairing nearshore function and reducing the conservation value of critical habitat for PS Chinook salmon. Migration values are not expected to be impaired for PS steelhead as these species do not rely on the nearshore area for migration. PS/GB bocaccio, PS/GB yelloweye rockfish and SRKW are also not expected to migrate within the LDW, and thus would not be have physical exposure to structures at the project site.

Prey Quantity and Availability for SRKW

Although SRKW do not occur within the LDW and thus would not have direct exposure to habitat effects limited to the LDW, prey quantity and availability may be negatively affected by The Lacy et al. (2017) model also found that Chinook salmon abundance was the most important threat to SRKW population growth; however, they also emphasized that prey increases alone would likely not be sufficient to recover the whales and that the other threats would need to be addressed as well.

The most recent effort to review the relationships of SRKW vital rates and Chinook salmon abundance was conducted by an Ad Hoc Workgroup through the PFMC (PFMC 2020). However, the Workgroup did not assess the cumulative threats, and found that the small population size limited their ability to detect a quantitative relationship between Chinook salmon abundance and SRKW demographic metrics (e.g. fecundity and survival) to input into their PVA and the relationship is likely not linear or not constant over time (PFMC 2020). Although there are challenges to detecting quantitative relationships and others have cautioned against overreliance on correlative studies (see Hilborn et al. 2012), given the status of the species (endangered with low abundance and productivity), and their strong preference for Chinook salmon prey, the continued existence and potential for recovery of the species is highly dependent on healthy numbers of Chinook salmon throughout its range.

The intermittent and long-term effects of the action include the suppression of productivity (i.e., reduced survival of juvenile) among PS Chinook salmon populations during the 50-year time period, and spatial and temporal depletions in Chinook salmon presence. This in turn limits the number of adult PS Chinook salmon available as prey for SRKW over the long-term, as well as causing SRKW to expend energy to seek prey in other locations due to spatial and temporal depletions. These effects of the proposed action are likely to be experienced by all members of this species for the life of the proposed structures (estimated 50 years). We anticipate a reduction in prey quantity of only a small number of adult PS Chinook salmon on an annual basis. This would represent a very small portion of prey availability in the much larger area of SRKW critical habitat within the Puget Sound. Furthermore, given the treatment of all discharges from the PGIS at the project areas, and the proposed conservation measures, we believe that prey communities would continue to support the conservation role of SRKW critical habitat.

Critical Habitat Summary

Short and long-term effects of the proposed action would reduce (or retain poor conditions of) water quality, forage, cover, and habitat forming processes that are necessary to support the conservation role of the habitat for survival, growth, maturation, and physiological transitions of the listed fish species, primarily PS Chinook and PS steelhead. Water quality degradation (stormwater contaminants) would also reduce the conservation role of habitat for the survival, growth, maturation and physiological transitions of listed rockfish species and SRKW in the Puget Sound marine portions of the action area.

2.5.2 Effects on Species

Effects on species is a function of exposure and response to the effects described above, and response can be influenced by the lifestage and species exposed, and the health or condition of the species at the time of exposure.

Period of Exposure

As described in Section 1.3 (Proposed Action), all in-water work below the OHWM would occur between May and August. However, the Corps has not indicated when work landward of OHWM would occur. For the purpose of this effects analysis we assume work above the OHWM would occur both during the May to August window as well as other periods. This would create short-term exposure pathways for all Chinook salmon and steelhead lifestages. Enduring long-term effects would also affect all PS Chinook salmon, PS steelhead, PS/GB bocaccio and PS/GB yelloweye rockfish lifestages.

PS Chinook Salmon

Juvenile PS Chinook salmon are most likely to be exposed to effects of the proposed action given their extensive use of estuarine environments. Juvenile PS Chinook salmon generally emigrate from freshwater natal areas to estuarine and nearshore habitats from January to April as fry, and from April through early July as larger sub-yearlings. However, juveniles have been found in the Puget Sound nearshore and estuarine waters between April and November (Rice et al. 2011). In the Duwamish/Green River juvenile Chinook salmon have been found in relatively high densities between RM 4.7 and 6.5 (Ruggerone et al. 2006). It has also been observed that juveniles may be present in the Duwamish Waterway up to the point of saltwater influence year-round, as juveniles frequently re-renter the waterway from the Puget Sound. The proposed work window for construction occurring below the OHWM is from May through August when flows are expected to be the lowest. The work window overlaps with sub-yearling PS Chinook salmon presence from April through July. Additionally, some juvenile Chinook salmon rear in Puget Sound without migrating to ocean areas, which could prolong their presence in the LDW. Any juvenile PS Chinook salmon found in or around the LDW would be actively migrating or holding to feed and grow. However, since construction above the OHWM would occur outside of the May – August timeframe it is likely that other PS Chinook salmon life stages would also be exposed to construction effects.

Adult Chinook salmon typically enter the LDW from mid-June through October. Many adults hold in the lower river until early fall depending on water conditions. Upstream movement to spawning grounds in the middle and upper Green River basins typically occurs following autumn rains. Given the timing of adult migration, it is likely that adult Chinook salmon would be present in the action area during the work window. Although, given the degraded habitat conditions in the LDW it is unlikely that adults would spend a significant amount time in the action area. We expect adults to move quickly upstream to more suitable habitat. Spawning habitat does not exist in or near the action area. Thus, we expect little exposure to short-term habitat effects from the proposed action among adult PS Chinook salmon. However, enduring long-terms effects are likely to adversely expose adult Chinook salmon.

PS Steelhead

Washington Department of Fish and Wildlife (WDFW) data indicates occurrences of both summer and winter-run steelhead stocks in the Green/Duwamish River; summer stocks are not included as part of the Puget Sound DPS. Green/Duwamish River winter steelhead enter the river from Puget Sound from November to May and migrate to the upper Green River to spawn. Winter fish spawn from late February through June. Similar to Chinook salmon, the action area does not currently provide any spawning habitat for steelhead. The presence of migrating adult PS winter steelhead in the action area overlaps with the in-water construction window of the proposed action. It is likely that adult winter steelhead would be actively migrating through the Lower Duwamish Waterway to spawning habitat in the middle and upper Green River basins while construction occurs. Puget Sound steelhead typically emigrate from natal streams in April and May, and appear to move directly out into the ocean to rear, spending little time in the nearshore or estuarine zones (Goetz et al. 2015). Migrating adults and juveniles are expected to pass through the action area quickly.

PS/GB Bocaccio and Yelloweye Rockfish

Adult, larval and adult PS/GB bocaccio and yelloweye rockfish occur yearly within Elliot Bay, and not occur within the LDW, other than perhaps as larvae near the mouth of the LDW, and thus would not be exposed to the more localized, construction related-effects occurring upriver near the project site. However, they would be expected to be exposed to any habitat effects that extend to the Puget Sound, including water quality degradation by contaminants and toxins in stormwater runoff from PGIS landward of the sheet pile wall, discharged through the proposed outfalls, as well as reduced forage quality, quantity and availability caused by water quality degradation and project area habitat modifications.

SRKW

SRKW may occur Elliot Bay and near the mouth of the LDW, in deeper areas of the bay with water deeper than about 20 feet, where they may be exposed to stormwater contaminants from the project site. They would not occur within the LDW and thus would not be exposed to the more localized (contained within the LDW) effects of construction activities and permanent structures.

<u>Species Response to Noise from Sheet Pile Wall Installation and Pile Removal</u>

Only PS Chinook salmon and steelhead are expected to be exposed to construction noise since elevated noise levels would be isolated to a relatively small part of the LDW, adjacent to the project site. In-water noise would be associated with sheet pile wall installation and removal of range track dock piles. Exposure to elevated noise levels can cause a temporary shift in hearing sensitivity (referred to as a temporary threshold shift), decreasing sensory capability for periods lasting from hours to days (Turnpenny et al. 1994; Hastings et al. 1996). Popper et al. (2005) found temporary threshold shifts in hearing sensitivity after exposure to noise as low as 184 dB. Temporary threshold shifts reduce the survival, growth, and reproduction of the affected fish by increasing the risk of predation and reducing foraging or spawning success. We anticipate minimal in-water noise to result from the sheet pile wall installation as all but 1 lf is above the OHWM and work would be conducted in the dry. We expect greater in-water noise to result from the use of vibratory hammers to remove piles for range tracks 2, 3 and 4 since they are located below the OHWM and in-water. We do not anticipate noise levels that cause injury to individual fish, but instead to only temporarily disturb fish, possibly causing them to move away from the work area. However, the persistent noise may result in the reduced ability to detect and avoid predators, and thus may result in injury or death of juvenile salmonids (e.g. Everley et al. 2016; Simpson et al. 2016; Popper and Hawkins 2019).

Because work would be completed within a 3-month period, and any in-water work would occur within the approved in-water work window to minimize exposure to listed salmonids, we anticipate that only a small number of juvenile PS Chinook salmon and PS steelhead rearing in or migrating through the action area would be exposed to elevated noise from sheet pile wall installation and range track dock pile removal. A small number of adult salmonids are also likely to be exposed to the noise since the project would occur while adult steelhead are migrating upstream through the action area, and would also slightly overlap with PS Chinook salmon upstream migrations. We do not expect fish to be injured by the noise levels, but disturbance may cause fish to avoid the area and migration to be slightly delayed. Given the short-term nature of proposed pile driving and intermittent noise effects, we expect any avoidance of these areas by fish to be brief and result in only a minor delay in upstream and downstream migrations. With the relatively small area of noise disturbance relative to available habitat in upstream and downstream areas we expect only an extremely small, short-term reduction in forage, which would be extremely unlikely to affect fish growth or survival. However, we expect that some juvenile salmonids would experience a greater risk of predation as a result of a decreased ability to detect and avoid predators. Juveniles rearing in the LDW adjacent to the project site, as opposed to those migrating through the area, would be particularly susceptible to increased predation risk due to the longer duration of exposure to noise disturbance.

<u>Species Response to Degraded Water Quality</u>

There are three pathways for water quality degradation, turbidity and low DO during construction, PAH introduction from creosote pile removal, and stormwater. Only PS Chinook salmon and steelhead are expected to be exposed to degraded water quality conditions caused by construction activities (turbidity and dissolved oxygen from in-water work, and PAH introduction from pile removal) since these conditions would be isolated to the LDW, where SRKW and rockfish do not occur. ESA-listed salmonids, rockfish and SRKW would all be expected to be exposed to stormwater contaminants, which would be present within the LDW and downstream in the Puget Sound.

Turbidity and Dissolved Oxygen

Nearshore work below OHWM (bulkhead installation, excavation for stormwater drains, pile removal and repair, and dock removal) may cause short-term temporary and localized increases in turbidity and total suspended solids (TSS). Temporary declines in dissolved oxygen and increases in construction related pollutants such as PAHs are also likely. These potential effects could extend up to 300 feet radially from the project location during construction and would likely return to background conditions within a few days following completion of construction. However, because most construction activities would occur above OHWM and during low tide “dry” conditions, and all work would be completed within a 3-month period, we anticipate only minor, infrequent increases in turbidity.

