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-2024-02448

April 10, 2025

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

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, Section 7(a)(4) Conference Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Port of Seattle and Port of Tacoma Comprehensive Mitigated Maintenance and Repair Permits, Puget Sound, Washington (NWS-2024-311-WRD; NWS-2024-446-WRD).

Dear Mr. Atkins:

Thank you for your letter of October 1, 2024, 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.) and conference opinion for the Port of Seattle and Port of Tacoma Comprehensive Mitigated Maintenance and Repair Permits (hereinafter, CMMPs).

NMFS also reviewed the proposed action for potential effects on essential fish habitat (EFH) designated under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1855(b)). This review was pursuant to section 305(b) of the MSA, implementing regulations at 50 CFR 600.920, and agency guidance for use of the ESA consultation process to complete EFH consultation. NMFS concluded that the action would adversely affect EFH designated under the Pacific Coast Groundfish fishery management plan (2024), the Pacific salmon fishery management plan (2022) and the Coastal Pelagic fishery management plan (2024). Therefore, we have included the results of that review in this document, and provide one conservation recommendation.

In this conference and biological Opinion (hereafter, Opinion), NMFS concludes that the proposed action is not likely to jeopardize the continued existence of Puget Sound evolutionarily significant unit (ESU) Chinook salmon (*Oncorhynchus tshawytscha*), PS distinct population segment (DPS) steelhead (*Oncorhynchus mykiss*), Puget Sound-Georgia Basin (PS/GB) DPS bocaccio rockfish (*Sebastes paucispinis*), PS/GB DPS yelloweye rockfish (*Sebastes ruberrimus*), southern resident killer whales (SRKW; *Orcinus orca*), or the Central America (CAM) or Mexico (MEX) DPS humpback whale (*Megaptera novaeangliae*).

The NMFS also concluded the action is not likely to result in the destruction or adverse modification of designated critical habitat for PS Chinook salmon, PS steelhead, PS/GB rockfish, or for SRKW.

The NMFS also concluded the proposed action is not likely to adversely affect yelloweye rockfish critical habitat.

This Opinion also includes a conference opinion evaluating the effects of the proposed program of activities on sunflower sea stars (*Pycnopodia helianthoides*).

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

Please contact Stephanie Ehinger with the Central Puget Sound Branch at Stephanie.Ehinger@noaa.gov if you have any questions concerning this consultation or require additional information.

Sincerely,

Kathleen Wells
Assistant Regional Administrator
Oregon Washington Coastal Office

cc: LeeAnn Simmons, U.S. Army Corps of Engineers

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

Port of Seattle and Port of Tacoma Comprehensive Mitigated Maintenance and Repair Permits
Puget Sound, Washington (NWS-2024-311-WRD; NWS-2024-446-WRD)

NMFS Consultation Number: WCRO-2024-02448

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

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	If likely to adversely affect, Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	If likely to adversely affect, is Action Likely to Destroy or Adversely Modify Critical Habitat?
Puget Sound ESU Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	Yes	No
Puget Sound DPS steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	Yes	No
Puget Sound-Georgia Basin DPS bocaccio rockfish (*Sebastes paucispinis*)	Endangered	Yes	No	Yes	No
Puget Sound-Georgia Basin DPS yelloweye rockfish (*Sebastes ruberrimus*)	Threatened	Yes	No	No	No
Southern resident DPS killer whale (*Orcinus orca*)	Endangered	Yes	No	Yes	No
Central America (CAM) DPS humpback whale (*Megaptera novaeangliae*)	Endangered	Yes	No	NA	NA
Mexico DPS humpback whale (*Megaptera novaeangliae*)	Threatened	Yes	No	NA	NA
Sunflower Sea Star *(Pycnopodia helianthoides)*	Proposed	Yes	No	NA	NA

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
Coastal Pelagic Species	Yes	Yes
Pacific Coast Groundfish	Yes	Yes

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

Issued By:

Kathleen Wells
Assistant Regional Administrator
Oregon Washington Coastal Office

Date: April 10, 2025

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1. INTRODUCTION

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

1.1. Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion and conference opinion (hereafter "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.

For many years, the U.S. Army Corps of Engineers (Corps) has requested individual section 7(a)(2) ESA and EFH consultations to address maintenance, repair, and sampling at Port of Seattle (Seattle) or Port of Tacoma (collectively, the Ports) facilities that may affect federally listed species and their designated critical habitats. These activities are typically minor, repetitive, and routine repairs or sampling activities and maintenance of existing infrastructure. In an effort to increase efficiency and more thoroughly analyze the collective effects of these actions, the Corps, Ports, and NMFS agreed to programmatically consult on this array of proposed actions.

The maintenance, repair, and scientific sampling activities considered in this consultation have a federal nexus with the Seattle District of the Corps based on its regulatory authority to issue permits under section 404 of the Clean Water Act (33 U.S.C. 1344) and section 10 of the Rivers and Harbors Act (33 U.S.C. 403).

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

1.2. Consultation History

In October of 2022, NMFS and USFWS (the Services) met with representatives of the Ports of Seattle and Tacoma, to discuss regulatory pathways available for their Corps permits that would be expiring. The conversation evaluated options such as programmatic consultation styled after the then recently completed Salish Sea Nearshore Programmatic, or a batched comprehensive consultation.

Subsequently, in the February of 2023, the Ports requested the Services review an impacts assessment calculator of their own design. Over the course of several meetings, beginning with a site visit in May of 2023, the Services indicated a calculator that would support evaluating both impact and benefit, and address multiple species, would be desirable.

The Services and the Ports proceeded to meet at least monthly (see Table 1, wherein ALL signifies both Ports and both Services), and frequently more often, for the next 20 months to coordinate on the development of a calculator suitable to highly developed estuarine environments, and a supporting scientific rationale document.

On October 1 2024, the USACE submitted Biological Evaluations for the USACE's proposed authorization of each port's 10-year plan of facilities maintenance, repair, and replacement, and habitat improvement activities. The USACE determined that the proposed actions are likely to adversely affect the Puget Sound (PS) Evolutionary Significant Unit (ESU) of Chinook salmon (*Oncorhynchus tshawytscha*), PS Distinct Population Segment (DPS) of steelhead (*Oncorhynchus mykiss*), Puget Sound/Georgia Basin (PS/GB) DPS of bocaccio rockfish (*Sebastes paucispinus*), and PS/GB yelloweye rockfish (*Sebastes ruberrimus*).

The consultation request included a "not likely to adversely affect" (NLAA) determination for Southern resident killer whale (SRKW; *Orcinus orca*) and Central American (CAM) and Mexico (MEX) DPS of humpback whale (*Megaptera noveaengliae*). It also made an NLAA determination on critical habitat for all species except for humpback whale critical habitat (the USACE did not request consultation on humpback whale critical habitat because the proposed action occurs outside of designated critical habitat for this species).

The USACE also requested conference on sunflower sea stars on January 2, 2025.

The Services provided comments recommending that the proposed action be presented in a more unified manner, to facilitate development of a batched consultation, opinion, and track taking method.

The revised proposed action as well as the proposed Ports' calculator and calculator rationale documents were then provided by the USACE on December 17. 2024. The consultation was initiated on that date.

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

Table 1. Consultation History

Entity	Date	Topic	Consultation Activity
All	10/2022	Permits	Discussion with NMFS on permit pathway options
Ports	2/2/2023	Proposed action	Requested Services Reviw Ports' HEA calculation June 2023 – October 2023.
Seattle	4/11/2023	Calculator	Group work session
All	5/18/2023	Calculator	Seattle facility boat tour with Services
Both	7/10/2023	Proposed Activities	Liaison/Ports preconsultation meeting
Both	8/18/2023	Proposed Activities	Liaison/Ports preconsultation meeting
Both	8/22/2023	Calculator	Group work session
Both	9/8/2023	Proposed Activities	Liaison/Ports preconsultation meeting
Both	9/25/2023	Proposed Activities	Liaison/Ports preconsultation meeting
All	10/18/2023	Calculator	Group work session
All	11/14/2023	Proposed Activities	Pre-consultation coordination meeting with the Corps, NMFS, United States Fish and Wildlife Service (USFWS). Discussion of programmatic BE information needs and activities to include within the proposed action.
All	11/30/2023	Calculator	Group work session
Ports	12/8/2023	Proposed Activities	At USFWS suggestion, Ports provide draft BE project description and programmatic implementation sections for a courtesy review.
Ports	2/6/2024	Proposed Activities	Services send Ports comments on the draft project description, Ports incorporate into subsequent draft
All	3/7/2024	Calculator	Technical group meeting
All	3/14/2024	Calculator	Technical group meeting
All	3/20/2024	Calculator	Technical group meeting
All	4/10/2024	Calculator	Technical group meeting
Services	4/11/2024	Proposed Activities	Services send Ports comments on the draft project description, Ports incorporate into subsequent draft
Seattle	4/12/2024	Proposed Activities	Seattle pre-app meeting
Both	4/25/2024	Calculator	Technical group meeting
Both	5/5/2024	Proposed Activities	Services send Ports comments on the draft project description, Ports incorporate into final draft
All	5/7/2024	Calculator	Group work session
All	5/23/2024	Calculator	Technical group meeting
All	5/30/2024	Calculator	Technical group meeting
All	6/6/2024	Calculator	Technical group meeting
Ports & COE	6/6/2024	Proposed Activities	Ports submit individual BEs to Corps as part of Section 10 and Section 401 permit request Seattle tracking no: NWS-2024-311-WRD Tacoma tracking no: NWS-2024-446-WRD
All	6/13/2024	Calculator	Technical group meeting
All	6/27/2024	Calculator	Group work session
All & COE	7/18/2024	Proposed Activities	Services meet with Ports and Corps and request a revised consistent project description between the Port's BEs
All	7/18/2024	Calculator	Technical group meeting

Entity	Date	Topic	Consultation Activity
All	7/25/2024	Calculator	Technical group meeting
Tacoma	8/14/2024	Proposed Activities	FWS/Port of Tacoma waterway and habitat tour
All	8/15/2024	Calculator	Technical group meeting
Seattle	8/26/2024	Proposed Activities	FWS/Port of Seattle waterway tour
All	8/29/2024	Proposed Activities	Port of Tacoma submits additional information, including combined project description
All	9/5/2024	Calculator	Technical group meeting
All	9/19/2024	Calculator	Technical group meeting
All	9/26/2024	Calculator	Technical group meeting
COE	10/1/2024	Proposed Activities	Corps submits batch consultation request
Seattle	11/14/2024		Seattle submits Errata to project description
NMFS	12/12/2024	Calculator	NMFS advised Ports and USACE of additional rationale for calculator revisions on habitat values
ALL	12/12/24 – 1/30/25	Proposed action	Services, USACE, and Ports met weekly to refine project details such as best management practices, beneficial activities, sediment clean up etc.
NMFS & Tacoma	3/7/2025	Advance Mitigation	Field visit to verify existing habitat conditions at Place of Circling Waters advance mitigation site.
All	3/20/2025	Calculator	Ports proposed NMFS requested Calculator revisions as part of proposed action
All	4/8/2025	Calculator	Ports send Calculator Version 1.1 that includes the revisions agreed upon on 3/20/2025 (Appendix A)

This Opinion includes analysis of the Corps determinations with which we did not concur: NLAA on critical habitat for the PS Chinook salmon, PS steelhead, PDS/GB bocaccio, and SRKW; or with the NLAA on SRKW and humpback whales species.

Consultation was not requested for humpback whale critical habitat because the proposed action occurs outside of designated critical habitat for this species.

1.3. Proposed Federal Action

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

The United States Army Corps of Engineers (USACE) intends to issue permits under its CWA section 404, and Rivers and Harbors Act, Section 10 authorities to the Ports of Seattle and Tacoma. The Ports each propose at their respective facilities to conduct routine maintenance and repair and replacement activities of their infrastructure, offsetting beneficial activities, and scientific sampling. The issuance of a CWA or Rivers and Harbors Act permit represents a federal nexus, subject to review under Section 7 of the ESA. Each Corps permit would be active/viable for 10 years from the date of issuance. The maintenance/repair permits would broadly cover the Ports' routine maintenance, repair, replacement and/or removal activities within Waters of the United States. Activities are described in greater detail below, where each activity category outlined in full. Activities include the repair, replacement, and maintenance of piling, outfalls, bulkheads, fender systems, shoreline protection, utilities, maintenance dredging, sediment sampling, and habitat enhancement activities intended as mitigation over the 10-year time period. Proposed activities would be conducted within each Port's respective facilities. Assessments of impacts and benefits will include quantification using a calculator developed for ports-specific activities in the highly industrialized estuaries where these two ports exist. The use of this Port's Calculator is part of the proposed action, and this calculator is supported by a scientific rationale document (Appendix A) which was part of the consultation package. The Ports intend to generate conservation credits and utilize them across the term of the permits.