The effects of suspended sediment on fish increase in severity with sediment concentration and exposure time can progressively include behavioral avoidance and/or disorientation, physiological stress (e.g., coughing), gill abrasion, and at extremely high concentrations, death. Newcombe and Jensen (1996) analyzed numerous reports on documented fish responses to suspended sediment in streams and estuaries, and identified a scale of ill effects based on sediment concentration and duration of exposure, or dose. Exposure to concentrations of suspended sediments expected during the proposed in-water construction activities could elicit sublethal effects such as a short-term reduction in feeding rate or success, or minor physiological stress such as coughing or increased respiration. Studies show that salmonids have an ability to detect and distinguish turbidity and other water quality gradients (Quinn 2005; Simenstad 1988), and that larger juvenile salmonids are more tolerant to suspended sediment than smaller juveniles (Servizi and Martens 1991; Newcombe and Jensen 1996).

Juvenile and adult PS Chinook salmon and steelhead are likely to be present during construction activities occurring below OHWM and are may be exposed to the temporary construction effects, most notably elevated levels of suspended sediment. The proposed minimization measures (e.g.., only working in the dry for the sheet pile wall) indicate that turbidity and TSS levels would be only slightly elevated near the construction area (turbidity mixing zone; 150-feet from the source of turbidity as defined by WAC 173-201A-210) and would return to background levels. Any decreased DO levels are expected to be contemporaneous with and in the same footprint of the suspended sediment. While juvenile and adult PS Chinook salmon and steelhead are likely to encounter these areas, exposure is expected to be brief, as they can detect and avoid areas of high turbidity. Thus, duration and intensity of exposure of PS Chinook salmon and steelhead is also unlikely to cause injury or a harmful response. Based on the best available information, work-related turbidity concentrations would be too low and short-lived to cause more than temporary, non-injurious behavioral effects such as avoidance of the plume and mild gill flaring in any PS Chinook salmon or PS steelhead that may be exposed to them. None of these potential responses, individually, or in combination would affect the fitness or meaningfully affect the normal behaviors of exposed fish.

Creosote-Treated Pile Removal

The proposed action includes removal of three range track docks (2, 3, and 4) which includes 13 creosote-treated pilings. The removal of the creosote-treated piles mobilizes PAHs into the surrounding water and sediments (Smith et al. 2008; Parametrix 2011). PAHs can also be released directly from creosote-treated timber during the demolition of overwater timber and if any piles break during removal (Parametrix 2011). The concentration of PAHs released into surface water rapidly dilutes. Smith et al. (2008) reported concentrations of total PAHs of 101.8 μg/l thirty seconds after creosote-pile removal and 22.7 μg/l sixty seconds after. 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.

There are two pathways for PAH exposure to listed fish species in the action area, direct uptake through the gills and dietary exposure (Lee and Dobbs 1972; Neff et al. 1976; Karrow et al. 1999; Varanasi et al. 1993; Meador et al. 2006; McCain et al. 1990; Roubal et al. 1977). Fish rapidly uptake PAHs through their gills and food but also efficiently remove them from their body tissues (Lee and Dobbs 1972; Neff et al. 1976). Juvenile Chinook salmon prey, including amphipods and copepods, uptake PAHs from contaminated sediments (Landrum and Scavia 1983; Landrum et al. 1984; Neff 1982). Varanasi et al. (1993) found high levels of PAHs in the stomach contents of juvenile Chinook salmon in the Duwamish estuary. The primary response of exposed salmonids, from both uptake through their gills and dietary exposure, are immunosuppression and reduced growth. Karrow et al. (1999) characterized the immunotoxicity of creosote to rainbow trout (*O. mykiss*) and reported a lowest observable effect concentration for total PAHs of 17 µg/l. Varanasi et al. (1993) found greater immune dysfunction, reduced growth, and increased mortality compared to control fish. In order to isolate the effects of dietary exposure of PAHs on juvenile Chinook salmon, Meador et al. (2006) fed a mixture of PAHs intended to mimic those found by Varanasi et al. (1993) in the stomach contents of field-collected fish. These fish showed reduced growth compared to the control fish.

Pile removal would occur during low tide when conditions are “dry”. Therefore, the likelihood of exposure to contaminants in the water column originating from creosote-treated piles that would result in detrimental effects to listed species is low and insignificant. Removal of creosote-piles would, over time, reduce PAH exposure of PS Chinook salmon and PS steelhead to PAHs.

Stormwater

Stormwater runoff is certain to continue to deliver toxic and potentially lethal contaminants originating from Boeing’s facilities to the action area (Lower Duwamish Waterway, Elliott Bay, and Puget Sound) resulting in adverse effects to listed species. The proposed action includes repairing 31,500 square feet of existing asphalt and installing 500 square feet of new asphalt. These PGIS would accumulate contaminants such as heavy metals, PAHs, among others which would be washed into the action area during and following storm events.

Assessments for transportation-related runoff and species/habitats protected under the Endangered Species Act (ESA) and Magnuson-Stevens Fishery Conservation and Management Act (MSA) will need to consider toxic risk in the aggregate. This will necessarily include chemicals beyond 6PPD-q and stressor-response dynamics involving complex chemical mixtures, effects that may be sublethal and/or delayed in time, impacts mediated through food webs, and interactions with non-chemical forcing pressures (most notably climate change).

Petroleum-related toxicity to the early life history stages of fish has been a primary scientific focus area for NOAA’s Northwest Fisheries Science Center (NWFSC) for the last 20 years. This targeted research has centered on PAHs and related compounds in the context of two overlapping mission goals for NOAA. These are to understand and minimize the adverse ecological impacts of PAHs from 1) major oil spills, and 2) urban stormwater runoff. A large and growing body of environmental monitoring data (analytical chemistry) has established PAHs as a ubiquitous component of stormwater-driven runoff to Puget Sound streams, lakes, rivers, wetlands, and estuaries. Whether originating from oil spills or stormwater, PAH toxicity to fish can be framed as a bottom-up approach to understanding the impacts of complex mixtures, where one or more PAH compounds may share a common mechanism of action, interact with other chemicals in mixtures, and/or interact with non-chemical variables such as the thermal stress anticipated with a changing regional climate. The historical NOAA research on oil spills and urban stormwater are increasingly converging on a risk framework where certain PAHs (Figure 1; described in more detail below) cause a well-described syndrome involving the abnormal development of the heart, eye and jaw structure, and energy reserves of larval fish (Harding et al., 2020).

The 1989 *Exxon Valdez* oil spill in Prince William Sound, Alaska, produced a dissolved PAH mixture in marine and nearshore habitats dominated by compounds with 2 to 4 benzene rings (Figure 2, top panel, Alaskan North Slope Crude Oil). The multiple ring structure is the basis for the descriptors "polycyclic" or "heterocyclic", the latter for ring configurations having a slight modification, such as the dibenzothiophenes. Over the ensuing 30 years, combined research from NOAA's Alaska Fisheries Science Center (AFSC) and the NWFSC clearly established the developing fish heart as the primary biological target organ for the toxic impacts of water-soluble chemical mixtures derived from petroleum (Incardona, 2017; Incardona and Scholz, 2016, 2017, 2018; Incardona et al. 2011). At the egg (developing embryo, pre-hatch) and larval stages, organ-specific detoxification pathways (e.g., cytochrome P450 enzymes in the liver) are not yet in place, and therefore do not offer the same intrinsic metabolic protections available to older fish with a fully developed hepatic function. Absent this protective metabolism in larval fish, petroleum-derived hydrophobic compounds such as PAHs bioconcentrate to high tissue levels in fertilized eggs, resulting in more severe corresponding toxicity.

Numerous controlled laboratory exposure-response studies have elucidated a toxicity syndrome with a distinctive and characteristic suite of developmental abnormalities. Severe PAH toxicity is characterized by complete heart failure, with ensuing extra-cardiac defects (secondary to loss of circulation) and mortality at or soon after hatching. More moderate forms of PAH toxicity, such as might be expected for untreated/unfiltered roadway runoff, include acute and latent alterations in subtle aspects of cardiac structure, reduced cardiorespiratory performance and latent mortality in surviving larvae and juveniles. These effects have been studied extensively and characterized in over 20 species of fish at the organismal, tissue and cellular levels (Marty et al., 1997; Carls et al., 1999; Heintz et al., 1999; Hatlen et al., 2010; Hicken et al., 2011; Incardona et al., 2013; Jung et al., 2013; Brette et al., 2014; Esbaugh et al., 2016; Morris et al., 2018). Unlike 6PPD-quinone, which varies in hazard across closely related salmonids (e.g., high acute toxicity to coho, low toxicity to chum; McIntyre et al., 2018, 2021), all fish species studied to date are vulnerable to PAH toxicity, with thresholds for severe developmental abnormalities often in the low parts-per-billion (µg/L) range (Figure3).

Figure 3. Examples of PAH-induced developmental abnormalities in a wide range of fish species (freshwater to marine, tropical to temperate).

Our current understanding of PAH toxicity to fish embryos and larvae is drawn from several NOAA-F studies, representing major lessons learned from the Exxon Valdez and Deepwater Horizon disasters, and has been widely confirmed by independent research groups around the world. The primary form of toxicity is a loss of cardiac function, as exemplified by circulatory failure and accumulation of fluid in the pericardial space around the heart (arrows). The pattern of excess fluid (edema) varies according to the anatomy of each species. Related abnormalities include small eyes, jaw deformities, and a dysregulation of the lipid stores, or yolk, the animal needs to survive to first feeding. This suite of defects, while sublethal, will almost invariably lead to ecological death. Consequently, "delayed-in-time" toxicity is a common risk concern for fish that spawn in PAH-contaminated habitats.

PAH toxicity in fish is often sublethal and delayed in time. The latent impacts of low-level PAH exposures – i.e., representative of the cardiotoxic PAH concentrations and discharge durations comparable with conventional Puget Sound roadway runoff – have been particularly well studied in salmonids (pink salmon, *Oncorhynchus gorbuscha*). Large-scale tagging (mark-and-recapture) studies dating back to Exxon Valdez were among the first to show that embryonic exposure to oil-derived chemical mixtures with total PAH (∑PAH) levels in the range of 5 - 20 µg/L resulted in cohorts of salmon that survived the exposure (and appeared outwardly normal), but nevertheless displayed reduced growth and reduced survival to reproductive maturity in the marine environment. Follow-up studies at NWFSC have linked this poor survival to reduced individual fitness manifested by reduced swimming performance and subtle changes in cardiac structure. In essence, embryonic exposure to petroleum mixtures leads to juvenile fish that show signs of pathological hypertrophy of the heart (Incardona et al., 2015, 2021; Gardner et al., 2019). The latter is well known to be associated with considerable morbidity and mortality across vertebrate species in general, as evidenced by the downstream consequences of congestive heart failure in humans.

To illustrate how PAHs in runoff from the Puget Sound transportation grid align with historical NOAA research on oil spills, stormwater from the SR520 collection location at the NWFSC in Seattle shows considerable overlap with the pattern of PAHs derived from a pure oil spill (Figure 4 top). Notably, as an added consequence of the engine internal combustion process, the mixture in stormwater is even more complex due to the appearance of larger numbers of 4-ring and ≥ 5-ring compounds. Much of this higher molecular weight PAH mass is associated with the fine particulate matter from vehicle exhaust. The bioavailability of compounds in waters that receive highway runoff is demonstrated by uptake into passive samplers, which have properties very similar to fish eggs. Passive samples vary in design, but generally consist of a housing for a membrane material that passively accumulates lipophilic compounds such as PAHs, which can subsequently be extracted for chemical analyses. They are particularly useful for profiling patterns of bioavailable PAHs in fish spawning habitats.