An extremely small number of projects is proposed in the freshwater portion of the Port of Seattle in the Lake Washington Ship Canal. The Port's Calculator is not designed with freshwater in mind and the ports propose offsets for those areas on a case-by-case basis.

NMFS has evaluated the Biological Evaluations (BEs) (Port of Seattle 2024; Port of Tacoma 2024a) and a subsequently combined description of the proposed action (Port of Tacoma 2024b) and other materials submitted for the initiation packages for each port's permit, and determined that they provide a comprehensive description of the proposed federal action.

Routine Maintenance and Repair Activities

The Port of Seattle (Seattle) and Port of Tacoma (Tacoma; collectively, the Ports) propose to conduct routine maintenance and repair activities at facilities with shoreline frontage in Seattle and Tacoma, Washington. The work proposed by the Ports consist of routine maintenance, repair, relocation, replacement and/or removal of its structures (e.g., piling, outfalls, bulkheads, fender systems, slope protection, etc.) and utilities (e.g., fire, water, storm, electrical, etc.), maintenance dredging, sediment sampling, and beneficial activities for the purposes of mitigation over a 10-year time period. The activities generally consist of maintenance and repair conducted within the existing footprint of the facility.

No new development, additional structures, or significantly[1] expanded footprints are part of the proposed activities. Best management practices (BMPs) and avoidance and minimization measures will be implemented to reduce, eliminate, or minimize the effects of the proposed action to listed species or their habitat.

Tables 2 and 3 summarize the proposed Program activities for each Port, and proposed quantity per year based on the respective Ports' anticipated maintenance and repair needs over the next 10 years. It is important to note that the exact number, size, and type of maintenance and repair needs in any given year is not known. The numbers provided are maximum estimates based on historical maintenance needs, along with inspections and engineering evaluations of structural conditions. Tables 1 and 2 also detail the in-water work timing, and the Port Calculator requirements for each activity that is expected to have long-term effects to habitat and species. Activities identified as "unlimited" are expected to have low likelihood of significant effect on species or critical habitat.

[1] Any expansion of overwater coverage associated with reconfigurations during replacements is limited to one percent over the life of the permit and proposed to be mitigated.

Table 2. Port of Seattle Activities

Activity (Replacement, Maintenance, and Repair)	Estimated Maximum Quantity (Annually)	Unit[1]	Submit PIF[2]	In-water Work Window[3]	Assessed in Port Calculator
Pile Replacement	400	EA	X	Zone 1 (marine): July 16 - February 15. Zone 2 (estuarine): October 1 - February 15 (for bull trout) Zone 3 (freshwater): October 1 - April 15[4]	X (structural pile only)
Pile Repair	Unlimited	EA	X	No restrictions if completed in the dry, otherwise subject to approved in-water work window above	
Pile Jacket Installation	15	EA	X	No restrictions if completed in the dry, otherwise subject to approved in-water work window above	
Fender Systems and Rub Strips	Unlimited	EA	X	No restrictions	
Cathodic Protection Systems	Unlimited	EA	X	No restrictions	
Marina Piers, Ramps (gangways), and Float Assemblages	5,000	SF	X	In-water work window	X
Boathouses, Covered Moorage	20,000	SF	X	No restrictions if completed in the dry, otherwise subject to approved in-water work window above	X
Overwater Safety and Security Equipment (platforms, ladders, fencing, etc.)	50	SF	X	No restrictions	X (new platforms only)
Shoreline Stabilization	1,600	LF	X	No restrictions if completed in the dry, otherwise subject to approved in-water work window above	X
Outfall & Tide gates[2] Cleaning/Maintenance	Unlimited	EA		No restrictions if completed in the dry, otherwise subject	

[2] In this proposed action, tide gates as part of Port infrastructure are stormwater outfall gate. Different from tide gates in agricultural settings, there is no upstream habitat that but for the stormwater outfall gate would be intertidal habitat.

Activity (Replacement, Maintenance, and Repair)	Estimated Maximum Quantity (Annually)	Unit[1]	Submit PIF[2]	In-water Work Window[3]	Assessed in Port Calculator
				to approved in-water work window above	
Outfall & Tide gates Replacement	15	EA	X	No restrictions if completed in the dry, otherwise subject to approved in-water work window above	X
Boat Ramps, Launches (incl. vessel hoists and marine rail track systems)	5,000	SF	X	No restrictions if completed in the dry, otherwise subject to approved in-water work window above	X
Vessel Berths (maintenance dredging)	30,000	CY	X	In-water work window	X
Geotechnical/Sediment Sampling	Unlimited	EA		No restrictions	
Under-Pier Utilities	Unlimited	LF		No restrictions	
Subtidal Utility Cable	Unlimited	LF/SF	X	In-water work window	
Navigational Aids	5	EA		No restrictions	
Bull Rails – Timber/Concrete	Unlimited	LF		No restrictions	
Bollards/Cleats/Walers/ Other Hardware	Unlimited	EA		No restrictions	
Existing Paved/Impervious Surfaces	9.2 acres	SF		No restrictions	X (if base course is replaced)
Crane Rails	Unlimited	EA		No restrictions	
Safety and Security Equipment (incl. fencing)	10	EA		No restrictions	
Navigation Lights	6	EA		No restrictions	
Light Poles	10	EA		No restrictions	
Utilities	Unlimited	EA		No restrictions	
Exterior Building Repair	Unlimited	EA		No restrictions	
Beneficial Pile Removal	Unlimited	EA	X	In-water work window	X
Alternative Bankline Stabilization including Soft and Hybrid Armoring	Unlimited	LF	X	No restrictions if completed in the dry, otherwise subject to approved in-water work window	X
Beneficial Debris Removal	Unlimited	SF	X	No restrictions if completed in the dry, otherwise subject to approved in-water work window	X

Activity (Replacement, Maintenance, and Repair)	Estimated Maximum Quantity (Annually)	Unit[1]	Submit PIF[2]	In-water Work Window[3]	Assessed in Port Calculator
Enhancement Pilot/Research Activities	Unlimited	N/A	X	No restrictions if completed in the dry, otherwise subject to approved in-water work window	

[1] EA = Each; SF = Square feet; LF = Linear feet; N/A = Not applicable

[2] PIF: Project Information Form

[3] The Port of Seattle will conduct in-water work within the approved in-water work windows. The USFWS, NMFS, and Washington Department of Fish and Wildlife (WDFW) set closure periods during which in-water work cannot be conducted to protect out-migrating salmonids. Specific work windows will be identified by WDFW Hydraulic Project Approvals for each project location and construction planned accordingly. Departures from these windows require minor alterations approval per section 1.3.4.

[4] Generally, IWWs are as follows: Zone 1 (marine): July 16 - February 15. Zone 2 (estuarine): October 1 - February 15 (for bull trout). Zone 3 (freshwater): October 1 - April 15. Floats and other prefabricated structures may be delivered and manually installed outside the regulated in-water work window.

Table 3. Port of Tacoma Activities

Activity (Replacement, Maintenance, and Repair)	Estimated Maximum Quantity (Annually)	Unit[1]	In-water Work Window[2]	Assessed in Port Calculator
Pile Replacement	200	EA	Yes	X (structural pile only)
Pile Jacket Installation	15	EA	Yes, unless in dry	
Pile Repair	Unlimited	EA	Yes, unless in dry	
Replace/Repair Minor Pile Accessories	Unlimited	EA	Yes, unless in dry	
Fender Systems and Rub Strips	Unlimited	EA	No	
Cathodic Protection Systems	2	EA	No	
Overwater Coverage Replace/Repair	25,000	SF	Yes	X
Safety Platforms	50	SF	No	X
Safety Ladders and Fencing	Unlimited	EA	No	

Activity (Replacement, Maintenance, and Repair)	Estimated Maximum Quantity (Annually)	Unit[1]	In-water Work Window[2]	Assessed in Port Calculator
Shoreline Stabilization Repair/Replacement	250	LF	Yes, unless in dry	X
Maintenance Dredging	30,000	CY	Yes	X
Outfall and Tide Gate Repair or Replacement	15	EA	Yes, unless in dry	X
Outfall and Tide Gate Cleaning/Maintenance	Unlimited	EA	No	
Boat Ramps	5000	SF	Yes, unless in dry	X
Geotechnical/Sediment Sampling	Unlimited	EA	No	
Navigational Aids	5	EA	No	
Under-Pier Utilities	Unlimited	EA	No	
Bollards/Cleats/Walers/ Berthing Hardware	Unlimited	EA	No	
Bull Rails	Unlimited	LF	No	
Crane Rails	Unlimited	LF	No	
Existing Paved/Impervious Surfaces	92 acres	SF	No	
Exterior Building Repair	Unlimited	EA	No	
Light Poles	10	EA	No	
Navigation Lights	6	EA	No	
Safety and Security Equipment (incl. fencing)	10	EA	No	
Utilities	Unlimited	EA	No	
Alternative Bankline Stabilization including Soft and Hybrid armoring	5,000	LF	Yes unless in dry	X

Activity (Replacement, Maintenance, and Repair)	Estimated Maximum Quantity (Annually)	Unit[1]	In-water Work Window[2]	Assessed in Port Calculator
Beneficial Overwater Structure Removal	Unlimited	SF	No	X
Beneficial Pile Removal	Unlimited	EA	Yes	X
Beneficial Debris Removal	Unlimited	SF	Yes unless in dry	X
Other Beneficial Activities	Unlimited	N/A	Yes unless in dry/approved by Services	X

[1] EA = Each; SF = Square feet; LF = Linear feet; N/A = Not applicable

[2] The Port of Tacoma will conduct in-water work within the approved in-water work windows. The USFWS, NMFS, and Washington Department of Fish and Wildlife (WDFW) set site specific closure periods during which in-water work cannot be conducted to protect out-migrating salmonids. Work windows will be identified for each project location and construction planned accordingly. Generally, the work window for Commencement Bay is July 15 to February 15.

Port of Seattle Pile General Information

Existing pile systems include approximately 36,000 piles of various sizes and material types in all three zones (marine, estuarine, freshwater). The Program will include repair and maintenance (including replacement) of structural, fender, dolphin, float, test, double-walled, and other types of piling ranging in size between 12-30 inches in diameter, and sheet piles in 24-32-inch sheets over the next 10 years. These estimates are considered to be maximum impact, for purposes of this evaluation; the actual number of piling replaced is likely much lower. Piles to be installed may include ammoniacal copper zinc arsenate (ACZA)-treated and untreated timber, concrete, and steel; piles to be removed may include those and creosote-treated timber piles; and piles to be repaired may include concrete piles and use of pile wraps.

- Approximately 75 percent of the piling that will be driven over a 10-year period will be fender piles and 25 percent will be structural piles.
- Fender piles are typically 18-inch diameter, but up to 20-inch diameter.
- Structural piles will be as large as 30-inch diameter.
- Replacement piles will be smaller than or equal to the original pile size or may be larger if code or engineering determines that larger pile size may result in a net reduction or not a significant[3] increase in pile footprint.
- Vibratory driving is anticipated to be sufficient to fully install 90 percent of the fender pilings and 75 percent of the structural pilings. Structural piles require impact driving

[3] No more than one percent over the life of the permit.

more frequently than fender piles due to their deeper embedment and load requirements. Structural piles will be proofed with an impact hammer to ensure proper installation.
- For purposes of this evaluation, of the maximum number of pilings anticipated to be replaced, an estimated 10 percent of the fender piles and 25 percent of the structural piles require impact driving for full embedment due to hard substrate conditions (e.g., glacial till); however, it is likely the actual number of piles required to be fully embedded by impact driving will be much lower.
- A maximum of 10 ACZA-treated timber piles may be replaced at any given time during the in-water work window. All ACZA-treated piles will be properly cured (per Western Wood Preservative Institute Standards); unwrapped ACZA-treated piles may be used to replace both creosote-treated and ACZA-treated timber piling <u>if concrete or steel piles cannot be used due to site specific engineering needs.</u>

In the Port of Seattle, free-standing sheet piles (e.g., breakwater) will be replaced as part of the Program. Sheet piles supporting upland areas (e.g., bulkhead) may be repaired or replaced in 24-32 inch-wide (one sheet) sections. Repair entails cleaning the area to be patched, then fitting and welding the steel plate patch to the existing sheet pile. Replacement entails driving a new sheet pile in front of or behind the existing sheet pile, then filling the space between the old and new with concrete. All concrete work will be conducted following appropriate BMPs for overwater concrete placement.

Port of Tacoma Pile General Information

Port engineers were consulted to characterize the anticipated number of piles to be replaced or repaired (Table 4):

- Port of Tacoma estimates that 75 percent of piles to be replaced will be timber structural or sacrificial fender piles (approximately 150 per year) and 25 percent will be concrete, steel, or steel sheet structural piles (approximately 50 per year combined); however, the percentage may change year-to-year as needed.
- Timber piles (typically Douglas fir) are tapered (not a uniform diameter for the whole length), so they may range from 8 to 24 inches in diameter based on the natural width of the tree. Timber piles will be installed with a vibratory hammer and may be proofed with an impact hammer.
- A maximum number of 1500 new ACZA-treated piles will be installed over the life of the 10-year permit with approximately 150 per year, and limited to no more than 15 new ACZA-treated piles per week at a single facility. Further, the Port proposes the continued use of properly cured (per Western Wood Preservative Institute Standards) ACZA treated wood, which is air dried for 4 weeks prior to rain exposure.
- Concrete piles will range from 12 to 24 inches in diameter. Concrete piles will be installed with an impact hammer only.
- A combined maximum number of 500 concrete, steel, and steel sheet piles will be installed over the life of the 10-year permit. Within that maximum number, it is proposed that approximately 50 steel piles (not to exceed 24” in diameter) will be installed and approximately 10 steel sheet piles (24-32” sheets) will be installed. Steel pilings may be used for dolphins.

Table 4. Port of Tacoma projected piling replacement over the course of the Program.

Types of Piles	Annually (for 10 years)	Overall Total
ACZA-Treated Timber structural/sacrificial fender piles	Approximately 150 piles per year.	1,500 maximum
Concrete/steel/sheet structural piles	Approximately 44 concrete piles, 5 steel piles and 1 sheet piles per year.	500 combined maximum of concrete, steel and, sheet piles
Total		**2,000**

Port engineers provided the following assumptions used to characterize the expected pile installation activities performed under this Program:

- A maximum of eight (8) piles can be installed in one day.
- Port of Seattle - Pile driving will be up to 16 hours per day. If work must occur beyond the 16-hour day, Port of Seattle will notify USACE and the Services prior to increasing the hours.
- Port of Tacoma - Typical pile driving days will be no longer than 12 hours to allow for a 12-hour quiet period. If work must occur beyond the 12-hour day, Port of Tacoma will notify the USACE and the Services prior to increasing the hours.
- Time to drive one steel or timber pile with a vibratory hammer is approximately 60 minutes.
- Impact driving is required for concrete pile installation, for proofing structural piling, and occasionally for timber or steel piling that encounter refusal due to hard substrate.
- Time to drive one concrete pile with an impact hammer is approximately 120 minutes, depending on substrate.
- Impact proofing of steel or timber structural piles require approximately 20 strikes per pile.
- If refusal is encountered and impact driving to reach embedment is required, full embedment is anticipated to require 300-400 strikes (to use a maximum impact scenario, 400 strikes will be assumed in this assessment).

1.3.1. Beneficial Activities for Offsets

Beneficial activities are those which provide an increase in habitat function and value. CMMP beneficial activities fall into two main categories:

- Integrating beneficial activities into a CMMP repair and maintenance action. Examples of this include reducing the overall footprint of a structure by removing portions of it; replacing solid surface decking with materials that allow light penetration; removing anthropogenic debris from the shoreline and/or seabed; or installing alternative shoreline stabilization features such as logs, root-wads, native plants, and topsoil lifts to improve habitat functions.
- Implementing stand-alone beneficial activities as part of the CMMP, such as removal of structures, fill, rip-rap, bulkheads, and creosote-treated piles (see more details below).

Both types of beneficial activities will be assessed/quantified by the Port Calculator. These activities may occur anywhere in saltwater within the South-Central Puget Sound service area[4] and preferably, to keep impact and benefit in close proximity in Commencement Bay and Elliott Bay.

The Ports will calculate the credits generated by these beneficial activities, include them in the ledger, and use them as offsets for activities that require mitigation as detailed in the Credit Savings Instruments for both Ports (Appendix B).

Specific habitat improvement activities that may be undertaken include, but are not limited to:

- minor maintenance of existing restoration site access infrastructure (i.e., access bridges, walkways, etc.) in the restoration sites (i.e., Gog-le-hi-te, Clear Creek, Lower Wapato Creek, Place of Circling Waters) along the creeks and rivers upstream of Commencement Bay
- In or overwater structure removal
    - Removal of existing over-water structures or piles
    - Removal of distinct portions of over-water structures that can be removed without affecting the structural integrity of the remaining structure (for example one float of a multi float complex)
    - Removal of creosote
- Softening shoreline stabilization
    - Removal of hard shoreline armoring including replacement of hard armoring with soft and hybrid approaches
    - Partial removal of shoreline armoring where a pocket beach is incorporated
    - Ports will identify bankline/shoreline areas that are at risk of failure (i.e., require repair and maintenance actions). The Ports will perform "asset condition assessments" and maintenance needs will be identified. Once at-risk or failing banklines are identified, the Ports will analyze and evaluate repair options and potential for enhancement, ranging from in-kind replacement of hard armor to replacement with alternative nature-based techniques.
    - The Port of Seattle will utilize the Shoreline Stabilization Decision Flowchart (see Appendix C of this document) to prioritize alternative shoreline stabilization techniques over the use of hard armor and to ensure compliance with local, state, and federal standards.
- Debris or derelict vessels removal
    - Debris removal can include physically removing chunks of concrete, metal, tires, asphalt, broken creosote timber, large pieces of HDPE or other forms of plastic, broken Styrofoam floats, etc. dispersed along the shoreline and transporting them to upland facilities for disposal.
    - Derelict vessels removal is a similar process for abandoned vehicles (i.e., boats).

[4] A service area is the geographic area in which conservation offsets can be traded to balance the loss of salmonid resource functions. A description of the South-Central Service Area can be found in Ehinger et al. 2025 Puget Sound Nearshore Habitat Calculator User Guide which is available on NOAA's Nearshore web page; and in Ehinger et al. 2023. The Puget Sound Nearshore Habitat Conservation Calculator. Draft Report.

    - Derelict vessel removal will include an assessment if fuels require specific handling prior to removal.

An unlimited amount of removal of piles, overwater structure, shoreline armor, and creosote removal is proposed.

- Other enhancement activities may include
    - minor planting
    - beach nourishment
    - restoration activities or studies to enhance habitat function (e.g., floating wetlands). The Port recognizes that not all proposed scientific studies and/or experimental habitat restoration will qualify for offsetting credits, and the Services will review potential credit generating activities on a case-by-case basis. The Port will work with regulatory agencies, including the Services, to formulate and implement enhancement activities/studies that they expect to generate credit.
    - Release of credit for other enhancement activities is dependent upon the submittal of a Habitat Improvement Plan (HIP) and achievement of performance monitoring objectives as further described in Appendix B and Section 2.4.6.
    - repair and maintenance of existing habitat restoration/scientific study sites or equipment5.
    - remediation of contaminated soil or sediment, outside of NRDA, Model Toxics Control Act (MTCA) or CERCLA. These are proposed in-water during the in-water work window, or in nearby uplands. These activities would remove or isolate contaminants found in soils, sediments, or groundwater so that they cannot interact with ESA listed species or their prey.

The Services will evaluate potential credit generating activities on a case-by-case basis as described in Appendix B. If credits are generated in excess of those necessary to offset in any year of the permit, the credit savings instrument for each Port (Appendix B) will govern the use of those credits during the term of the permit and at the end of the 10-year permit term.

1.3.2. General Avoidance, Minimization, and Best Management Practices

We summarize here key elements of the proposed avoidance and minimization measures and best management practices (the full list of activities and BMPs per activity type is found in the Combined Proposed Action).

General Avoidance:

Routine maintenance work will not expand the existing footprints of the existing structure/facility/development.

[5] For example, the Port of Seattle has several ongoing and planned studies to enhance habitat function (e.g., floating wetlands) or address data gaps in scientific literature (e.g., Smith Cove blue carbon). Some of these ongoing studies require repair and maintenance of equipment (e.g., “Octopot” transects, floating wetland platforms, etc.) to ensure their continued function and benefit

General Minimization:

Redevelopment will be designed to:

- Reduce overwater footprint (e.g., less overwater structure, fewer support pile)
- Reduce footprint of structures
- Increase grating in decking

Generally Applicable Best Management Practices:

In Water Work - Both Ports will adhere to applicable in-water work windows for salmonids for all routine/planned maintenance and repairs.

- For Seattle, the window is July 2 through March 2 in saltwater areas of Tidal Reference Area 5 (Seattle); October 1 through April 15 in the Lake Washington Ship Canal.
- Tacoma is subject to the WDFW-approved in-water work window for Commencement Bay (July 16–February 15 of each year).

The USACE also intends to conditions its permits with the following special condition:

> *Forage fish may be spawning in the project area during the allowed work window. If work is occurring outside approved in-water work windows, in order to meet the requirements of the Endangered Species Act and for the protection of Pacific herring, sand lance, and surf smelt, prior to construction, you must have an approved biologist confirm, in writing, that no forage fish are spawning in the area. For information on approved biologists for conducting forage fish surveys, contact the Washington Department of Fish and Wildlife (WDFW). If a WDFW Habitat Biologist has volunteered to conduct a survey as part of the Hydraulic Project Approval, this survey may be submitted to the U.S. Army Corps of Engineers (Corps). The letter or memorandum from the approved biologist or the WDFW Habitat Biologist must include the date of the inspection, the forage fish spawning findings, and must be provided to the Corps, Seattle District, Regulatory Branch, FAX (206) 764-6602 (or via email to LeeAnn.W.Simmons@usace.army.mil), prior to construction. Address the letter or memorandum to LeeAnn Simmons and include reference number NWS-2024-311-WRD or NWS-2024-446-WRD. If the approved biologist or WDFW Habitat Biologist confirms that no forage fish are spawning in the project area, you have two weeks from the date of the inspection to complete all work below Mean High Water OR High Tide Line.*

Pile Driving: Both Ports will utilize vibratory pile driving to the fullest extent possible in order to avoid or minimize impact driving. Each port will comply with its Marine Mammal Monitoring Plan (MMMP). The Port of Seattle will implement a MMMP during pile installation and removal in "Zone 1[6]." The Port of Tacoma's MMMP will be implemented to avoid impacts to ESA-listed marine mammals during pile activities at the following sites:

- During vibratory pile removal or installation at West Sitcum Terminal, East Sitcum Terminal, Terminal 7, Husky Terminal, WUT, Blair Dock, Parcel 115, TOTE, and Trident Piers 24 and 25 (Sites 1-6 and 9-11), the area within 120 dBRMS zone of ensonification will be monitored.
- During steel impact pile proofing or installation at Trident Piers 24 and 25, the area within 160 dBRMS zone of ensonification will be monitored and maintained as a marine mammal buffer area.

<u>Stormwater:</u> Both Ports have Stormwater Management Plans that will be adhered to. Each has specific BMPs in their respective Stormwater Management Plans.

Stormwater effluent will be managed under the Port's Stormwater Management Program. Stormwater construction BMPs apply to all construction activities included as part of the proposed action[7]. Activities will be performed in accordance with the applicable existing NPDES, MS4, and ISGP stormwater permits using BMPs described in the Port's Stormwater Management Program Plan (SWMP; 2024) and Stormwater BMP Playbook (2021), which meet or exceed the minimum requirements outlined in Ecology's Stormwater Manual for Western Washington (Stormwater Manual; Ecology 2019). These documents detail the operational and structural BMPs to be implemented during construction, post-construction, operations and maintenance, and/or source control, that have been designed to meet or exceed applicable treatment benchmarks and reduce non-point pollution in runoff.