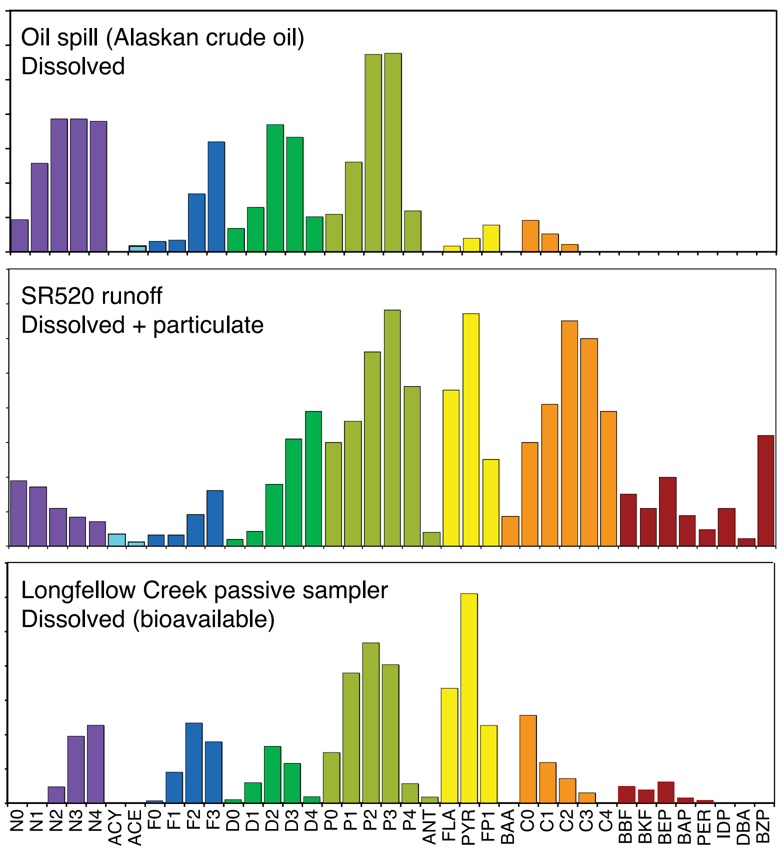

Figure 4. Patterns of PAHs in environmental samples. Top, effluent in seawater flowing over gravel coated with Alaskan crude oil (source for Exxon Valdez). Middle, runoff from the SR520 highway adjacent to NWFSC. Bottom, PAHs extracted from a polyethylene membrane device (PEMD) incubated one week in Longfellow Creek, West Seattle. X-axis shows proportion of total PAH, and values are omitted for simplicity to emphasize overall patterns. Abbreviations: N, naphthalenes; BP, biphenyl; AY, acenaphthylene; AE, acenaphthene; F, fluorene; D, dibenzothiophene; P, phenanthrene; ANT, anthracene; FL, fluoranthene; PY, pyrene; FP, fluoranthenes/pyrenes; BAA, benz[a]anthracene; C, chrysene; BBF, benzo[b]fluoranthene; BKF, benzo[j]fluoranthene/benzo[k]fluoranthene; BEP, benzo[e]pyrene; BAP, benzo[a]pyrene; PER, perylene; IDY, indeno[1,2,3-cd]pyrene; DBA, dibenz[a,h]anthracene/dibenz[a,c]anthracene; BZP, benzo[ghi]perylene. Parent compound is indicated by a 0 (e.g., N0), while numbers of additional carbons (e.g. methyl groups) for alkylated homologs are indicated as N1, N2, etc.

The pattern of bioavailable PAHs in Seattle-area urban streams closely resembles a pure oil spill pattern, with the exception of a larger proportion of combustion-associated 4-ring compounds such as pyrenes and fluoranthenes (Figure 4). Accordingly, urban runoff is a transport pathway for PAHs, and the pattern of bioavailable PAHs closely resembles the relative enrichment of cardiotoxic phenanthrenes. Although more work is needed for Pacific salmonids (e.g., species beyond pink salmon), collected runoff from SR520 containing ∑PAH of 7.5 μg/L produced the stereotypical syndrome of heart failure and associated developmental defects in Pacific herring (Harding et al. 2020). Measured concentrations of PAH runoff from SR520 runoff are often considerably higher than the petroleum toxicity threshold for pink salmon. There is a risk that untreated runoff could cause delayed mortality in ESA-listed salmonids, and also the prey available to salmon and higher-trophic species such as killer whales through losses of nearshore spawning forage fish. This risk declines but may not be entirely avoided by treatment.

After years of forensic investigation, the urban runoff coho mortality syndrome has now been directly linked to motor vehicle tires, which deposit the compound 6PPD and its abiotic transformation product 6PPD-q onto roads. 6PPD or [(N-(1, 3-dimethylbutyl)-N'-phenyl-p-phenylenediamine] is used to preserve the elasticity of tires. 6PPD can transform in the presence of ozone (O3) to 6PPD-q. 6PPD-q is ubiquitous to roadways (Sutton et al. 2019) and was identified by Tian et al. (2020) as the primary cause of urban runoff coho mortality syndrome described by Scholz et al. (2011). Laboratory studies have demonstrated that juvenile coho salmon (Chow et al. 2019), juvenile steelhead, and juvenile Chinook salmon are also susceptible to varying degrees of mortality when exposed to urban stormwater (French et al. 2022). 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). Research and corresponding adaptive management surrounding 6PPD is rapidly evolving. Nevertheless, key findings to date include:

- 6PPD/6PPD-q has been killing coho in Puget Sound urban streams for decades, dating back to at least the 1980s, likely longer (McCarthy 2008; Scholz 2011)
- Wild coho populations in Puget Sound are at a very high risk of localized extinction, based on field observations of adult spawner mortality in > 50 spawning reach stream segments (Spromberg 2011).
- Source-sink metapopulation dynamics (mediated by straying) are likely to place a significant drag on the future abundances of wild coho salmon in upland forested watersheds (the last best places for coho conservation in Puget Sound). In other words, urban mortality syndrome experienced in one part of the watershed could lead to abundance reductions in other populations because fewer fish are available to stray (Spromberg 2011)
- Coho are extremely sensitive to 6PPD-q, more so than most other known contaminants in stormwater (Scholz 2011; Chow 2019; Tian 2020).
- Coho juveniles appear to be similarly susceptible to the acutely lethal toxicity of 6PPD/6PPD-q (McIntyre 2015; Chow 2021).
- The onset of mortality is very rapid in coho (i.e., within the duration of a typical runoff event) (French et al. 2022).

- Once coho become symptomatic, they do not recover, even when returned to clean water (Chow 2019)
- It does not appear that dilution will be the solution to 6PPD pollution, as diluting Puget Sound roadway runoff in 95% clean water is not sufficient to protect coho from the mortality syndrome (French et al. 2022).
- Preliminary evidence indicates an uneven vulnerability across other species of Puget Sound salmon and steelhead, and a need to further investigate sublethal toxicity to steelhead and Chinook salmon. For example, McIntyre et al. (2018) indicate that chum do not experience the lethal response to stormwater observed in coho salmon.
- Following exposure, the onset of mortality is more delayed in steelhead and Chinook salmon (French et al. 2022).
- The mechanisms underlying mortality in salmonids is under investigation, but are likely to involve cardiorespiratory disruption, consistent with symptomology. Therefore, special consideration should be given to parallel habitat stressors that also affect the salmon gill and heart, and nearly always co-occur with 6PPD such as temperature (as a proxy for climate change impacts at the salmon population-scale) and PAHs.
- Simple and inexpensive green infrastructure mitigation methods are promising in terms of the protections they afford salmon and stream invertebrates, but much more work is needed (McIntyre 2014, 2015, 2016a&b; Spromberg 2016).
- The long-term viability of salmon and other Puget Sound aquatic species is the foremost conservation management concern for NOAA, and thus it will be important to incorporate effectiveness monitoring into future mitigation efforts – i.e., evaluating proposed stormwater treatments not only on chemical loading reductions, but also the environmental health of salmon and other species in receiving waters (Scholz 2011).

Individuals of the SRKW DPS are likely to be occasionally exposed to contaminants in stormwater discharges from the proposed facility. Toxic effects on marine mammals can include anemia, increased oxygen consumption, growth retardation, immunotoxicity, reduced reproduction, neurotoxicity, mutagenesis and carcinogenesis (Harris et al., 2011 and D Jong et al., 1999). For the endangered SRKW exposure to PAHs can potentially cause adverse health effects" (Braig et al. 2021). SRKW scat samples indicate baseline PAH levels in the whales are generally low and exposure includes ingestion by this species in Puget Sound from ambient conditions including as vessel exhaust (Lundin et al 2018). SRKW health effects of PAH exposure presented here are derived from evaluating exposure to exhaust gases (Lacmuth et al. 2011). These include observed effects from acute exposure are: asthma aggravation, respiratory infection, transient changes in pulmonary function, pulmonary and systemic inflammation, oxidative stress, arterial vasoconstriction, and mortality (Koenig 2000; Pope and Dockery 2006). Effects arising from chronic exposure are: disease prevalence, lung growth or decline, lung inflammation, atherosclerosis, and mortality (Koenig, 2000, Pope and Dockery, 2006).

While we expect exposure to PAHs derived from water quality rather than from air quality would avoid some effects, such as lung condition, other effects such as atherosclerosis and greater susceptibility to disease could occur. The SRKWs are among the most contaminated populations of marine mammals in the world, mostly by persistent organic pollutants (e.g., PCBs) and the toxicity of extremely high levels of persistent organic pollutants could be additive or synergistic with exposure to pollutants such as PAHs (Kagawa, 2002). However, we anticipate only occasional exposure to reduced levels of PAHs from the facility in a relatively small portion of their habitat, which we would not expect to cause injury or mortality. The toxicity effects to marine fish described above could also result in a small reduction to the prey available to the whales if they were foraging in the area concurrent with impairment or mortality to their primary prey, Chinook salmon.

Toxics in stormwater discharged from the proposed project stormwater outfalls are likely to result in negative health effects on PS Chinook salmon, PS steelhead, PS/GB bocaccio, PS/GB yelloweye rockfish, and SRKW. The effect of the proposed action with the largest "reach" in the environment is chemical contamination introduced via stormwater, because of its chronic nature, persisting in-water, sediments, and in exposed species that themselves travel into and throughout Puget Sound. Relevant environmental cycles influencing exposure include the probabilistic time necessary for existing pollutants to flush from the basin by river discharge as measured in a half-life estimated to last for days for dissolved pollutants, but would require decades for pollutants adsorbed or absorbed onto sediment. PS Chinook salmon may rear for a year before their migration to the marine environment and are at high risk of exposure to contaminated stormwater. PS steelhead are also at risk as they move through the action area during periods when stormwater discharge may be high. Although, SRKW and rockfish are expected to be exposed to reduced concentrations of stormwater contaminants, through dilution in the LDW and Puget Sound as they move from the project site into the Puget Sound, they are considered likely to experience low levels of harm.

Species Response to Diminished Habitat Complexity, Cover and Passage Conditions

As was detailed in the effects to critical habitat section above, the proposed action would cause an array of negative impacts to the availability and function of intertidal and nearshore habitat. Once repaired or newly constructed, the structures would be expected to remain in the aquatic environment for a 50-year useful life period. Thus, multiple cohorts of PS Chinook salmon and PS steelhead would experience the long-term habitat modifications associated with the presence of the structures.