1.3.3. Activity Specific Best Management Practices

BMPs for Pile Systems

<u>The following project design BMPs will be applied to all pile work</u>:

- Piling will be replaced in same general location as the existing pile, and pile will not extend beyond the footprint of existing structures.
- Piles will not be placed within 25 feet of sites designated by WDFW as suitable for forage fish spawning (WDFW 2022a).
- No pile will be installed in or within 25 feet of any eelgrass beds and barges will not anchor over any eelgrass beds.

Additional BMPs listed below will be applied to each specified pile systems activity type as appropriate.

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[6] Zone 1 contains portions of Puget Sound and Greater Elliott Bay, including East and West Waterways.
[7] The following actions do not require any post-construction stormwater management: 1. Removing marine debris or marine life from existing outfalls, 2. Replacing outfall flap gates or flow control devices, 3. Minor repairs or non-structural pavement preservation, such as installation or repair of guard rails, patching, chip seal, grind/inlay, overlay; removal or plugging of scuppers in a way that benefits stormwater treatment.

Pile Removal/Installation Water Quality Measures

- Pile repair and replacement activities in or within 25 feet of an existing or previously designated Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Washington State Model Toxics Control Act (MTCA) site, will follow BMPs established by the USEPA during CERCLA coordination or by Washington State Department of Ecology (Ecology) during MTCA coordination.
- The Ports' contract specifications for pile removal and disposal will incorporate the highly protective Best Management Practices for Pile Removal and Placement in Washington State (2016) promulgated by the EPA, or most recent revision thereof.
- No piling treated with creosote, pentachloraphenol, or coal tar will be used. The Program will result in a significant net reduction of creosote-treated timber piling.
- Vegetable-based hydraulic fluid will be used in pile driving equipment.
- A boom will be installed around the work area prior to removal of the timber piling and related structures to contain and collect debris. Debris will be disposed of at an approved upland location.
- Hydraulic water jets will not be used to remove or place piling.
- All treated wood as defined by the Western Wood Preservers Institute (WWPI 2012), will be contained on land or on barges during removal. Treated wood placed on barges during removal will be transferred to land after removal to preclude sediments and any contaminated material from re-entering the aquatic environment.
- If treated piling are fully extracted or cut below the mudline, the holes or piles will be capped with appropriate materials (e.g., clean sand for cut piles). This practice ensures that chemicals from existing piling do not leach into the adjacent sediments or water column.
- Piling will be replaced in same general location, and piling will not extend beyond the footprint of existing structure.
- Piling will be removed slowly to minimize sediment disturbance and turbidity in the water column.
- Prior to extraction the operator will "wake up" the pile to break bond with sediment to break the friction between the pile and substrate to minimize sediment disturbance.
- The work surface on the barge deck or pier will include a containment basin for piling and any sediment removed during pulling. Any sediment collected in the containment basin will be disposed of at an appropriate upland facility, as will all components of the basin (e.g., straw bales, geotextile fabric) and all piling that has been removed.
- Upon removal from the substrate, piling shall be moved expeditiously from the water into a containment basin. Piling will not be shaken, hosed-off, stripped or scraped off, left hanging to drip, or any other action intended to clean or remove adhering material from the pile.
- If a creosote piling is fully extracted or cut below the mudline, holes or piling will be capped with clean sand for cut piling. This practice ensures that chemicals from existing piling do not leach into the adjacent sediments or water column.
- ACZA-treated timber piles will not be wrapped. Please see BMPs specific to Pile Repair, later in section 1.3.3.

- All ACZA-treated timber fender piling will be fitted with an approved rub strip(s) in a manner that prevents direct contact with vessels, vessel bumpers, and piling. The rub strips will be composed of UHMW or HDPE plastic.
- Removed creosote-treated pile piling will be disposed of in a manner that precludes their further use. Piles will be cut into manageable lengths (4 feet or less) for transport and disposal in an approved upland location that meets the liner and leachate standards contained in the Washington Administrative Code (WAC), Chapter 173-304, Minimum Functional Standards, and that complies with the ESA. No reuse of treated wood will occur.
- If a pile breaks above the surface of uncontaminated sediment, or less than 2 feet below the surface, all measures to remove it entirely will be made, short of excavation. If the pile cannot be removed without excavating it, it may be driven deeper.
- If a pile in contaminated sediment is intractable or breaks above the surface of contaminated sediment, the pile or stump will be cut off at the sediment line.

Pile Removal/Installation Noise Abatement

- Vibratory hammer installation is the preferred method to minimize the generation of potentially injurious sound. Impact pile driving will be limited to concrete pile installation, proofing of structural pile piling, and driving if refusal is met.
- Noise attenuation measures will be employed for impact-driving of all steel piling. When using an impact hammer to drive or proof a steel pile, an appropriate attenuation device will be used, when applicable. If a bubble curtain is used, it will be monitored to ensure it is properly installed and attenuating underwater noise as designed.
- In intertidal areas, piling will be driven during periods of low tide when substrates are exposed.
- Maps and analysis of potential noise effects zones during construction, as well as marine mammal monitoring plans for both ports are included in Appendix D (Seattle) and Appendix E (Tacoma), respectively. Tacoma's noise analysis document does not describe effects to fish, however in-depth analysis of noise effects on all species is included in the effects analysis below.
- A marine mammal monitoring plan (MMMP) will be implemented to avoid impacts to ESA-listed marine mammals during pile removal or installation that produces underwater noise within the range known to cause 'disturbance' of cetaceans. Detailed MMMPs are included as Appendices D and E. Briefly, qualified biologists will be stationed at appropriate points to ensure that work is stopped if listed cetaceans enter the mapped disturbance threshold. Monitoring areas are site-dependent and based on the pile size, material, and driving method. Some sites will not require formal monitoring; however, the Ports will ensure the contractor is aware of marine mammals that may be present near the Action Area through contract documents.

Pile Repair BMPs

- Pile cleaning in preparation for pile jackets will be limited to physical cleaning, or use of cleaning agents approved   for in-water work.

- Cleaning is anticipated to occur primarily by hand with a stiff brush or other physical scraping methods. Power tools may also be used.
- If used for cleaning, a pressure washer will be a minimum of 5 feet from the bottom. The nozzle will be angled up in the water column away from bottom sediment to minimize the potential for mobilization of sediments.
- Only products designed for underwater/aquatic use will be used; materials (e.g., primer paste, petrolatum tape) are insoluble solids and will not form a solution with the water.
- The contractor will be required to capture any anthropogenic debris associated with project activities.
- At the Port of Seattle, fewer than 10 ACZA treated wood piles will be replaced at any given time during the in-water work window. Port of Tacoma proposes to install a maximum number of 150 new ACZA-treated piles per year, but not install more than 15 new ACZA-treated piles per week at a single facility. The Ports propose the continued use of properly cured (per Western Wood Preservative Institute Standards) ACZA treated wood, which is air dried for four weeks prior to rain exposure.

BMPs for Overwater Structures

- The Ports will evaluate if replacement of solid-surface float structures with systems that include grated decking to maximize light penetration can be incorporated and will include grated decking whenever engineering design load determines it is suitable.
- Minimize the total size (area) of coverage or linear feet of the structure.
- No significant increase (no more than one percent over the life of the permit) in total overwater coverage will occur.
- Workers will operate a vacuum while using power tools to cut decking, capture falling debris with floats or tarps as conditions allow, and/or skim any debris that may escape to minimize impacts to the waterbody.
- For Port of Seattle boathouse and covered moorage work, all work will be performed above water and use a containment system built off the existing floats to prevent construction debris from entering the water.
- Minimize impacts to submerged aquatic vegetation (SAV).
    - Delineate SAV for the project area within 25 feet of proposed structures that are located with mapped eelgrass and kelp habitat areas per DNR's SAV Monitoring Program.
    - Floating structures will never "ground out" on the substrate, and stoppers/pin piles/feet will hold the structure at least 12 inches above the substrate.
    - If SAV is present within 25 feet of the proposed float, the bottom side of the float must be elevated at least 4 feet above the substrate at low tide to reduce prop scour impacts on SAV.

BMPs for Maintenance Dredging

At both Ports, dredging will be accomplished using mechanical dredging equipment; no hydraulic dredging is proposed. The Ports propose to allow contractors to use a clamshell bucket (or similar) or an enclosed environmental bucket, depending on the specific location conditions and sediment characteristics. Work will generally occur from barges. Barges will be moored over subtidal substrate avoiding grounding.

The Ports will implement the following BMPs to reduce, eliminate, or minimize the effects of the proposed action to listed species or their habitat:

- Dredging will only remove targeted material to maintain the authorized, permitted, or previously dredged depths.
- No dredging will occur in sand lance, surf smelt, or herring spawning beds.
- No dredging will occur in areas with seagrass or kelp.
- The Ports will require the contractor to utilize real-time positioning control when implementing dredging operations. Only clamshell dredges will be used. Hydraulic dredges will not.
- The dredging contractor will not take multiple "bites" during a single clamshell cycle. When the clamshell bucket hits the bottom, it will close and be raised to the surface for disposal.
- The dredging contractor will not stockpile material on the bottom.
- The clamshell bucket will fully close and move through the water column carefully. When dredging contaminated material, the contractor will use a smooth-edged clamshell (environmental bucket). Other material will be removed with a toothed production bucket.
- If water quality exceedances occur beyond the compliance level and distance per Ecology's water quality certification, the dredging contractor will stop dredging immediately until turbidity falls below the WAC, then institute and maintain additional turbidity management BMPs to meet water quality requirement.
- Dredged material will be disposed of at an approved in-water disposal site per DMMO requirements or in an approved location.
- The barge used to transport dredged material to the disposal site will have tightly sealing doors and compartments and have minimal leakage during transit.
- Work will generally occur from barges. Barges will be moored over subtidal substrate avoiding grounding. No vegetated shallows exist within the vicinity of maintenance dredging.
- An oil-absorbing floating boom, appropriate for the size of the work area, will be available on site whenever dredging equipment is operated. The boom will be stored in a location that facilitates its immediate deployment in the event of a spill.

The following BMPs will be employed to avoid and limit potential environmental impacts of dredging and backfilling activities:

- Based on the results of water quality monitoring, additional operational controls may be applied to dredging operations, as required to meet water quality standards, including:
    - Increasing cycle time: A longer cycle time reduces the velocity of the ascending bucket through the water column, which reduces potential to wash sediment from the bucket.
- Operational controls will be applied to the return water from hopper and haul barges, including:

- Increasing barge retention time: Increasing the duration of time that water is held in the barge prior to discharge will reduce the turbidity of the return water.
    - Dredged material will be placed on a barge for transportation to an upland or open water disposal site. If water must be decanted from the barge, it will be filtered through straw bales or similar.
    - Eliminating barge overflow: Eliminating or reducing barge overflow reduces the volume of fine material that flows from the barge.
- Backfill, if required, will typically consist of sands and gravel material up to 2-inch minus with less than 5% of the sand fraction passing the 200 sieve.
- If sediment is temporarily stockpiled in the upland, the offloading site will include drainage and temporary erosion and sedimentation controls, such as spill plates and jersey barriers, to prevent uncontrolled release of sediment or effluent discharge to aquatic areas or upland areas.
- Water quality BMPs associated with backfill placement are the same as those identified for dredging.

BMPs for Outfalls and Tide Gates

Seattle's stormwater system consists of approximately 223 outfalls that discharge into several USACE jurisdictional waterbodies throughout Zones 1-3; in Tacoma, the stormwater system consists of approximately 161 outfalls that discharge into USACE jurisdictional waterbodies located throughout the Tacoma Tideflats. Approximately 28 Seattle and 32 Tacoma outfalls have tide gates installed to prevent tidal waters from entering the storm system.

Maintenance activities include removing marine growth (e.g., barnacles, mussels, algae, etc.) and other debris from the outfall structure, the stormwater pipe, the tide gate, and/or the spillway using hand tools. For repairs, generally, no heavy construction equipment will be required; however, in some cases, a crane or excavator will be required to lift a tide gate into place, lift and place pipe sections, and/or to remove and replace riprap. Work will be conducted in-the-dry e.g., during periods of low tide when the outfall structure is exposed.

The Ports will implement the following BMPs for outfall and tide gate maintenance, repair, and installation:

- Work will be conducted in-the-dry during periods of low tide when the outfall structure is exposed.
- If a mobile crane is required, it will operate from previously developed upland areas above MHHW, with paved, graveled or compacted soils.
- No dragging, digging, dredging, demolition, grading, or filling of sediment or shoreline soils will occur as part of this project.
- During entrance and egress from a work site, equipment and material will not be dragged through shoreline sediment.
- Tarps will be used to collect rust, dirt, debris and any other foreign material (including in-line sediment) from the work site, and all collected material will be removed from the site and disposed as solid waste.

BMPs for Boat Ramps and Launches

- Precast concrete will be used for replacements.
- If uncured concrete must be used, it will not be allowed to come into contact with surface water and will be allowed to cure a minimum of 7 days before contact with surface water.
- Whenever possible, the contractor will perform work in the dry. This will include phasing work to isolate construction areas from the aquatic environment and scheduling work for periods of tidal exposure during low tides.
- The contractor will comply with water quality restrictions imposed by Ecology and implement corrective measures if temporary water quality standards are exceeded.
- The contractor will be required to capture any debris associated with construction and not allow it to enter waters.
- Excess or waste materials will not be disposed of or abandoned waterward of MHHW or allowed to enter waters of the state.
- Concrete ramps must use pre-cast concrete slabs below HTL, although the slabs may be cast-in-place if completed in the dry.
- The extent, size, and amount of rock used to prevent scouring, down-cutting, or failure at the boat ramp will be determined by a professional engineer.
- For elevated boat ramps, debris will be removed from under the boat ramp for the life of the project. While man-made debris (e.g., Styrofoam, fishing line, etc.) should be disposed of properly in an upland location, organic material, including wood and marine algae, will be moved to the beach down drift of the structure.

BMPs for Shoreline Stabilization

- No increase in coverage of riprap will occur below the HTL.
- In intertidal areas, material will be placed in-the-dry during low tide periods in order to minimize shoreline impacts.
- Instead of a traditional “hard armoring” bulkheads (concrete, steel, rock), soft-shore or hybrid armoring will be used. Rock bulkheads will be sloped landward and incorporate native woody plantings.
- A cofferdam system may be used during sheet pile bulkhead coating repairs below MLLW, if there are outfalls or utility vaults in the vicinity, or to remove tidal dependence from repairs. The cofferdam will either extend down to mudline or be hung off the side of the existing bulkhead and contain an interior floor. Cofferdamming would include fish exclusion. No more than five occasions of cofferdamming are expected during the course of the 10-year permit.

BMPs for Sediment Sampling

The Ports will implement the following BMPs for geotechnical and sediment sampling:

- During sampling design, consult utility location resources to avoid disturbing buried utilities. Resources may include internal utility map layers, public utility data map layers, and/or public utility locate services. Maps of any buried utilities should be on board the sampling vessel to aid field adjustment of sample locations.
- Follow USEPA, Dredged Material Management Office, and Ecology guidance for the disposal of excess sediment material.
- Limit re-suspension of sediments during sampling activities.
- If hydraulic fluid or waste is visible in water, make all possible efforts to contain the spill and promptly execute cleanup action.

BMPs for Beneficial Activities

Work windows are applicable for in-water activity. Sediment control measures, equipment cleaning and staging area applicable for upland activity.

BMPs for removal of debris and derelict vessels include the following:

- Removal would occur using hand tools and/or machinery staged from either the uplands or from a floating barge with appropriate turbidity controls and construction BMPs in place.
- All efforts will be made to have the least impact on the surrounding substrate during removal.
- Removal would take place in-the-dry if debris is at an elevation where it is exposed during low tide.
- Collected debris will be calculated by square foot.
- All equipment that will operate over water or below high tide line (HTL) will be cleaned of accumulated grease, oil, or mud. All leaks will be repaired prior to arriving on site. Equipment will be inspected daily for leaks, accumulations of grease, etc., and any identified problems will be fixed before operating over water or below the HTL.
- No stockpiling or staging of materials will occur below the HTL of any waterbody.
- Excess or waste materials will not be disposed of or abandoned waterward of the HTL or allowed to enter waterbodies. Waste materials will be disposed of at an approved facility.
- Fuel, oil, and other toxic materials will be removed from sunken vessels prior to being moved or removed and transported according to state and federal regulations to an approved hazardous waste disposal facility.
- Install a containment boom and floating silt curtain around the vessel to contain any debris, turbidity, and remnant oils.
- Use a crane barge or lift bags to lift and remove the sunken vessel; lifting slings will be placed around the vessel and pumps will dewater the vessel while it is lifting.
- In-water work must be conducted during daylight hours.
- Intact vessels will be brought to shore and dismantled on land, per environmental regulations, and the pieces will either be recycled or disposed of at an approved landfill.

- If the process of removing a derelict vessel will damage habitat more than its presence, the derelict vessel will not be removed, or the derelict vessel may not be removed in its entirety.
- Photos and/or a map of the locations and sizes of vessels should be provided to the Corps PM.

1.3.4. Minor Alterations

The proposed action includes *minor* alterations to project activities, to avoidance and minimization methods, or to best management practices described in this program, in circumstances where:

- it is infeasible or impracticable to conform with the specifications laid out above; and/or
- if best available science supports an altered approach; and/or
- if the minor alteration was requested by Tribes for consistency with Tribal treaty agreements or cultural resource needs; and/or
- if the work is urgently needed to address unforeseen damage or loss of equipment or infrastructure;

and, provided the minor alteration is consistent with the overall parameters and purpose of the proposed action.

Minor alterations are limited to alterations that are very small in scope or scale, and do not represent a significant change to what is otherwise set out in this proposed action. For example, minor alterations to locations are limited to alternate locations that are proximate to and/or have similar habitat features to those specified in the proposed action; minor alterations to timing are those that are very small relative to the overall temporal scope specified in the proposed action; minor alterations to materials or methods are limited to alternate materials or methods that are similar in function and/or characteristics; and, minor alterations to the size of a proposed work are those that are very small relative to the overall scale of the work.

Minor alterations might include changes such as the following:

- Using newly-developed material or methods other than those specified in the proposed action, where best available science shows the new material or method to have reduced effects on species and habitat.
- Alternate location for equipment, refueling, and staging due to topographical or other site-specific constraints with appropriate additional avoidance and minimization measures.
  Maximum 2 weeks exceedance of the IWWW with added marine mammal and fish monitoring as needed.
  Minor in- or overwater work outside of the specified in-water work window for the purposes of relocation/moving/staging of construction equipment. For example: equipment transportation and staging, relocating or reconfiguring floats or access points. The objective of this work is to efficiently prepare for the main construction work such that the main work can occur in the limited IWWW. None of the minor

relocation/moving/staging will include pile driving or temporarily increase overwater cover over the one percent proposed.

- Repair or replacement of infrastructure damaged or loss due to unanticipated circumstances for a maximum period of 72 hours outside of the standard IWWW, which work will incorporate protective measures such as bubble curtain, sediment curtain, and marine mammal monitoring/stop work protocols (see Appendices D and E).

The Port will submit all Minor Alteration requests to the Services and the USACE detailing how the requested alteration meets the criteria laid out above. The Services need to verify that the request does meet the minor alteration criteria, and may request additional clarifying information, if needed. Alterations exceeding the criteria above and not verified by the Services are not covered by this consultation and the Ports will submit those for separate section 7 consultation.

1.3.5. Program Administration

The proposed action is intended to result in no-net loss of nearshore habitat.

Offsetting Strategy

The Port Calculator will be run for the maintenance and repair activities indicated in Table 2 and Table 3 during the design phase to inform project design to avoid or minimize adverse effects. Where the Port can demonstrate that mitigation in perpetuity was provided for maintenance of an existing facility, no additional mitigation will be required for maintenance of that facility.

Any unavoidable adverse long-term effects on nearshore habitat from the proposed activities will be calculated as conservation debits and offset with a proportional amount of conservation credits. A Compensatory Mitigation Credit Scheme has been developed to achieve this goal. We describe the details of that Scheme in the Credit Savings Instrument, see Appendix B. In summary, post-project Calculators will be used to ledger credits over the year. At the end of each Program year, the Reporting Form/Ledger (Appendix G) will be reconciled by rolling remaining credits forward to the next year's ledger, or by canceling out debits with credits from any of the credit generating activities described in section III.A. of the Credit Savings Instrument. Debits accrued during any one fiscal year of the CMMP must be offset by conservation debits during that fiscal year or within the subsequent two fiscal years. The Instruments prohibits double-counting of credits and includes limitations of use of CMMP credits during and after the term of the CMMP.

The Ports intend to focus on providing offsets through beneficial elements incorporated into project design, supplemented by performing the mitigation actions described in the Credit Savings Instrument. . Details on each Port's currently-available sites are provided in the following subsections.

Seattle

If a project or activity performed as part of the proposed action results in a debit, Seattle has identified several sites that have legacy structures that can be removed and/or can be restored/enhanced to provide offsetting mitigation credits. These sites are applicant-responsible sites within the south-central service area and the Elliot Bay project area, and include but are not limited to:

- Jack Block Park pier (legacy structures and habitat enhancement)
- North end of Terminal 5 (legacy structures)
- Pier 34 (legacy structures)
- Terminal 108 (legacy structures)
- Terminal 115 (legacy structures)
- Debris removal at facilities, as it is identified during individual project design

In addition to the sites listed above, as described in Section 1.3.3 and Appendix B, Seattle will assess if a failing bankline is a candidate for alternative shoreline stabilization. The "softening" of a shoreline using nature-based solutions results in habitat benefits as well as prevents erosion. The Port anticipates these projects will provide a habitat benefit greater than what is required to offset the impact. The Port Calculator will estimate the number of credits generated from removing hard armor from the environment, and these credits will be added to the ledger to provide offsets to projects or activities that may result in a debit.

Port of Seattle is in the process of certifying a joint Clean Water Act and ESA mitigation bank for aquatic resources in the Green-Duwamish watershed. Once certified by the Corps and NMFS, Seattle may use credits from its Green-Duwamish mitigation bank if additional conservation offsets are needed to balance the ledger. To ensure that credits from the Green-Duwamish bank are available to balance the ledger if needed, the Port of Seattle proposes to reserve (not sell) some bank credits for the 10-year duration of the Comprehensive Repair and Maintenance Programs.

Tacoma

Tacoma currently has two approved sources of credits:

- The Upper Clear Creek Mitigation Bank is a 40-acre site that provides approximately 10.5 wetland acre credits and 273.16 DSAYs. The site reconnected channelized Clear Creek to its floodplain, created and improved wetlands, reestablished Clear Creek near its original channel with two braids and created off-channel rearing ponds. That site has documented use by several types of salmonids including both hatchery and wild PS Chinook salmon. This site is certified as a joint bank for 404 and ESA mitigation. NMFS is a signatory to the Mitigation Banking Agreement and has consulted on the mitigation bank.[8]
- The Place of Circling Waters is a 30-acre combined compensatory mitigation area that includes 9.72 acres at an Advance Compensatory Mitigation ("ACM") site. Of these advance credits, the joint ledger shows at the time of this consultation availability of 3.02

[8] https://ecology.wa.gov/Water-Shorelines/Wetlands/Mitigation/Wetland-mitigation-banking/Mitigation-bank-projects/Port-of-Tacoma (Upper Clear Creek Mitigation Bank Mitigation Banking Instrument February 2000; WCR 2020-00550)

wetland acre credits and 110.395 discounted service acre years [DSAYs])[9] built on Hylebos Creek. The Place of Circling Waters ACM site was created in 2011 to provide an ecologically beneficial mitigation site that could be used to offset impacts from future Port projects. Habitat restoration activities include creation of saltwater tidal marsh, creation of open water channels, creation of a Category I estuarine intertidal wetland habitat, creation of upland riparian habitat, and removal of invasive species.

Calculating Impacts

Habitat impacts and improvements resulting from the Program will be calculated, using a calculator developed specifically for maintenance and repair activities in highly developed estuaries, or, where that is not possible, by an individual credit assessment conducted or approved by NMFS. The Port Calculator is based on the Habitat Equivalency Analysis (HEA) model. HEA models have been widely accepted for decades and for multiple applications including National Resource Damage Assessment (NRDA) liability, restoration projects, and ESA consultations. The HEA model assesses impacts (net ecological loss) and/or benefits (net ecological gain). HEA models calculate a service-to-service ecological equivalency and assign habitat values to baseline and post-project conditions. The change in values from baseline to post-project condition calculates credits or debits resulting from the project. These models are suitable tools for Port projects for a variety of reasons:

- They can use an ecosystem approach to account for impacts to multiple ESA-listed species, including salmonids, groundfish, and avian species.
- They can accurately reflect baseline conditions.
- Because of the more general descriptive nature of the inputs, they can accommodate larger, more complex projects.
- The format of entering baseline habitat conditions and post-project habitat conditions allows for accounting of a wide range of activities often undertaken by ports, including cleanup/beneficial projects, as well as redevelopment projects.
- They are geographically-specific—the table of values is based on local conditions and how protected species use that habitat.