Chinook salmon and steelhead use the action area for rearing, foraging, and outmigration. Degraded habitat conditions resulting from proposed shoreline armoring (i.e. sheet pile wall) may reduce growth and fitness of juveniles as well as force individuals to seek out suitable habitat elsewhere. This is particularly true for juvenile Chinook salmon which are more nearshore-oriented than steelhead during migration and rearing. Bank armoring reduces feeding opportunity, increases predation risk, and reduces shallow habitat areas. Hardened banks result in a steepened shoreline and reduced shallow water habitat, forcing juvenile salmonids into deeper water where they are more likely to be exposed to predation by larger fish. Simultaneously, their prey resource availability would be limited along the shoreline (shallow littoral zone) by the armoring, thereby decreasing their feeding success and growth rate. In turn, the aggregate impact of this disruption among individuals would amount to an overall reduction in survival rate.

Habitat suitability of submerged aquatic vegetation would also decrease as increased erosion and channelization rates further degrade habitat conditions for juvenile PS Chinook salmon and PS steelhead. Impacts to SAV and epibenthic communities from shore steepening, and sediment coarsening would affect juvenile Chinook salmon by reducing available forage and reducing channel complexity. While degradation of instream habitat would not occur immediately, the effects would last well into the future for the useful life period of the structure. We cannot estimate the number of individuals that would experience these effects from the proposed shoreline armoring covered in this consultation. However, given the duration and extent of effects, we expected bank armoring to adversely affect PS Chinook salmon by reducing nearshore/stream margin habitats along the LDW and forcing individuals to seek out suitable habitats elsewhere and exposing them to higher rates of predation.

The proposed action includes repairing range track dock 1 and removing range track docks 2, 3, and 4. Range track dock 1 extends into the OHWM and repairs would ensure the overwater obstructions would exist for the 50-year useful life of the structure adversely effecting juvenile PS Chinook salmon. Removal of range track docks 2, 3, and 4 would benefit juvenile PS Chinook salmon. In and overwater structures cause delays in migration for PS Chinook salmon from disorientation, fish school dispersal (resulting in a loss of refugia), and altered migration routes (Simenstad 1999). Juvenile salmonids stop at the edge of the structures and avoid swimming into their shadow or underneath them (Heiser and Finn 1970; Able et al. 1998; Simenstad 1988; Southard et al. 2006; Toft et al. 2013). Swimming around structures lengthens the migration distance and is correlated with increased mortality. Overwater structures prevent sunlight from penetrating the water surface limiting submerged aquatic vegetation growth and recruitment. Which, in turn, limits cover and feeding opportunities for juvenile salmonids. Juvenile Chinook salmon migrate along shallow nearshore habitats, and range track dock 1 would disrupt their migration and increase their predation risk. While the area of OWS would decrease by 550 square feet as a result of the proposed action, adverse effects from range track dock 1 would remain. The removal of 550 square feet of OWS would incrementally improve habitat conditions for juvenile PS Chinook salmon, but measurable changes in population viability as a result is unlikely.

Replanting of riparian vegetation following dock removal efforts may, overtime, result in a small benefit to PS Chinook salmon and steelhead through increased cover and forage potential. This is especially true for Chinook salmon, which rely more heavily on stream margins and nearshore areas for forage and migration. The addition of riparian vegetation may stabilize localized areas of streambanks and reduce erosion, provide cover and refuge areas for juvenile salmon and steelhead, and provide small amount of organic materials over time. The addition of riparian vegetation would not eliminate or offset the long-term effects of shoreline stabilization resulting from the sheet pile wall. However, relative to current conditions the addition of riparian vegetation would incrementally improve habitat conditions, thus benefiting listed species. However, we expect that benefit to be small and unlikely to result in measurable changes to abundance or productivity. However, we do expect the addition of riparian vegetation to slightly increase PS Chinook salmon and steelhead carrying capacity within the LDW.

Species Response to Reduced Quality and Quantity of Prey

Temporary, episodic, and enduring reductions in forage base, whether benthic prey communities or forage fish, would occur as a chronic additional reduction over the baseline condition from the proposed repairs of in and overwater structures and shoreline armoring. Prey base is likely to be diminished temporarily due to disturbed substrate. However, benthic prey recruits would likely re-establish the impacted areas within a short period of time. We expect only the cohorts of PS Chinook salmon and steelhead that are present in the action area during construction to be exposed to this temporary reduction of prey. While this reduction in benthic prey would be temporary it would cause foraging juveniles to seek out areas to feed and may increase the likelihood of predation from avian or piscivorous predators.

Reduction in forage habitat resulting from bank armoring may also result in increased competition along with a slight decrease in carrying capacity of the action area. This would result in slight but chronic reductions in abundance from each cohort of Duwamish/Green River Chinook and steelhead populations, but at levels impossible to predict or measure. The long-term effect of downward abundance would be an overall reduction in productivity, spatial structure, and diversity of the various fish species.

Stormwater runoff would also ensure exposure of forage fish, prey species, and benthic invertebrates to harmful contaminants that would accumulate in fish tissues and would over time adversely affect species consuming contaminated prey. Most at risk are juvenile PS Chinook salmon and to a lesser extent juvenile PS steelhead. Because juvenile Chinook salmon utilize estuarine and nearshore habitats extensively prior to transitioning fully to marine habitats they are more likely to consume a greater abundance of contaminated prey likely reducing growth, survival, and altering behaviors.

Consequently, diminishments in Chinook salmon as a result of reduced forage opportunities would in turn effect SRKWs. Chinook salmon are an important prey species for SRKW and reduction in Chinook salmon survival would adversely affect SRKWs by reducing their prey base. Further, contaminants accumulated in the tissues of Chinook salmon would then be transferred to SRKW and consequently accumulate in their tissues over time. As described in the species status section, accumulation of chemical toxins can disrupt endocrine and reproductive function, causing immunotoxicity, neurotoxicity, and cancer in SRKW. The continued input of toxic contaminants into the action area via stormwater runoff and the accumulation of those contaminants in Chinook salmon through direct uptake and compromised forage adversely affects SRKW via degraded prey quality. While it is impossible to quantify this effect on SRKW we expect survival, growth, and reproductive rates to decline incrementally over time as a result of the consumption of contaminated prey and metabolizing toxic pollutants.

<u>Effects on Population Viability</u>

Fish Species

We assess the importance of effects in the action area to the Evolutionarily Significant Units (ESUs)/Distinct Population Segments (DPS) by examining the relevance of those effects to the characteristics of Viable Salmon Populations (VSPs). The characteristics of VSPs are sufficient abundance, population growth rate (productivity), spatial structure, and diversity. While these characteristics are described as unique components of population dynamics, each characteristic exerts significant influence on the others. For example, declining abundance can reduce spatial structure of a population when habitats are less varied diversity among the population declines. We expect a persistent, chronic, negative effect from the proposed action, on the survival of PS Chinook salmon, PS steelhead, PS/GB bocaccio, and PS/GB yelloweye rockfish.

Abundance: While numbers cannot be ascertained, it is certain there would be temporary, episodic and enduring effects that diminish water quality, forage base, and safe migration for salmonids over time. Because some effects occur for each year they are in place and have the potential to reduce fitness and survival among individuals from the listed fish species that use the action area, we find it likely that there would be chronic reductions in survival and thus abundance from each cohort of each population of the listed species. This effect would be most influential on the abundance of PS Chinook salmon given their greater reliance on nearshore and shallow water areas during juvenile life stages. Duwamish/Green River Chinook and steelhead populations would be most impacted by the proposed action and would disproportionately impacted relative to other populations within the PS ESU/DPS.

Juvenile salmonids would be the most likely life-stage harmed given their expected greater duration of exposure to project structures and water quality effects. Death of juvenile salmonids would represent a decrease in abundance of an even smaller number of adults, based on typical low juvenile to adult survival of Chinook salmon (Duffy and Beauchamp 2011) and steelhead (Moore et al. 2015) in the PS. For example, Gamble et al. (2018) estimated marine survival of subyearling Chinook salmon in the Puget Sound to be between 0.18% and 11.7%. Moore et al. (2015) estimated that in the Puget Sound, only about 16% of wild and 11% of hatchery steelhead smolts survive the migration from the mouths of their natal rivers to the Pacific Ocean. Once in the ocean, many more would die before reaching adulthood and returning to natal streams to spawn. Therefore, we expect a very small number of adult PS Chinook salmon and steelhead to be harmed or killed, with a very small effect at the population level.

Stormwater would over time, until properly treated, also expose PS/GB bocaccio, and PS/GB yelloweye rockfish to a suite of toxic contaminants. Although there remains some uncertainty about the full scale of effects of stormwater contaminants (e.g. 6PPD-q) on rockfish, we expect that this exposure would reduce survival and negatively impact reproduction and growth over time. Given the dilution of discharged contaminants within the LDW and the Puget Sound, where rockfish would be exposed, we anticipate than only a small number of fish would be killed and that this would result in a very small decrease in abundance.

Productivity: There is sufficient evidence to indicate that ESA-listed PS Chinooks salmon and PS steelhead productivity may be negatively impacted by the habitat structure and water quality stressors discussed above. While it is impossible to attribute the decline in returning cohorts to specific causes of death at marine life stages, it is likely that declines in abundance of juvenile salmonids while in Puget Sound allows fewer fish, and less fit fish, to reach an ocean life stage. Typical sources of mortality while in their ocean life stage then work against smaller entering cohorts, and further reduce the numbers of fish that ultimately return to spawn, which we recognize as decreased productivity. Similarly, water quality effects in the Puget Sound from contaminants in stormwater discharge would negatively affect PS/GB bocaccio and PS/GB yelloweye rockfish productivity. We anticipate only a small reduction in the abundance of salmonid and rockfish species, and a very small decrease in productivity.

Spatial structure and Diversity: As abundance and productivity decline, the spatial extent of habitat utilized for rearing and migration by PS Chinook salmon and PS steelhead is also expected to decline. Spawning habitat for salmonids is not present in the action area and would not be affected by the proposed action. Once Duwamish/Green River juvenile Chinook salmon and steelhead leave estuarine/delta habitats and enter the Puget Sound, they distribute widely. We anticipate a very small decrease the abundance of Duwamish/Green River salmonids to occur as a result of the proposed action, and thus a very small decrease in diversity of the Puget Sound ESU/DPS.

Although larvae rockfish are widely dispersed by currents, unique oceanographic conditions within the Puget Sound likely result in most larvae staying within the basin where they are released (Drake et al. 2010). Unlike ESA-listed salmonids, we have not identified biological populations of each species below the DPS level, instead we use the term "populations" to refer to groups within each of the five identified basins of the action area (See Section 2.2.1 Status of the Species). We expect that any larval and juvenile bocaccio and yelloweye rockfish harmed or killed as a result of water quality effects would primarily be from the PS Main basin that includes Elliot Bay. However, given the relatively small number of rockfish expected to be harmed or killed, we do not anticipate a measurable effect on population spatial structure or diversity.

SRKW

We review the population level effects on SRKW using the same parameters for viability, namely abundance, productivity, spatial structure, and distribution. This distinct population segment comprises three groups, J, K, and L pods. Abundance is low, (J pod = 24, K pod = 17, L pod =34) as of May, 2021. Productivity is likely to be impaired by the relatively high number of males to females. Spatial distribution has high inter-annual variability, and diversity is at risk because of the low abundance. These threats were reviewed by Murray et al. (2021), who found a "cumulative effects" model was better at determining population impacts compared to individual threats. The "cumulative effects" model indicated that Chinook salmon abundance was the most sensitive model parameter, however they highlighted the importance of considering threats collectively. Lacy et al. (2017) developed a PVA model that attempts to quantify and compare the three primary threats affecting the whales (e.g. prey availability, vessel noise and disturbance, and high levels of contaminants).

Abundance and Productivity:
As mentioned previously, there are several factors identified in the final recovery plan for SRKWs that may be limiting recovery: quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. It is likely that multiple threats are acting together, and while it is not clear which threat or threats are most significant to the survival and recovery of SRKW, all of the threats are important to address. Effects of the proposed action on SRKW would be due to the project's adverse effects on Chinook salmon, the whales preferred prey. Given the status of the species (endangered with low abundance and productivity), and their strong preference for Chinook salmon prey, the continued existence and

potential for recovery of the species is highly dependent on healthy numbers of Chinook salmon throughout its range.

The reduction in the number of adult PS Chinook salmon available as prey for SRKW over the long-term would likely result in additional stress and a lower likelihood of survival and reproduction for individual whales in response to decreased prey availability, the SRKW would likely increase foraging effort or abandon areas in search of more abundant prey. Reductions in prey or a resulting requirement of increased foraging efficiency would increase the likelihood of physiological effects. Some individuals of SRKW DPS would likely experience nutritional, deficit from this reduced prey availability. This could in turn impact reproductive or other health conditions (e.g., reduced immune function from drawing on fat stores and mobilizing contaminants in the blubber. In particular, the reduction in available prey could put further stress on SRKW juveniles, pregnant females, and nursing females, producing reduction in fitness among a small number of individuals.

Spatial Structure and Diversity:
Because of this population's small size, it is susceptible to rapid decline due to demographic stochasticity, and genetic deterioration. Small populations are inherently at risk because of the unequal reproductive success of individuals within the population. The more individuals added to a population in any generation, the more chances of adding a reproductively successful individual. Random chance can also affect the sex ratio and genetic diversity of a small population, leading to lowered reproductive success of the population as a whole. For these reasons, the failure to add even a few individuals to a small population in the near term can have long-term consequences for that population's ability to survive and recover into the future. A delisting criterion for the SRKW DPS is an average growth rate of 2.3 percent for 28 years (NMFS 2008). In light of the current average annual growth rate of 0.1 percent, this recovery criterion and the risk of stochastic events and genetic issues described above underscore the importance for the population to grow quickly.

Particularly in light of the small population size and the associated risks, the enduring effects of the proposed action could limit survival and impede the recovery of the PS Chinook salmon ESU by reducing the potential for population growth and increasing the likelihood of additional loss of individual whales. Further reductions in SRKW prey quantity, or spatial or temporal depletions would reduce the representation of diversity in SRKW life histories, resiliency in withstanding stochastic events, and redundancy to ensure there is a margin of safety for the salmon and SRKW to withstand catastrophic events. Long-term prey reductions affect the fitness of individual whales and their ability to both survive and reproduce. Reduced fitness of individuals increases the mortality and extinction risk of SRKW and reduces the likelihood of recovery of the DPS.

Episodic and enduring declines of SRKW's prey as a result of the proposed actions are expected. Sufficient quantity, quality, and availability of prey are an essential feature of the critical habitat designated for SRKW. Increasing the risk of a permanent reduction in the quantity and availability of prey, and the likelihood for local depletions in prey populations in multiple locations over time, incrementally reduces the conservation value of critical habitat in the action area for SRKWs. Temporary construction effects would not cause significant enough effects to SRKW prey species to reduce the conservation value of critical habitats.

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.

Within the action area, the non-federal effects most likely to occur are the commercial, industrial and recreational presence of vessels, creating noise and water quality reductions. Other anticipated effects are the continued effects of upland activities that cause water quality reductions as point or non-point discharges. The action area is influenced by actions within Puget Sound marine waters, along the shoreline, and in tributary watersheds, including the Duwamish/Green River. Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PBFs, many of which are activities that have occurred in the recent past and had an effect on the environmental baseline. These can be considered reasonably certain to occur in the future because they occurred frequently in the recent past, especially if authorizations or permits have not yet expired. State, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, shoreline growth management, and resource permitting. Private activities include continued resource extraction, vessel traffic, development, and other activities which contribute to poor water quality in the marine and freshwater environments of Puget Sound region.

The human population in the Puget Sound region increased from about 1.29 million people in 1950 to about 4.2 million in 2020, and is expected to reach nearly 5 million by 2040 (Puget Sound Regional Council 2020). If population growth trends remain relatively consistent with recent trends, we can anticipate future growth at approximately 1.5 percent per year. Thus, future private and public development actions are very likely to continue in and around Puget Sound. As the human population continues to grow, demand for agricultural, commercial, and residential development and supporting public infrastructure is also likely to grow. We believe the majority of environmental effects related to future growth will be linked to these activities, in particular land clearing, associated land-use changes (i.e., from forest to impervious, lawn or pasture), increased impervious surface, and related contributions of contaminants to area waters. Land use changes and development of the built environment that are detrimental to salmonid habitats are likely to continue under existing regulations. Though the existing regulations minimize future potential adverse effects on salmon habitat, as currently constructed and implemented, they still allow systemic, incremental, and additive degradation to occur.
All such future non-federal actions, in the LDW as well as in tributary watersheds, will cause long-lasting environmental changes and will continue to harm ESA-listed species and their critical habitats. Especially relevant effects include the loss or degradation of nearshore habitats, pocket estuaries, estuarine rearing habitats, wetlands, floodplains, riparian areas, and water quality. We consider human population growth to be the main driver for most of the future negative effects on salmon and steelhead and their habitat.

Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NMFS finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities, as described in the Environmental Baseline, these effects may occur at somewhat higher or lower levels than those described in the Baseline.

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, while all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4), we reiterate some effects of climate change here.

Anticipated climate effects on abundance and distribution of PS Chinook salmon and PS steelhead include a wide variety of climate impacts. The greatest risks will likely occur during incubation, when eggs are vulnerable to high mortality due to increased flooding and variability in seasonal flow (Ward et al. 2015). Crozier et al. (2019) identified early life stages such as incubating eggs as highly sensitive when exposed to more variable hydrologic regimes. Crozier et al (2019) also predicted that 8% of spawning habitat will change from snow-dominated to transitional, and 16% will change from transitional to rain-dominated. These projections suggest that winter flooding will become more common, directly affecting incubating eggs and increasing the risk of high flows scouring out redds. Stream temperature ranks high in the extent of change expected, which could increase pre-spawn mortality in low-elevation tributaries (Cristea and Burges 2010). Rising temperatures during late spring and summer may also impact Chinook salmon juveniles in estuary and riverine habitats. Most Puget Sound estuaries already surpass optimal summer rearing temperatures, and the expectation of additional warming would further degrade already degraded habitat (Crozier et al 2019, Appendix S3). Salinity, acidity, and water temperatures are also expected to shift increasingly with climate change, though the degree of these changes is difficult to predict. These shifting conditions are likely to modify prey communities and food web interactions over time.

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

Notwithstanding the beneficial effects of ongoing habitat restoration actions (e.g., riparian planting, instream habitat enhancement, creation of complex channel, fish passage, etc.), the cumulative effects associated with continued development are likely to have ongoing adverse effects on all the listed species populations addressed in this Opinion. Only improved low-impact development actions together with increased numbers of restoration actions, watershed planning, and recovery plan implementation would be able to address growth related impacts into the future. To the extent that non-federal recovery actions are implemented and offset ongoing development actions, adverse cumulative effects may be minimized, but will probably not be completely avoided.

2.7. Integration and Synthesis

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

2.7.2 Critical Habitat

Within the action area, critical habitat is designated for PS Chinook salmon and PS steelhead in the LDW, and for PS Chinook salmon, PS/GB bocaccio, PS/GB yelloweye rockfish and SRKW in the Puget Sound. Throughout the designated area, multiple features of habitat are degraded, but despite such degradation, many accessible areas remain ranked with high conservation value because of the important life history role it plays.

For PS Chinook salmon and steelhead, limiting factors (impaired or insufficient PBFs) include; riparian areas and LWD, fine sediment in spawning gravel, water quality, fish passage and estuary conditions. Loss of freshwater and nearshore critical habitat quality is a limiting factor for both species. Current state and local regulations do not prevent much of the development that degrades the quality of nearshore critical habitats. There is no indication these regulations are reasonably certain to change in the foreseeable future.

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

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

To this degraded baseline we add the habitat effects we expect to be caused by the action. Because the action area includes critical habitat for PS Chinook salmon, PS steelhead, PS/GB yelloweye rockfish, PS/GB bocaccio and SRKW, we anticipate effects of the proposed project to degrade critical habitat for these species. As described above, the proposed action would cause short-term and long-term low-level adverse effects on water quality, substrate, forage, and natural cover.

Based on the best available information, the scale of the proposed action's effects, when considered in combination with the degraded baseline, cumulative effects, and the effects of climate change, habitat degradation would reduce the potential for the habitat in the action area to support recovery, but the proposed project effects themselves would be too small to attribute to that reduction. Nevertheless, the conservation value of the critical habitat for PS Chinook salmon, PS steelhead, PS/GB yelloweye rockfish, PS/GB bocaccio and SRKW is largely retained. Therefore, the overall effect of the project on critical habitat, while adverse and chronic, cannot be considered to reduce the conservation potential of critical habitat in the action area.

2.7.1 ESA-Listed Species

Each of the ESA-listed species considered in this opinion are threatened, except PS/GB bocaccio which are endangered. The status of all species is based in low abundance relative to historic numbers, with reduced productivity, spatial structure, and diversity. This depressed condition is a function of many factors, including reductions in the amount or quality of habitat throughout their range, and overharvest in previous years. Baseline conditions in the action area which were described earlier in this document reflect habitat degradation typical of urban areas of the Puget Sound and highly developed tributary watersheds.

To this status, we add the species' response to project effects. Most of the effects of the proposed action are spatially very constrained (i.e. bank modification, overwater structures) with limited effects on listed species. The exception is the discharge of stormwater effluent. The proposed action's discharge would create a chronic area of exposure for PS Chinook salmon, PS steelhead, PS/GB yelloweye rockfish, PS/GB bocaccio and SRKW. Contaminants in this discharge are likely to produce a range of adverse health effects – both acute and latent, particularly among juvenile rockfish and juvenile salmonids. However, it is important to note that the discharge is of treated stormwater, and reductions in PGIS included as part of the proposed project. For this reason, we expect harm or death associated with the proposed action may occur at a lower rate than at the pre-project level.

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

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

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

When we evaluate the cumulative effects on these species, we anticipate additional stress added to existing stressors in the baseline in both fresh and marine environments from anthropogenic changes in habitat and increasingly modified conditions related to climate change (e.g. warmer temperatures, and more variable volume and velocities in freshwater, changing temperature, pH, and salinity in marine waters). All of these are likely to exert negative pressure on population abundance and productivity. In this context we add the effects of the proposed action. Even considered over multiple years, with highly variable ocean conditions and climate change stressors, only a small number of fish relative to the affected populations would be killed or injured by the effects that result from the proposed action, so that the reductions in abundance would not rise to create effects on productivity, diversity and spatial structure at discernible levels. Therefore, the proposed action is unlikely to alter the current or future trends for PS Chinook salmon, PS steelhead, PS/GB yelloweye rockfish, PS/GB bocaccio or SRKW population viability even when cumulative effects and baseline conditions are added to the effects of the proposed action.