The Port Calculator is built based on quantification of the concepts outlined in the Army and NOAA Joint Resolution Memorandum for Evaluating the Effects of Projects Involving Existing Structures in Endangered Species Act Section 7 Consultations (2022) also considering components of the Nearshore Habitat Values Model (NHVM), the NMFS Nearshore Habitat Calculator, the best available science, best professional judgement, and feedback from the Services. The Port Calculator modifies the traditional HEAs and the NMFS Nearshore Habitat Calculator by:

- Expanding habitat zone inputs to accurately describe habitat conditions (both baseline and post-project) in a highly modified port environment.

[9] Based on Grette Associates 2013. Technical Memorandum Port of Tacoma Place of Circling Waters Advanced Compensation Mitigation Area Habitat Equivalency Analysis Methods, NOAA review included an updated credit ledger (Appendix B).

- Calculating the different impacts to three ESA-listed species (Chinook, bull trout, Marbled Murrelets) and selecting the species that experiences maximum impact, as requested by the Services which results in a model that considers many aspects of the entire ecosystem.
- Recognizing that industrial structures are built to last longer than residential structures.
- Accounting for the enduring effects associated with maintaining these industrial structures, while also acknowledging that without routine maintenance the site potential for habitat within a port environment is limited and will never revert to a pre-development condition without significant restoration actions.
- Analyzing the potential net ecological loss or gain through a range of habitat conditions found in a port environment.

Calculating the benefits of removing creosote from the environment. Through coordination with the Services, the Ports have submitted the Port Calculator, proposed updates[10] to the Calculator, and an accompanying rationale that provides justification and guidance for how the Port Calculator will calculate impacts (positive or negative). The Port Calculator and proposed updates are based on best available science and best professional judgement from subject matter experts in a port-specific environment. (Appendix A)

The Port acknowledges that the following maintenance and repair activities will require an analysis using the Port Calculator to determine conservation offsets credits and/or debits:

- Pile replacement and removal (including removal of horizontal components and attachment hardware)
- Replacement, minor expansion, or removal of overwater structures
- Replacement or repair of shoreline stabilization (unless required to isolate upland contamination)
- Maintenance dredging
- Beneficial activities

Actions that do not require analysis with the Ports Calculator are listed in Tables 1 and 2 and are activities that largely do not have long-term habitat impacts, or the impacts are expected to be minor or insignificant.

NMFS Review and Verification

The Ports anticipate that the Program will be implemented under an individual permit issued by the Corps. For projects that trigger calculation, the Ports will provide NMFS at CMMP.wcr@noaa.gov post-project Calculators as described in detail in the Credit Savings Instrument (Appendix B) with supporting information to finalize project Calculators. NMFS will finalize post construction Calculators. Submittals will use a naming convention that will allow the Services to track all projects for clear evaluation of the full number of debits and credits generated annually. The annual verification process includes a permit compliance tracking

[10] Due to time constraints, the incorporation of the updates into the Calculator itself was not complete in time for consultation; however, as part of the proposed action, the Port has agreed to update the Calculator per NMFS' recommendations.

system between the Corps and the Services and the applicants. A numbering system will be created to keep track of reviewed projects under this Opinion based on Port, date, and order of submission. Annual verification includes tracking of actions with limited volumes and quantities and impact/benefit ledger tracking which is further detailed in Appendix B.

The Ports will notify the Corps and the Services *in advance of undertaking activities* (pre-project notice) in these circumstances:

1. When submitting a request for Minor Alterations or (section 1.3.5 above)
2. When seeking credit for habitat improvements for the purpose of generating credit, and therefore, as appropriate for the type or habitat improvement, include Habitat Improvement Plans (see Appendix B).

Pre-project notifications would include a brief project description, including the relevant information described in 1.3.5. and a draft calculator.

For all other Program activities that are covered by the USACE's permits, the Port will submit notifications to the Corps, treaty tribes, and other agencies with regulatory jurisdiction via established processes. Supporting documents including site plans, monitoring specifications, and avoidance and minimization measures (see sections 1.3.2 and 1.3.3 for BMPs) may also be provided when applicable to the proposed work.

Each year of the Program, the Ports, the USACE, and the Services will meet annually in May to review the Port's ledgers, as laid out in the credit savings instrument section IX, (found at Appendix B) as well as the Ports' Annual Monitoring Reports; and also to verify that take metrics are not exceeded.

The Annual Meeting each May also serve as an opportunity to discuss the Program broadly and suggest areas for improvement. This may include administrative and logistical changes to Program implementation, and consideration of new best-available science/technologies. The Port and Services will present proposed refinements or updates to the Port calculator during the Annual Meeting. The Port calculator is adaptable and can be expanded to include previously unconsidered species, areas, actions, or structures, if warranted. Proposed refinements will be based on new best available information and/or edits to the existing spreadsheet. If the proposed changes are agreed-upon by the USACE and Services during the Annual Meeting, the new version of the Port calculator will be approved for use. The revised Port calculator will only apply to projects and the ledger balance going forward (i.e., discrepancies with prior versions will not be calculated or rectified).

1.3.6. Role of Ports' Calculator and Calculator Rationale

The Port applicants seeking USACE authorizations for their maintenance, repair, and replacement activities will include with their proposed work redesign and habitat improvement actions in order to achieve long term balance of habitat features and values. They intend to validate this no net loss strategy using a Services-approved calculator (See appendices A & B).

The Ports will calculate both the long-term impacts (identified as debits) and habitat improvements (identified as Credits) with their "Ports' Calculator" developed for the specific habitat conditions and species found in the project area. Credits and debits will be tracked in a ledger separately by both the Ports and by the Services. Ledgers will be compared and reviewed annually to ensure that the proponent's intention for achieving no net loss is implemented. As described above, the Ports' Calculator will be revised through an adaptive management approach when scientific information indicates that the valuation within the calculator should be updated and the USACE and Services agree with the changes.

1.4. Action Area

"Action area" means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area consists of all the areas where the environmental effects of actions under this program may occur.

For each proposed action (i.e. for the Port of Tacoma's permit and the Port of Seattle's permit), there are short-term construction-related effects, operational effects associated with the continued use of the replacement structures, enduring (or long-term) effects caused by the replacement of the in- and overwater structures, and, for many action elements, beneficial effects of offsetting activities. We considered, under the ESA, whether or not the proposed action would cause any other activities and determined that it would cause commercial vessel traffic.

Because the primary purpose of this infrastructures is to provide moorage for vessels, repair and replacement of Ports 'structures will cause future vessel operation. Intermittent impacts from these vessels would include noise, propeller wash, shading of nearshore areas when vessels are moored, and the introduction of a small number of contaminants (i.e., fuel). The most far-reaching effect of each proposed activity is the operational effects from the vessels that will continue to utilize the Port. Intermittent biological effects (i.e., sound, pollution) associated with these vessels within Puget Sound are expected to occur to listed species in the areas described below. Non-vessel effects are localized around the marine port facilities in Seattle and Tacoma. Beneficial effects, while expected to occur mostly within the marine port facilities project area, may extend throughout the entire South-Central Puget Sound service area as described in Ehinger et al. (2023). To reach the Ports, vessels travel south from the entrance to the Strait of Juan de Fuca (SJDF), through Admiralty Inlet, and into Elliott Bay (Seattle) or Commencement Bay (Tacoma). Commercial vessels traveling either route follow well-defined navigation lanes known as the Traffic Separation Scheme (TSS), monitored by the U.S. Coast Guard (USCG) and the Canadian Coast Guard (CCG), and recognized by the International Maritime Organization (WDOE 2009). While it is impossible to predict the exact course of each individual commercial vessel utilizing the Ports, it is reasonable to assume they will travel from the SDJF via Admiralty Inlet in the established TSS lanes, then disperse into either Elliott or Commencement Bay.

Therefore, the proposed action (10-year Corps permits for both Port of Seattle and Port of Tacoma) creates an action area defined by the overlap between the South Central Puget Sound service area (Figure 1) and the area affected by vessel traffic which is the marine waters of Puget Sound along vessel routes to the entrance of the Strait of Juan de Fuca, as bounded by the geographic range of the TSS (Figure 2) and the freshwater portions of the ports.

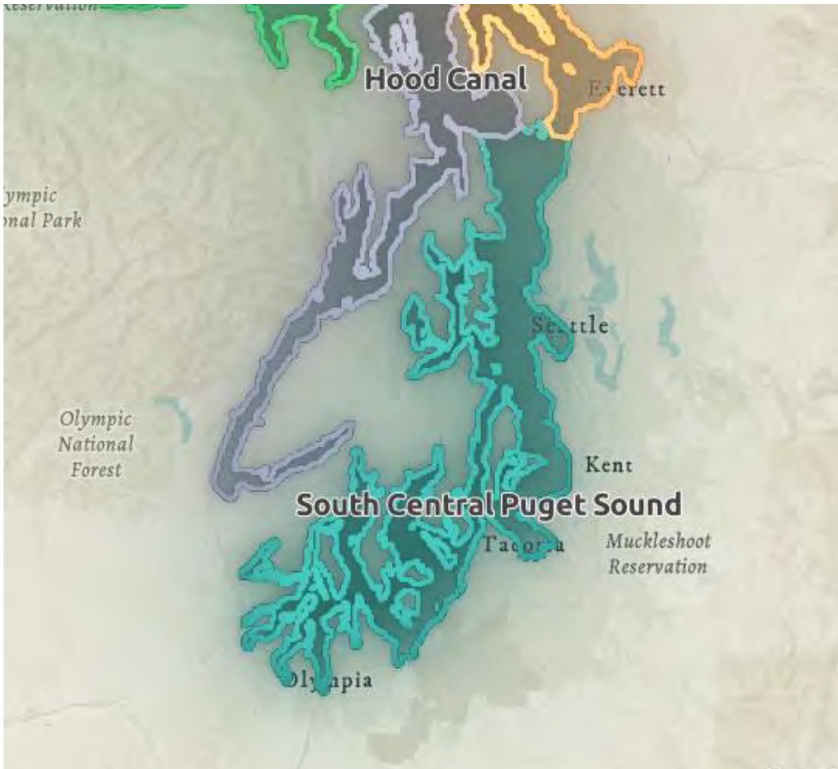

Figure 1: South Central Puget Sound service area. Graphic from Puget Sound Partnership https://www.psp.wa.gov/pspnc.php

Figure 2: Approximate location of shipping lanes (TSS). The approximate shipping lane portion of the action area is highlighted in the yellow polygon. The geographic extent of the action area shown here is defined by commercial shipping lanes from Seattle to the

The action area contains ESA-listed Puget Sound (PS) Evolutionary Significant Unit (ESU) of Chinook salmon (*Oncorhynchus tshawytscha*), PS Distinct Population Segment (DPS) steelhead (*Oncorhynchus mykiss*), Puget Sound-Georgia Basin (PS/GB) DPS of bocaccio (*Sebastes paucispinus)* and yelloweye (*Sebastes ruberrimus)* rockfish,Southern Resident Killer Whale (SRKW; *Orcinus orca*), Central America (CAM) and Mexico (MEX) DPS humpback whale (*Megaptera noveaengliae*), and critical habitat for each of these species. The action area is also likely to have presence of, in low abundance, the ESA-proposed for listing species sunflower sea star (*Pycnopodia helianthoides*). The action area also is EFH for Pacific Salmon, Coastal Pelagic Species, and Groundfish, and includes habitat areas of particular concern (HAPCs).

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 USACE determined the proposed action is not likely to adversely affect critical habitat for PS Chinook salmon, PS steelhead, rockfish, or SRKW, and SRKW or humpback whales. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.9).

2.1. Analytical Approach

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

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

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

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

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their critical habitat using an exposure–response approach.
- Evaluate cumulative effects.