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

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, any effects of activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of PS Chinook salmon, PS steelhead, PS/GB bocaccio, or PS/GB yelloweye rockfish. Further, the proposed action is not likely to destroy or adversely modify the designated critical habitat for PS Chinook salmon, PS steelhead, PS/GB bocaccio, or PS/GB yelloweye rockfish.

2.9. Incidental Take Statement

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

2.9.1 Amount or Extent of Take

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

Harm of PS Chinook salmon and PS steelhead from exposure to:

- Construction-related habitat exclusion, disrupted migration and turbidity (juveniles and adults);
- Increased predation (juveniles);
- Forage reductions (juveniles and adults); and
- Water quality degradation (juveniles and adults).

Harm of PS/GB bocaccio, PS/GB yelloweye rockfish and SRKW from exposure to:

- Forage reductions (juveniles and adults)
- Water quality degradation (juveniles and adults).

The NMFS cannot predict with meaningful accuracy the number of PS Chinook salmon, PS steelhead, PS/GB bocaccio, PS/GB yelloweye rockfish or SRKW that are reasonably certain to be injured or killed annually by exposure to any of these stressors. The distribution and abundance of the fish that occur within an action area are affected by habitat quality, competition, predation, and the interaction of processes that influence genetic, population, and environmental characteristics. 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 such circumstances, the NMFS uses the causal link established between the activity and the likely extent and duration of changes in habitat conditions to describe the extent of take as a numerical level of habitat disturbance. The most appropriate surrogates for take are action-related parameters that are directly related to the magnitude of the expected take.

The extent of PS Chinook salmon and PS steelhead take in the form of harm from construction effects is defined as 3 months of in-water work at the project site, as defined in Section 1.3 (Proposed Federal Action) to be completed between October 1 – February 15. The physical area of disturbance, and the timing and the duration of work, are the best available surrogates for the extent of take of juvenile and adult PS Chinook salmon and steelhead from exposure to construction-related effects. This metric is easily observed, and causal, because working outside of the planned work window and/or working for longer than planned would increase the number of fish likely to be exposed to these construction-related impacts.

The extent of take in the form of harm from long-term habitat degradation by the effects of permanent structures (sheet pile wall/armoring and overwater structures) are the dimensions of those structures - the. (range track dock 1, 900 square ft), and the proposed linear length of shoreline armoring structures (sheet pile wall; 1,405 linear ft). This is the best available surrogate for the extent of take of PS Chinook salmon and PS steelhead from habitat effects because the size of the structures is observable and also is directly correlated with the scale of habitat effects that produce harm.

The surrogate for take in the form of harm from long-term water quality degradation effects from stormwater discharge is the area of new and replaced impervious surfaces - 28,100 square feet of new and replaced PGIS, and 36.58 acres of tributary basins contributing stormwater to the two outfalls in the proposed sheet pile wall. These metrics describe the total area of the tributary basin contributing stormwater that is discharged through the two stormwater discharge outfalls (DC 2 and DC5) in the proposed sheet pile wall. These are the best available surrogates for the extent of take from exposure to roadway-related contaminated water because they are causal, as the size of the PGIS increases, the volume of stormwater runoff and contaminants increases. Similarly, as the size of the tributary basin that contributes stormwater to the outfalls increases, the volume of stormwater and associated contaminants increases.

Some of these take surrogates could be construed as partially coextensive with the proposed action. However, they nevertheless function as effective re-initiation triggers. The construction-related take surrogates would likely be monitored on a near-daily basis; thus any exceedance of the surrogates would be apparent in real-time and well before the project is completed. Further, if the size of permanent structures, the size of new or replaced impervious surface or contributing tributary basins, or the duration and timing of work exceed the proposal, it could still meaningfully trigger re-initiation because the Corps has authority to conduct compliance inspections and to take actions to address non-compliance, including post-construction (33 CFR 326.4).

2.9.2 Effect of the Take

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

2.9.3 Reasonable and Prudent Measures

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

The Corps shall require the applicant to:

1. Ensure completion of a monitoring and reporting program to confirm the proposed action is implemented as proposed and that conservation measures limit and minimize the extent of 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 term and condition implements reasonable and prudent measure 1: The USACE or the permit applicant shall provide to NMFS (projectreports.wcr@noaa.gov and jeff.vanderpham@noaa.gov; use subject line "Attn: WCRO-2019-03265") within 90 days of completion of the proposed project a report that provides the following:
    a. The length (linear feet) of the sheet pile wall;
    b. Confirmation that only 1 lf of the sheet pile wall is below the OHWM and the remainder is above HAT;
    c. The surface area (square feet) of range track dock 1;

d. Confirmation of the removal of range track docks 2, 3 and 4 and associated structures (i.e. piles);
e. Confirmation that riparian areas in the footprint of the removed range track docks 2, 3 and 4 were replanted with native vegetation;
f. The total number of days of construction activity below the OHWM;
g. The total square footage of new and replaced impervious surfaces at the project site; and
h. The total area of the tributary drainage basins contributing discharge to the DC2 and DC5 outfalls.

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. To further minimize effects of stormwater discharge from Boeing facilities, we recommend the Corps or permit applicant do the following:

   a. Develop and implement an adaptive management plan for all stormwater treatment at Boeing facilities in the Puget Sound Basin, which actively pursue and apply upgrades to treatment methods with future developments in stormwater science and treatment; and

   b. Integrate green infrastructure designs into facilities at the project site and elsewhere on Boeing properties in the Puget Sound Basin, and apply 100% stormwater runoff infiltration for all contributing sources to reduce discharge of contaminants to the Puget Sound and tributary rivers.

2. To address degraded habitat conditions in the LDW, we recommend that the Corps or permit applicant identify and implement habitat enhancement or restoration activities in the LDW, including the action area., as follows:

   a. Improve the quality of riparian habitat (e.g. vegetation planting, LWD placement, etc.) to increase cover and forage for juvenile salmonid migration and rearing; and

   b. Remove existing in-water structures such as docks, piles and bulkheads that are no longer in use.

2.11. "Not Likely to Adversely Affect" Determinations

Central America and Mexico DPS Humpback Whale

Humpback Whales: Humpback whale presence in Puget Sound has increased in recent decades. For example, OceanWatch indicates 3,052 locations of humpback whales sighting in the focal area of the waters around the San Juan Islands and Puget Sound reported to the B.C. Cetacean Sightings Network from 1990 through 2016. Data suggests approximately 69 percent of whales in Puget Sound are from the unlisted Hawaii DPS, while the remainder are from the Central American (6 percent) and Mexico DPSs (25 percent). Critical habitat is not designated within the action area.

Central America DPS humpback whale. Whales from this breeding ground feed almost exclusively offshore of California and Oregon in the eastern Pacific, with only a few individuals have been identified at the northern Washington-southern British Columbia feeding grounds. The Central America DPS is listed as endangered and has been most recently estimated to include 783 whales (CV = 0.170; Wade 2017) with unknown population trend.

Mexico DPS humpback whale. This DPS has also been documented within the Salish Sea (Calambokidis et al. 2017). Sightings of humpback whales in general have increased dramatically in the Salish Sea from 1995 to 2015, and at least 11 whales from this DPS have been matched to those sighted within this area (Calambokidis et al. 2017). This DPS was most recently estimated to have an abundance of 2,806.

Both DPSs of humpback whales occur infrequently in the action area, within Elliot Bay, but not within the LDW. The duration of presence at any occurrence is not expected to exceed several hours as members of these species would normally continue in search of prey during their migration. Given the brevity of exposure to contaminants discharged by the treatment facility, we expect no discernible behavioral or health response. While exposure is not discountable, response if it were to occur, is expected to be insignificant.

2.12. Reinitiation of Consultation

This concludes ESA consultation for Boeing Developmental Center and Thompson Shoreline Infrastructure Stabilization Project.

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

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

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

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

3.1. Essential Fish Habitat Affected by the Project

The environmental effects of the proposed action may adversely affect EFH for Pacific Coast salmon, Pacific Coast groundfish and coastal pelagic species, all of which are present in the action area. The action area also contains Habitat Areas of Particular Concern (HAPC) for Pacific Coast salmon and Pacific Coast groundfish. Impacts to EFH include water quality degradation by short-term elevated levels of turbidity within the LDW during construction activity below the OHWM; water quality degradation within the LDW and Puget Sound by the discharge of stormwater; and habitat quality degradation associated with bank armoring and overwater structures.

3.2. Adverse Effects on Essential Fish Habitat

The feature of EFH of Pacific Coast salmon, Pacific Coast groundfish and coastal pelagic species affected by the proposed action would include diminishments in water quality, as described above in this Opinion. We anticipate degraded water quality from elevated levels of turbidity approximately 300-feet waterward of the project construction areas below the OHWM intermittently over the 3-month construction period. We also expect degraded water quality associated contaminants in stormwater discharged from the proposed facility for the life of the contributing PGIS and discharge structures (estimated 50 years). As a result of permanent over-water structures and shoreline armoring, we anticipate increased predation risk, and reduced cover, forage and habitat availability.

3.3. Essential Fish Habitat Conservation Recommendations

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

1. To further minimize effects of stormwater discharge from Boeing facilities, we recommend the USACE or permit applicant do the following:

   a. Develop and implement an adaptive management plan for all stormwater treatment at Boeing facilities in the Puget Sound Basin, which actively pursue and apply upgrades to treatment methods with future developments in stormwater science and treatment; and

   b. Integrate green infrastructure designs into facilities at the project site and elsewhere on Boeing properties in the Puget Sound Basin, and apply 100% stormwater runoff infiltration for all contributing sources to reduce discharge of contaminants to the Puget Sound and tributary rivers.

2. To address degraded habitat conditions in the LDW, we recommend that the Corps or permit applicant identify and implement habitat enhancement or restoration activities in the LDW, including the action area., as follows:

   c. Improve the quality of riparian habitat (e.g. vegetation planting, LWD placement, etc.) to increase cover and forage for juvenile salmonid migration and rearing; and

   d. Remove existing in-water structures such as docks, piles and bulkheads that are no longer in use.

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

3.4. Statutory Response Requirement

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

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

3.5. Supplemental Consultation

The 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 and the applicant, Boeing. Other interested users could include citizens of King County. 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

Able, K. W., J.P. Manderson, and A.L. Studholme. 1998. The distribution of shallow water juvenile fishes in an urban estuary: The effects of manmade structures in the lower Hudson River. Estuaries. 21:731-744.

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

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.

Beamer, E.M., and R.A. Henderson. 1998. Juvenile salmonid use of natural and hydromodified stream bank habitat in the mainstem Skagit River, Northwest Washington. Skagit River System Cooperative. La Conner, WA. 51 p.

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., Bryant, M.D., Dolloff, C.A., Grette, G.B., House, R.A., Murphy, M.L., Koski, K.V., and Sedell, J.R. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present, future. In Streamside management: forestry and fisheries interactions. Edited by E.O. Salo and T.D. Cundy. University of Washington College of Forest Resources, Seattle, Wash. pp. 143–190.

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.

Bolton, S. and Schellberg, J., 2001. *Ecological issues in floodplains and riparian corridors*. University of Washington Water Center.

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.

Brette, F., B. Machado, C. Cros, J.P. Incardona, N.L. Scholz, and B.A. Block. 2014. Crude Oil Impairs Cardiac Excitation-Contraction Coupling in Fish. Science Vol 343. February 14, 2014. 10.1126/science.1242747. 5 pp

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

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-27, 131 p.

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.

Celedonia, M.T., R.A. Tabor, S. Sanders, D.W. Lantz, and I. Grettenberger. 2008b. Movement and Habitat Use of Chinook Salmon Smolts and Two Predatory Fishes in Lake Washington and the Lake Washington Ship Canal, Western WS Fish and Wildlife Office Lacey, WA.

Celedonia, M.T., R.A. Tabor, S. Sanders, S. Damm, D.W. Lantz, T.M. Lee, Z. Li, J.-M. Pratt, B.E. Price, and L. Seyda. 2008a. Movement and Habitat Use of Chinook Salmon Smolts, Northern Pike minnow, and Smallmouth Bass near the SR 520 Bridge, 2007 Acoustic Tracking Study. U.F.a.W. Service, editor. 139.

Chasco, B. E., B. J. Burke, L. G. Crozier, and R. W. Zabel. 2021. Differential impacts of freshwater and marine covariates on wild and hatchery Chinook salmon marine survival. PLoS ONE 16:e0246659. https://doi.org/0246610.0241371/journal.pone.0246659.

Chow, M., et al., 2019. An urban stormwater runoff mortality syndrome in juvenile coho salmon. Aquatic Toxicology 214 (2019) 105231.

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

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. 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. 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. 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.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.

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., 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., 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.

Dethier, M. N., W.W. Raymond, A.N. McBride, J.D. Toft, J.R. Cordell, A.S. Ogston, S.M. Heerhartz, and H.D. Berry. 2016. Multiscale impacts of armoring on Salish Sea shorelines: Evidence for cumulative and threshold effects. Estuarine, Coastal and Shelf Science. 175:106-117.

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.

Du, B. et al. 2017. Development of suspect and non-target screening methods for detection of organic contaminants in highway runoff and fish tissue with high-resolution time-of-flight mass spectrometry. Environmental Science: Processes and Impacts. 19:1185-1196.

Ecology (Washington Department of Ecology). 2023. Washington State Coastal Atlas. Webpage: https://apps.ecology.wa.gov/coastalatlas/Default.aspx. Accessed April 12, 2023.

Environmental Protection Agency (EPA). 2020. Biological Evaluation and Essential Fish Habitat Assessment for Endangered Species Act Section 7 Consultation on National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permits Located in the Lewiston, Idaho Urbanized Area: City of Lewiston and Lewis-Clark State College (IDS028061) and Idaho Transportation Department District #2 (IDS028258). U.S. EPA Region 10. August 2020.

Evans, M., K. Fazakas, J. Keating. 2009. Creosote Contamination in Sediments of the Grey Owl Marina in Prince Albert National Park, Saskatchewan, Canada. Water Air Soil Pollution. 201:161–184.

Everley, K.A., Radford, A.N. and Simpson, S.D., 2016. Pile-driving noise impairs antipredator behavior of the european sea bass Dicentrarchus labrax. In *The Effects of Noise on Aquatic Life II* (pp. 273-279). Springer New York.

Fardel. A., et al., 2020. Performance of two contrasting pilot swale designs for treating zinc, polycyclic aromatic hydrocarbons and glyphosate from stormwater runoff. Science Total Env. 743:140503 Feist, B. E. et al., 2018. Roads to Ruin: Conservation Threats to Sentinel Species across and Urban Gradient. Ecological Applications 27(8):2382-2396.

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.

Fischenich, J.C. 2001. Stability thresholds for stream restoration materials. ERDC TNEMRRP-SR-29. U.S. Army Corps of Engineers, Engineer Research and Development Center, Vicksburg, MS.

Fischenich, J.C., and R.R. Copeland. 2001. Environmental considerations for vegetation in flood control channels. ERDC TR-01-16. U.S. Army Corps of Engineers, Flood Damage Reduction Research Program, Engineer Research and Development Center, Vicksburg, MS. December.

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).

Florsheim, J.L., J.F. Mount, and A. Chin. 2008. Bank erosion as a desirable attribute of rivers. BioScience 58(6):519-529.

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.

Gustafson, R.G., T.C. Wainwright, G.A. Winans, F.W. Waknitz, L.T. Parker, and R.S. Waples. 1997. Status review of sockeye salmon from Washington and Oregon. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-33, 282 p.

Hard, J.J., R.G. Kope, W.S. Grant, F.W. Waknitz, L.T. Parker, and R.S. Waples. 1996. Status review of pink salmon from Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-25, 131 p.

Hard, J.J., J.M. Myers, E.J. Connor, R.A. Hayman, R.G. Kope, G. Lucchetti, A.R. Marshall, G.R. Pess, and B.E. Thompson. 2015. Viability criteria for steelhead within the Puget Sound distinct population segment. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-NWFSC-129. May 2015. 367 pp

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

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

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.

Heiser, D.W., and E.L. Finn 1970. Observations of Juvenile Chum and Pink Salmon in Marina and Bulkheaded Areas. State of Washington Department of Fisheries.

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.

Incardona, J.P., T.K. Collier, and N.L. Scholz. 2004. Defects in cardiac function precede morphological abnormalities in fish embryos exposed to polycyclic aromatic hydrocarbons. Toxicology and Applied Pharmacology 196: 191-205.

Incardona, J.P., M.G. Carls, H. Teraoka, C.A. Sloan, T.K. Collier, and N.L. Scholz. 2005. Aryl hydrocarbon receptor-independent toxicity of weathered crude oil during fish development. Environmental Health Perspectives 113: 1755-1762.

Intergovernmental Panel on Climate Change (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., 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).

Jeffres, C.A., Opperman, J.J. and Moyle, P.B., 2008. Ephemeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river. *Environmental biology of fishes*, *83*, pp.449-458.

Johnson, B.M., G.M. Kemp, and G.H. Thorgaard. 2018. Increased mitochondrial DNA diversity in ancient Columbia River basin Chinook salmon Oncorhynchus tshawytscha. PLoS One, 13(1), p.e0190059.

Johnson, O.W., W.S. Grant, R.G. Kope, K. Neely, F.W. Waknitz, and R.S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-32, 280 p.

Johnson, L.L., G.M. Ylitalo, M.R. Arkoosh, A.N. Kagley, C.L. Stafford, J.L. Bolton, J. Buzitis, B.F. Anulacion, and T.K. Collier. 2007. Contaminant exposure in outmigrant juvenile salmon from Pacific Northwest estuaries. Environmental Monitoring and Assessment 124: 167-194.

Jonsson, S., A. Andersson, M.B. Nilsson, U. Skyllberg, E. Lundberg, J.K. Schaefer, S. Akerblom, and E. Bjorn. 2017. Terrestrial discharges mediate trophic shifts and enhance methylmercury accumulation in estuarine biota. Science Advances 3: e1601239. 7

Jorgensen, J.C., M.M. McClure, M.B. Sheer, and N.L. Munn. 2013. Combined effects of climate change and bank stabilization on shallow water habitats of Chinook salmon. Conservation Biology 27: 1201-1211

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood pulse concept in river-floodplain systems, p. 110-127. In D.P. Dodge (ed.) Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquat. Sci. 106.

Karrow, N., H.J. Boermans, D.G. Dixon, A. Hontella, K.R. Soloman, J.J. White, and N.C. Bols. 1999. Characterizing the immunotoxicity of creosote to rainbow trout (*Oncorhynchus mykiss*): a microcosm study. Aquatic Toxicology. 45 (1999): 223–239.

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

LaSalle, M.W., Nestler, J., Miller, A.C. and ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS ENVIRONMENTAL LAB, 1988. Seasonal regulation of repair evaluation, maintenance, and rehabilitation(REMR) activities Repair, Evaluation, Maintenance, and Rehabilitation Research Program. *TECH. REP. U. S. ARMY ENG. WATERWAYS EXP. STN.*, *1988*, *28*.

Lee, R. and G. Dobbs. 1972. Uptake, Metabolism and Discharge of Polycyclic Aromatic Hydrocarbons by Marine Fish. Marine Biology. 17, 201-208.

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.

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.

McCain, B., D.C. Malins, M.M. Krahn, D.W. Brown, W.D. Gronlund, L.K. Moore, and S-L. Chan. 1990. Uptake of Aromatic and Chlorinated Hydrocarbons by Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in an Urban Estuary. Arch. Environ. Contam. Toxicol. 19, 10-16 (1990).

McCarthy, S.G., Incardona, J.P., and Scholz, N.L. (2008). Coastal storms, toxic runoff, and the sustainable conservation of fish and fisheries. American Fisheries Society Symposium, 64:7-27.

McIntyre, J.K., Davis, J.W., Incardona, J.P., Anulacion, B.F., Stark, J.D., and Scholz, N.L. (2014). Zebrafish and clean water technology: assessing the protective effects of bioinfiltration as a treatment for toxic urban runoff. Science of the Total Environment, 500:173-180.

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

McIntyre, J.K., Edmunds, R.C., Mudrock, E., Brown, M., Davis, J.W., Stark, J.D., Incardona, J.P. and Scholz, N.L. (2016a). Confirmation of stormwater bioretention treatment effectiveness using molecular indicators of cardiovascular toxicity in developing fish. Environmental Science and Technology, 50:1561-1569.

McIntyre, J.K., Anulacion, B.F., Davis, J.W., Edmunds, R.C., Incardona, J.P., Stark, J.D., and Scholz, N.L. (2016b). Severe coal tar sealcoat runoff toxicity to fish is reversed by bioretention filtration. Environmental Science and Technology, 50:1570-1578. McIntyre, J.K., et al., 2018. Interspecies Variation in the Susceptibility of adult Pacific salmon to Toxic Urban Stormwater Runoff. Env. Pollution 238:196-203.

McIntyre, J.K., Prat, J., Cameron, J., Wetzel, J., Mudrock, E., Peter, K.T., Tian Z., Mackenzie, C., Lundin, J., Stark, J.D., King, K., Davis, J.W., and Scholz, N.L. (2021). Treading water: tire wear particle leachate recreates an urban runoff mortality syndrome in coho but not chum salmon. Environmental Science and Technology, In press.

Meador, J.P., Sommers, F.C., Ylitalo, G.M. and Sloan, C.A., 2006. Altered growth and related physiological responses in juvenile Chinook salmon (Oncorhynchus tshawytscha) from dietary exposure to polycyclic aromatic hydrocarbons (PAHs). *Canadian Journal of Fisheries and Aquatic Sciences*, *63*(10), pp.2364-2376.

Moore, M.E., B.A. Berejikian, and E.P. Tezak. 2013. A Floating Bridge Disrupts Seaward Migration and Increases Mortality of Steelhead Smolts in Hood Canal, Washington State. PloS one. September 2013. Vol 8. Issue 9. E73427. 10 pp.

Moore, M.E., Berejikian, B.A., Goetz, F.A., Berger, A.G., Hodgson, S.S., Connor, E.J. and Quinn, T.P., 2015. Multi-population analysis of Puget Sound steelhead survival and migration behavior. *Marine Ecology Progress Series*, *537*, pp.217-232.

Morley, S.A., J.D. Toft, and K.M. Hanson. 2012. Ecological Effects of Shoreline Armoring on Intertidal Habitats of a Puget Sound Urban Estuary. Estuaries and Coasts. 35:774-784.

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.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-35, 443 p.

Neff, J.M. 1982. Accumulation and release of polycyclic aromatic hydrocarbons from water, food, and sediment by marine animals. Pages 282-320 in N.L. Richards and B.L. Jackson (eds.). Symposium: carcinogenic polynuclear aromatic hydrocarbons n the marine environment. U.S. Environ. Protection Agency Rep. 600/9-82-013.