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

The Comprehensive Repair and Maintenance Program requires projects authorized under this program do not result in a net-loss of nearshore habitat quality. The Port Calculator is a jointly (Services and Ports) developed tool available to determine long-term impacts and benefits and ensures no-net loss of nearshore habitat quality. The analytical approach to quantifying the long-term effects of maintenance actions is based on consideration of the current condition of the structure, how long it would likely exist irrespective of the action, and how much of it is being replaced, repaired, or strengthened, as well as the likely duration of the new structure[11].

While NMFS has a Nearshore Calculator with a science rationale that has been independently reviewed by a panel of expert scientists and validated as reliable and well supported by best available science, the proposed action reviewed in this consultation includes an alternative calculator prepared specifically for the highly developed estuarine setting and activities proposed by the Ports of Seattle and Tacoma, and a science rationale document. This "Ports' Calculator" is intended as part of the proposed action, to be utilized to quantify long-term habitat effects, both positive and negative, to confirm that no net-loss occurs annually under the Ports' respective permits.

The Services will assess the Ports' Calculator as part of the proposed action, to ensure that it represents the best available science and expert opinion regarding structural duration and habitat processes in a highly modified estuarine environment[12] and will produce repeatable and reliably accurate impact evaluation (calculator outputs). We note for the record, that the development of the Ports' Calculator was reviewed by the Services, which provided technical comment and advice. We anticipate that it will be the primary method of long-term effects quantification of the long-term effects of the maintenance, replacement, or repair of structures and other activities under the proposed action.

At present, the Ports' Calculator is only being evaluated for relevance and applicability to this proposed action (the domain of the Port Calculator is limited to brackish and saltwater). The reason for limited application is that science and expert opinion which informs this calculator was developed specifically for the unique habitat conditions and infrastructure at these highly modified estuarine locations. Specific Port's Calculator considerations include 1) how long structures in these two ports would likely exist irrespective of the action and 2) how habitat recovery, but for the proposed action, would affect each of the species within the project area.

[11] 50 CFR 402, and *A Memorandum Between the Department of the Army (Civil Works) and the National Oceanic and Atmospheric Administration (NOAA)* (Joint Memo)

[12] Details on the analytical approach and its quantitative translation allowing for the evaluation of the relevant aspects of the current condition are outlined in Chapter 4.3 and 4.4 of the Ports Calculator Rationale.

The habitat values developed for each of the proposed actions are different than for those of other ports, or for other developed estuarine settings, and thus the Port Maintenance Calculator – without adaptations – is not applicable to other geographies.

The Ports will work with the Services and USACE to update the Port Calculator as necessary, during the course of the permits, to accurately incorporate evolving scientific information regarding impacts, exposure, and response of habitat and/or species.

2.2. Rangewide Status of Critical Habitat and Species

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 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 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 2011; Crozier 2012; Crozier 2013; Crozier 2014; Crozier 2015; Crozier 2016; Crozier 2017; Crozier and Siegel 2018; Siegel and Crozier 2019; Siegel and Crozier 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 (Burke et al. 2013; Holsman et al. 2012). 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).

The potential impacts of climate and oceanographic change on whales and other marine mammals will likely involve effects on habitat availability and food availability. For species that depend on salmon for prey, such as SRKWs, the fluctuations in salmon survival that occur with these changes in climate conditions can have negative effects. Site selection for migration, feeding, and breeding may be influenced by factors such as ocean currents and water temperature. For example, there is some evidence from Pacific equatorial waters that sperm whale feeding success and, in turn, calf production rates are negatively affected by increases in sea surface temperature (Smith and Whitehead 1993; Whitehead 1997). Different species of marine mammals will likely react to these changes differently. MacLeod (2009) estimated, based on expected shifts in water temperature, 88% of cetaceans would be affected by climate change, with 47% likely to be negatively affected. Range size, location, and whether or not specific range areas are used for different life history activities (e.g. feeding, breeding) are likely to affect how each species responds to climate change (Learmouth et al. 2007).

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. Status of 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	Lowry 2024	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 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.	• 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
Puget Sound/Georgia Basin DPS of Bocaccio	Endangered 04/28/10	NMFS 2017d	Lowry 2024	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
Central America DPS humpback whale	Endangered 9/8/16	NMFS 1991	SWFSC 2015;	Whales from this breeding ground feed almost exclusively offshore of California and Oregon in the eastern Pacific, with only a few individuals identified at the northern Washington-southern British Columbia feeding grounds. The CAM DPS is listed as endangered and has been most recently estimated to include 783 whales (CV = 0.170, Wade 2017) with unknown population trend.	Entanglement in fishing gear and vessel collisions, in particular, were identified as the most significant threats to this DPS in the 2016 final listing rule (81 FR 62260, September 8, 2016).

Mexico DPS humpback whale	Threatened 9/8/16	NMFS 1991	SWFSC 2015;	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 whales	Entanglement in fishing gear, especially off the coasts of Washington, Oregon, and California, was identified as the primary threat to this DPS.
Sunflower Sea Star	Proposed Rule to List as Threatened 3/16/2023	NA	Lowry, 2022	Prior to 2013, the global abundance of *P. helianthoides* was estimated at several billion animals, but from 2013-17 sea star wasting syndrome (SSWS) reached pandemic levels, killing an estimated 90%+ of the population. Impacts varied by region across the range of the species and generally progressed from south to north. By 2017*, P. helianthoides* was rare south of Cape Flattery, WA, in areas where it had long been a conspicuous and ecologically important component of benthic marine ecosystems. Declines in coastal British Columbia and the Aleutian Islands exceeded at least 60%, and more likely 80%. While the root cause of SSWS has not yet been identified, Environmental factors such as temperature and dissolved oxygen likely contributed to the pandemic, and continue to interact with the disease agent to suppress recovery. The species is facing a moderate risk of extinction over the foreseeable future.	• Disease – Sea Star Wasting Disease SSWD • Elevated Ocean Temperatures and other Climate Change related effects (correlated with SSWD) • Lack of Regulation on Climate Change • Lack of direct species protection

To supplement the table found above, NMFS summarizes from Ford, 2022 and available 5-year reviews:

Puget Sound Chinook Salmon viability parameters:
Abundance across the Puget Sound Chinook salmon ESU has generally increased since the last status review, with only two of the 22 populations (Cascade River and North and South Fork Stillaguamish Rivers) showing a negative percentage change in the five-year geometric mean natural-origin spawner abundances since the prior status review. Across the Puget Sound Chinook salmon ESU, ten of 22 Puget Sound populations show *natural* productivity below replacement in nearly all years since the mid-1980s. We can see a declining trend in the proportion of natural-origin spawners across the ESU starting approximately in 1990 and extending through 2018. Overall, the Puget Sound Chinook salmon ESU remains at "moderate" risk of extinction, and viability is largely unchanged from the prior review. (Ford 2022).

Puget Sound Steelhead viability parameters:
The long-term abundance of adult steelhead returning to many Puget Sound rivers has fallen substantially since estimates began for many populations in the late 1970s and early 1980s; however, in the nearer term, there has been a relative improvement in abundance and productivity. Overall, the risk posed by hatchery programs to naturally spawning populations has decreased during the last five years with reductions in hatchery production. Overall, recovery efforts in conjunction with improved ocean and climatic conditions have resulted in an increasing viability trend for the Puget Sound steelhead DPS, although the extinction risk remains "moderate." (Ford 2022).

Puget Sound/Georgia Basin Bocaccio viability parameters:
The PS/GB bocaccio DPS includes all PS/GB bocaccio from inland marine waters east of the central Strait of Juan de Fuca and south of the northern Strait of Georgia. The waters of Puget Sound and Straits of Georgia can be divided into five interconnected basins that are largely hydrologically isolated from each other by relatively shallow sills (Burns 1985; Drake et al. 2010). The PS/GB bocaccio DPS exists at very low abundance and observations are relatively rare. No reliable range-wide historical or contemporary population estimates are available for the PS/GB bocaccio DPS. It is believed that prior to contemporary fishery removals, each of the major Puget Sound/Georgia Basin areas likely hosted relatively large, though unevenly distributed, populations of PS/GB bocaccio. They were likely most common within the South Sound and Main Basin, but were never a predominant segment of the total rockfish abundance within the region (Drake et al. 2010). The best available information indicates that between 1965 and 2007, total rockfish populations have declined by about 70 percent in the Puget Sound region, and that PS/GB bocaccio have declined by an even greater extent (Drake et al. 2010; Tonnes et al. 2016; NMFS 2017). Since the last 5-year status review (Tonnes et al. 2016), substantial new biological information pertinent to the status of this DPS is available from Remote Operated Vehicle surveys, scuba-based Young-of-Year surveys, recreational fisheries bycatch data, and a comprehensive catch reconstruction (Lowry et al. 2024). While progress has been made toward meeting several threats-based criteria, the full suite of criteria related to multiple threats has not yet been met. For some threats, such as bycatch and derelict fishing gear, significant progress has been made to reduce population-level impacts. For others, such as toxic contaminants and ocean acidification, fundamental science is still needed to develop appropriate

conservation responses. Overall, though recent data have provided better insights into historical bycatch and current population trends, this DPS remains at high risk of extinction (Lowry et al. 2022).

Puget Sound/Georgia Basin Yelloweye Rockfish viability parameters:
The PS/GB DPS of yelloweye rockfish was listed as "threatened" under the ESA on April 28, 2010 (75 Fed. Reg. 22276). Life history traits of PS/GB yelloweye rockfish suggest generally low levels of inherent productivity because they are long-lived, mature slowly, and have sporadic episodes of successful reproduction (Musick 1999; Tolimieri and Levin 2005). Yelloweye rockfish productivity may also be impacted by an Allee effect. This situation arises when reproductive adults are removed from the population and remaining individuals are eventually unable to encounter mates. This process then further reduces population density and can lead to extinction. Since the last 5-year status review (Tonnes et al. 2016), substantial new biological information pertinent to the status of this DPS is available from Remote Operated Vehicle surveys, scuba-based Young-of-Year (YOY) surveys, recreational fisheries bycatch data, and a comprehensive catch reconstruction (Lowry et al. 2024). These data allowed a novel evaluation of population status relative to a new baseline, with estimates indicating substantial recent population growth for this DPS (Min et al. 2023). Under some catch scenarios, population status in the U.S. portion of the DPS, excluding Hood Canal, now meets or exceeds minimum recovery criteria over one evaluation cycle. When combined with recent observations of YOY yelloweye rockfish at several locations within the DPS, positive progress toward recovery is apparent. Still, these biological recovery criteria must meet minimum thresholds over several evaluation cycles before delisting can be considered, and the PS/GB yelloweye rockfish remains at "moderate" risk of extinction (Lowry et al. 2022).

Mexico DPS humpback whale viability parameters

This DPS is threatened. The Mexico DPS consists of whales that breed along the Pacific coast of mainland Mexico, and the Revillagigedos Islands and transit through the Baja California Peninsula coast. The Mexico DPS feeds across a broad geographic range from California to the Aleutian Islands, with concentrations in California-Oregon, northern Washington-southern British Columbia, northern and western Gulf of Alaska and Bering Sea feeding grounds. The preliminary estimate of abundance of the Mexico DPS that informed our proposed rule was 6,000-7,000 from the SPLASH project (Calambokidis et al.2008), or higher (Barlow et al. 2011). There were no estimates of precision associated with that estimate, so there was considerable uncertainty about the actual population size. However, the BRT was confident that the population was likely to be much greater than 2,000 in total size (above the BRT threshold for a population to be not at risk due to low abundance). Estimates of population growth trends do not exist for the Mexico DPS by itself. Given evidence of population growth throughout most of the primary feeding areas of the Mexico DPS (California/Oregon (Calambokidis et al. 2008), Gulf of Alaska from the Shumagins to Kodiak (Zerbini et al. 2006)), it was considered unlikely this DPS was declining, but the BRT noted that a reliable, quantitative estimate of the population growth rate for this DPS was not available. The abundance estimate for the Mexico DPS is 3,264 individuals, and the population trend is unknown.

Vessel collisions and entanglement in fishing gear pose the greatest threat to this DPS.