Newbold JD, Erman DC, Roby KB. 1980. Effects of logging on macroinvertebrates in streams with and without buffer strips. Canadian Journal of Fisheries and Aquatic Sciences 37: 1076–1085.

Nightingale, B., and C.A. Simenstad. 2001b. Overwater Structures: Marine Issues. University of Washington, Washington State Transportation Center. 133.

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.

Northwest Fisheries Science Center (NWFSC). 2015. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. December 21, 2015. 356 pp.

National Marine Fisheries Service (NMFS). 2011. Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead. NMFS Northwest Region. Portland, OR. January. Prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc., subcontractor

NMFS. 2013. Programmatic Restoration Opinion for Joint Ecosystem Conservation by the Services (PROJECTS) by the U.S. Fish and Wildlife Service Using the Partners for Fish and Wildlife, Fisheries, Coastal, and Recovery Programs and NOAA Restoration Center Using the Damage Assessment, Remediation and Restoration Program (DARRP), and Community-Based Restoration Program (CRP) in the States of Oregon, Washington, and Idaho. NWR-2013-10221. December 3, 2013. 228 pp.

NMFS. 2014a. Endangered Species Act Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation Idaho Water Quality Standards for Toxic Substances. National Marine Fisheries Service, West Coast Region. NMFS Consultation Number: 2000-1484. May 7, 2014. 528 pp.

NMFS. 2017. 2016 5-Year Review: Summary and Evaluation of Puget Sound Chinook Salmon, Hood Canal Summer-run Chum Salmon, and Puget Sound Steelhead. NMFS West Coast Region, Portland, Oregon. April 6, 2017. 98 pp.

NMFS. 2019. ESA Recovery Plan for the Puget Sound Steelhead Distinct Population Segment (*Oncorhynchus mykiss*). National Marine Fisheries Service. Seattle, WA. 174p.

NMFS. 2022. 2021 Southern Resident Killer Whales (Orcinus orca) 5-Year Review: Summary and Evaluation January 04, 2022

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.

Parks, D., A. Shaffer, and D. Barry. 2013. Nearshore drift-cell sediment processes and ecological function for forage fish: implications for ecological restoration of impaired Pacific Northwest marine ecosystems. J. Coast. Res. 29:984–997.

Peter, K.T., F. Hou, Z. Tian, C. Wu, M. Goehring, F. Liu, and E.P. Kolodziej. 2020. More than a first flush: urban creek storm hydrographs demonstrate broad contaminant pollutographs. Environmental Science & Technology. 54 (10), 6152-6165 DOI: 10.1021/acs.est.0c00872.

Peter, K.T., Z. Tian, C. Wu, P. Lin, S. White, B. Du, J.K. McIntyre, N.L. Scholz, and E.P. Kolodziej. 2018. Using High-Resolution Mass Spectrometry to Identify Organic Contaminants Linked to Urban Stormwater Mortality Syndrome in Coho Salmon. Environ. Sci. Technol. 2018, 52, 10317−10327.

PFMC (Pacific Fishery Management Council). 1998. Description and identification of essential fish habitat for the Coastal Pelagic Species Fishery Management Plan. Appendix D to Amendment 8 to the Coastal Pelagic Species Fishery Management Plan. Pacific Fishery Management Council, Portland, Oregon. December.

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

PFMC. 2005. Amendment 18 (bycatch mitigation program), Amendment 19 (essential fish habitat) to the Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington groundfish fishery. Pacific Fishery Management Council, Portland, Oregon. November.

PFMC. 2008. Management of krill as an essential component of the California Current ecosystem. Amendment 12 to the Coastal Pelagic Species Fishery Management Plan. Environmental assessment, regulatory impact review & regulatory flexibility analysis. Pacific Fishery Management Council, Portland, Oregon. February.]

Popper, A.N. and Hawkins, A.D., 2019. An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes. *Journal of fish biology*, *94*(5), pp.692-713.

Quinn, T.P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. University of British Columbia Press.

Rice, C. A. 2006. Effects of shoreline modification on a northern Puget Sound beach: microclimate and embryo mortality in surf smelt (Hypomesus pretiosus). Estuaries and Coasts. 29(1): 63-71

Roni, P. and Quinn, T.P., 2001. Effects of wood placement on movements of trout and juvenile coho salmon in natural and artificial stream channels. *Transactions of the American Fisheries Society*, *130*(4), pp.675-685.

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.

Scholz, N.L., M.S. Myers, S.G. McCarthy, J.S. Labenia, J.K. McIntyre, G.M. Ylitalo, L.D. Rhodes, C.A. Laetz, C.M. Stehr, B.L. French, B. McMillan, D. Wilson, L. Reed, K.D. Lynch, S. Damm, J.W. Davis, and T.K. Collier. 2011. Recurrent die-offs of adult coho salmon returning to spawn in Puget Sound lowland urbans streams. PLoS ONE 6: e28013. doi.10.1371/journal.pone.0028013.

Segura, C., and D.B. Booth. 2010. Effects of geomorphic setting and urbanization on wood, pools, sediment storage, and bank erosion in Puget Sound streams. Journal of the American Water Resources Association 46(5):972-986.

Shared Strategy for Puget Sound (SSPS). 2007. Puget Sound Salmon Recovery Plan – Volume 1. Shared Strategy for Puget Sound, 1411 4th Ave., Ste. 1015, Seattle, WA 98101. Adopted by NMFS January 19, 2007. 503 pp.

Shirvell, C. S. 1990. Role of instream rootwads as juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout (O. mykiss) cover habitat under varying streamflows. Canadian Journal of Fisheries and Aquatic Sciences, 47.5: 852-861.

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.

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 \

Simenstad, C.A. 1988. Summary and Conclusions from Workshop and Working Group Discussions. Pages 144-152 in Proceedings, Workshop on the Effects of Dredging on Anadromous Pacific Coast Fishes, Seattle, Washington, September 8-9, 1988. C.A. Simenstad, ed., Washington Sea Grant Program, University of Washington, Seattle, Washington.

Simenstad, C. A., B. J. Nightingale, R. M. Thom and D. K. Shreffer. 1999. Impacts of ferry terminals on juvenile salmon migrating along Puget Sound shorelines, Phase I: synthesis of state of knowledge. Final Res. Rept., Res. Proj. T9903, Task A2, Wash. State Dept.Transportation, Washington State Trans. Center (TRAC), Seattle, WA. 116 pp + appendices

Simpson, S.D., Radford, A.N., Nedelec, S.L., Ferrari, M.C., Chivers, D.P., McCormick, M.I. and Meekan, M.G., 2016. Anthropogenic noise increases fish mortality by predation. *Nature communications*, *7*(1), p.10544.

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.

Sobocinski, K. L., J.R. Cordell and C.A. Simenstad. 2010. Effects of Shoreline Modifications on Supratidal Macroinvertebrate Fauna on Puget Sound, Washington Beaches. Estuaries and Coasts. 33:699-711.

Sommer, T., B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer, and L. Schemel. 2001. California's Yolo Bypass: Evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. Fisheries 26 (8):6-16.

Sommer, T.R., Harrell, W.C. and Feyrer, F., 2014. Large-bodied fish migration and residency in a flood basin of the S acramento R iver, C alifornia, USA. *Ecology of Freshwater Fish*, *23*(3), pp.414-423.

Southard, S. L., R.M. Thom, G.D. Williams, T.J. D., C.W. May, G.A. McMichael, J.A. Vucelick, J.T. Newell, and J.A. Southard. 2006. Impacts of Ferry Terminals on Juvenile Salmon Movement along Puget Sound Shorelines. Battelle Memorial Institute, Pacific Northwest Division.

Spromberg, J.A. and Scholz, N.L. (2011). Estimating the decline of wild coho salmon populations due to premature spawner mortality in urbanizing watersheds of the Pacific Northwest. Integrated Environmental Assessment and Management, 4:648-656. 8

Spromberg, J.A., et al., 2016. Coho Salmon Spawner mortality in western U.S. urban watersheds: bioinfiltration prevents lethal stormwater impacts. J.Applied Ecology 53:398-407.

Spromberg, J.A., Baldwin, D.H., Damm, S.E., McIntyre, J.K., Huff, M., Davis, J.W., and Scholz, N.L. (2016). Widespread adult coho salmon spawner mortality in western U.S. urban watersheds: lethal impacts of stormwater runoff are reversed by soil bioinfiltration. Journal of Applied Ecology (Editor's Choice), 53:398-407.

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.

Sutton, R., et al., 2019. Understanding Microplastic Levels, Pathways, and Transport in the San Francisco Bay Region, SFEI-ASC Publication #950, October 2019, 402 pages, https://www.sfei.org/sites/default/files/biblio_files/Microplastic%20Levels%20in%20SF%20Bay %20-%20Final%20Report.pdf

TerraLogic GIS, Inc. and Landau Associates. 2004. Final Lower Duwamish Inventory Report, May 2014.

Toft, J.D., J.R. Cordell, C.A. Simenstad, and L.A. Stamatiou. 2007. Fish Distribution, Abundance, and Behavior along City Shoreline Types in Puget Sound. *North American Journal of Fisheries Management*. 27: 465-480.

Toft, J.D., Ogston, A.S., Heerhartz, S.M., Cordell, J.R. and Flemer, E.E., 2013. Ecological response and physical stability of habitat enhancements along an urban armored shoreline. *Ecological Engineering*, *57*, pp.97-108.

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

Tian, Z., and 28 others. 2020. A ubiquitous tire rubber-derived chemical induces acute mortality in coho salmon. Science 10.1126/science.abd6951.

Varanasi, U., W.L. Reichert, J.E. Stein, D.W. Brown, and H.R. Sanborn. 1985. Bioavailability and biotransformation of aromatic hydrocarbons in benthic organisms exposed to sediment from an urban estuary. Environmental Science and Technology 19: 836-841.

Varanasi, U., E. Casillas, M.R. Arkoosh, T. Hom, D.A. Misitano, D.W. Brown, S.L. Chan, T.K. Collier, B.B. McCain, and J.E. Stein. 1993. Contaminant Exposure and Associated Biological Effects in Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) from Urban and Nonurban Estuaries of Puget Sound. NOAA Technical Memorandum NMFS-NWFSC-8. NMFS NFSC Seattle, WA. April 1993. 69 pp.

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), pp.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.

WDFW (Washington Department of Fish and Wildlife). 2023. Forage Fish Spawning Map – Washington State. Webpage: https://wdfw.maps.arcgis.com/home/webmap/viewer.html?webmap=19b8f74e2d41470cbd80b1af8dedd6b3&extent=-126.1368,45.6684,-119.6494,49.0781. Accessed April 12, 2023.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-NWFSC-24, 258 p.

West, J., A. Carrey, J. Lanksbury, L. Niewolny and S. O'Neill. 2014. Effectiveness Monitoring for Creosote-Piling Removal Project: Embryos of Pacific Herring (Clupea pallasii) as Sentinels for the Presence of Polycyclic Aromatic Hydrocarbons (PAHs). WDFW, Olympia, WA.

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.

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.

Winemiller, K.O., 2004. Floodplain river food webs: generalizations and implications for fisheries management. In Proceedings of the second international symposium on the management of large rivers for fisheries (Vol. 2, pp. 285-309). Mekong River Commission, Phnom Penh: Cambodia.

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/abf393