Central America DPS humpback whale viability parameters

The Central America DPS is composed of whales that breed along the Pacific coast of Costa Rica, Panama, Guatemala, El Salvador, Honduras and Nicaragua. Whales from this breeding ground feed almost exclusively offshore of California and Oregon in the eastern Pacific, with only a few individuals identified at the northern Washington-southern British Columbia feeding grounds. A preliminary estimate of abundance of the Central America population was ~500 from the SPLASH project (Calambokidis et al. 2008), or ~600 based on the reanalysis by Barlow et al. (2011). There were no estimates of precision associated with these estimates, so there was considerable uncertainty about the actual population size. Therefore, the actual population size could have been somewhat larger or smaller than 500-600, but the BRT considered it very unlikely to be as large as 2,000 or more. The size of this DPS was relatively low compared to most other North Pacific breeding populations (Calambokidis et al.2008) and within the range of population sizes considered by the BRT to be at risk based on low abundance. The trend of the Central America DPS was considered unknown. The abundance estimate of the Central America DPS is 411 individuals, with unknown population trend.

Vessel collisions and entanglement in fishing gear pose the greatest threat to this DPS.

Southern Resident Killer Whale viability parameters

The SRKW DPS, composed of J, K, and L pods, was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). NMFS considers SRKWs to be currently among eight of the most at-risk species, as indicated by the Species in the Spotlight initiative[13] based on their endangered status, declining population trend, and thus are high priority for recovery effort. The population has relatively high mortality and low reproduction, unlike other resident killer whale populations that have generally been increasing since the 1970s (Carretta et al. 2019).

The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated the population viability analyses conducted for the 2004 Status Review for SRKWs and the 2011 science panel review of the effects of salmon fisheries (Hilborn et al. 2012; Krahn et al. 2004; Ward et al. 2013). According to the updated analysis, the model results now suggests a downward trend in population size projected over the next 50 years. As the model projects out over a longer time frame (50 years) there is increased uncertainty around the estimates. The downward trend is in part due to the changing age and sex structure of the population. If the population of SRKW experiences demographic rates (e.g. fecundity and mortality) that are more similar to 2016 than the recent 5-year average (2011-2016), the population will decline faster than predictions based on conditions between 2011 to 2016 (NMFS 2016). There are several demographic factors of the SRKW population that are cause for concern, namely (1) reduced fecundity, (2) a skewed sex ratio toward male births in recent years, (3) a lack of calf production from certain components of the population (e.g. K pod), (4) a small number of adult males acting as sires (Ford et al. 2018) and (5) an overall small number of individuals in the population (review in NMFS 2016).

[13] https://www.fisheries.noaa.gov/resource/document/species-spotlight-priority-actions-2016-2020-southern-resident-killer-whale

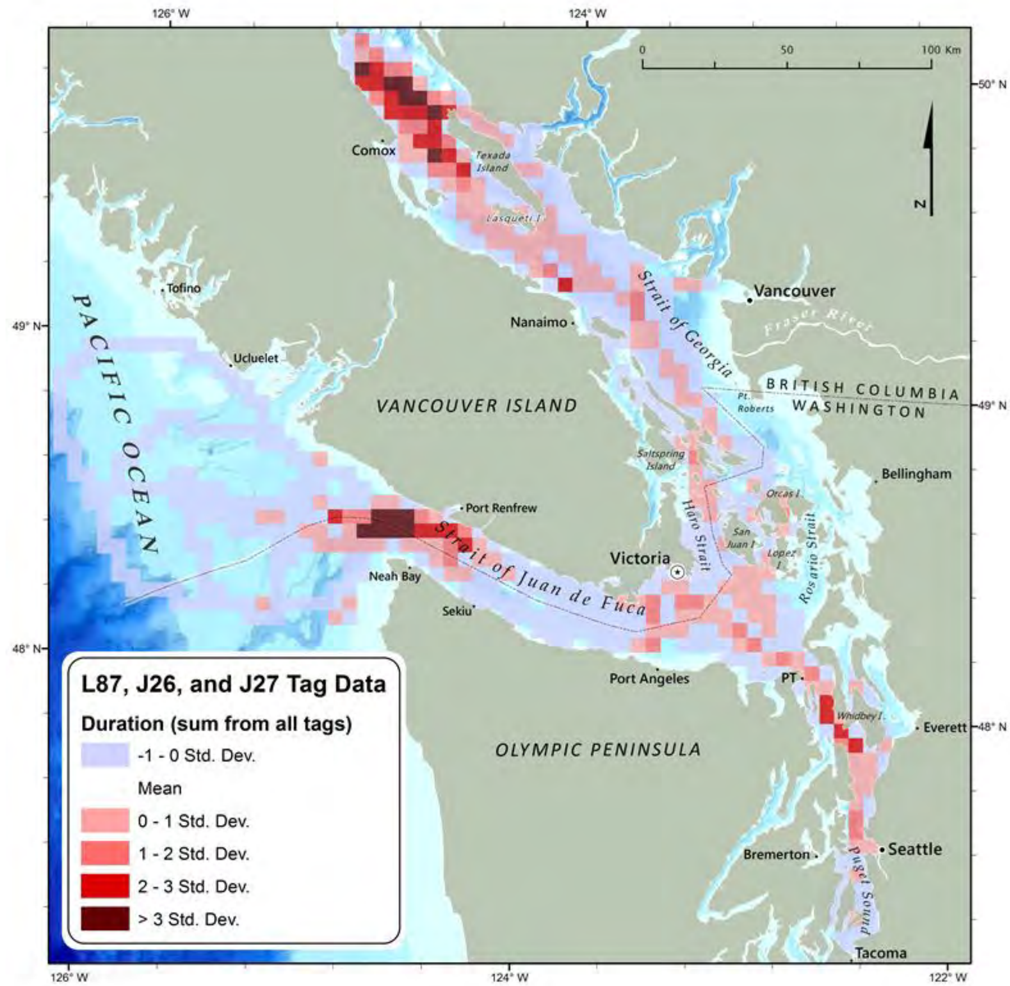

Figure 3. Duration of occurrence model output for J pod tag deployments (Hanson et al. 2017). "High use areas" are illustrated by the 0 to > 3 standard deviation pixels

<u>Sunflower Sea Star Viability Parameters.</u> We developed the Sunflower Sea Star viability parameters from the federal register's notice of findings on the petition to list this species: Populations of sunflower sea star saw severe declines between 2013 and 2017 with the onset of the sea star wasting syndrome (SSWS), with 99 to 100 percent declines in California and Oregon, and 92 to 99 percent decline in Washington (Hamilton et al. 2021; Harvell et al. 2019). This decline has led the International Union for Conservation of Nature to list the species as Critically Endangered (Gravem et al. 2020). While the cause of this disease remains unknown, prevalence of the outbreak has been linked to a variety of environmental factors, including temperature change, sustained elevated temperature, low dissolved oxygen, and decreased pH (Hewson et al. 2018; Aquino et al. 2021; Heady et al. 2022; Oulhen et al. 2022).

The sunflower sea star (*Pycnopodia helianthoides*) occupies nearshore intertidal and subtidal marine waters shallower than 450 m (~1400 ft) deep from Adak Island, Alaska, to Bahia Asunción, Baja California Sur, Mexico. They are occasionally found in the deep parts of tide pools. The species is a habitat generalist, occurring over sand, mud, and rock bottoms both with and without appreciable vegetation. Critical habitat is currently indeterminable because information does not exist to clearly define primary biological features. Prey include a variety of epibenthic and infaunal invertebrates, and the species also digs in soft substrate to excavate clams. This star is a well-known urchin predator and plays a key ecological role in control of these kelp consumers. More information about sea star biology, ecology, and their life history cycle is found in the proposed listing (88 FR 16212). As noted above, changes in physiochemical attributes of nearshore waters are expected to change in coming decades as a consequence of anthropogenic climate change, but the specific consequences of such changes on SSWS prevalence and severity are currently impossible to accurately predict.

While considered a generalist and opportunistic predator, the sunflower sea star is a keystone species across its distribution area, preying on many invertebrate predator species and with very few species feeding on the sunflower sea star (Herrlinger 1983; Mauzey et al. 1968). Sunflower sea stars are broadcast spawners, producing planktonic larvae that will spend up to ten weeks in the water column before settling and metamorphosing (Greer 1962). Although the species exhibits indeterminate growth, lifespan and growth rate are unknown (Heady et al. 2022). The SSWS is the only known threat to the species.

A range of different behavioral and physiological experiments have been conducted on sensory abilities of starfish and the general conclusion has been that they possess several senses, including chemoreception (gustation and olfaction), mechanoreception (touch, rheotaxis and geotaxis), and photoreception. Other senses (e.g., hearing, electroreception, and magnetoreception) might also be present, but these have never been evaluated experimentally (Garm 2017).

2.2.1. Status of the Critical Habitat

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

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

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 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.
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

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		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.
Sunflower Sea Star	N/A	Not proposed at this time

2.3. Environmental Baseline

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

Most effects of the proposed action are associated with construction or repair activities, plus the long-term effects of structures themselves, are spatially constrained to areas within or adjacent to each port’s facilities.

As described in Section 1.4, the action area is defined by the vessel traffic to and from the Ports in the marine waters of Puget Sound between the entrance to the Strait of Juan de Fuca and Commencement Bay, the South-Central Puget Sound basin service area where offsetting activities may occur, as well as port facilities involved in the actions in Table 2 and Table 3. The majority of construction and beneficial projects would take place in Seattle Port Area (portions of Puget Sound, Elliott Bay, tidally-influenced Duwamish Waterway, and Lake Washington Ship Canal), and the Tacoma Port Area (portions of Commencement Bay, the lower Puyallup River, working waterways, and select creeks that contribute to the waterways. These Project Areas are subsets of the action area; because Project Areas have historically been areas of intensive development, our environmental baseline discussion pays particular attention to those areas.

As described in Section 1.4, the action area includes portions of the Strait of Juan de Fuca (SJDF) and Salish Sea adjacent to the TSS, in addition to the Ports’ specific locations (Project Areas).

SJDF: Habitat in the SJDF includes 217 linear miles of shoreline between Cape Flattery and Point Wilson. The waters of the SDJF link the inner Salish Sea to the Pacific Ocean, and act as an essential pathway for exchange of incoming cold, dense saltwater with freshwater from many rivers influenced by intense tidal action (Strait Ecosystem Recovery Network Local Integrating Organization [LIO] 2017). Additionally, the connectivity of the SJDF makes it critical for marine transportation since almost all vessels entering or leaving Puget Sound or Georgia Basin ports for the Pacific Ocean travel through these waters (Strait Ecosystem Recovery Network LIO 2017). Increasing commercial and residential development around urbanizing areas have introduced anthropogenic pressure on habitat in the SDJF. A total area of 65 acres of overwater structures was observed in aerial photos taken between 2013 and 2016, and armored shoreline accounts for 15.7 percent of total shoreline length (Beechie et al. 2017). Other pressure sources and stressors identified as very high priority by the Strait Ecosystem Recovery Network LIO (2017) include: marine shoreline infrastructure, including roads, railroads, and culverts; freshwater levees, floodgates, and tide gates influenced by agriculture and residential development; conversion of natural resource lands to developed areas; abstraction of surface water; onsite sewage systems;

industrial infrastructure within geographically limited locations, legacy shoreline and sediment contaminants, and toxic chemicals; and, shipping lanes and oil spills.

The SJDF is utilized as a primary migration corridor for many species of fish, marine mammals, and birds that travel between the Salish Sea and the Pacific Ocean. The SJDF marine shoreline and nearshore contains the majority of Washington's coastal kelp resources, supporting 95 linear miles of floating kelp, 161 linear miles of non-floating kelp, and 75 linear miles of eelgrass (Strait Ecosystem Recovery Network LIO 2017). These resources, along with numerous bays and pocket estuaries, provide habitat and food webs supporting ESA-listed fish and marine mammals, including humpback whale and SRKW. (PSI 2023).

Salish Sea: Habitat in the Salish Sea nearshore within the action area, considered at the landscape scale, is generally degraded from coastal development and pollution. Throughout the Salish Sea, nearshore areas have been modified by human activity, disrupting the physical, biological, and chemical interactions that are vital for creating and sustaining the diverse ecosystems of this area. There are approximately 503,106 acres of overwater structure in the nearshore of Puget Sound (Schlenger et al. 2011) and approximately 27 percent of Puget Sound's shoreline has been modified by armoring (Simenstad et al. 2011). Habitat stressors include reduced water quality, reduced forage and prey availability, reduced quality of forage and prey communities, reduced amount of estuarine habitat, reduced quality of nearshore and estuarine habitat, and reduced condition of migration habitat due to structure noise and vessel perturbations. The input of pollutants affects water quality, sediment quality, and food resources in the nearshore and deep-water areas of critical habitat. The Salish Sea supports salmonid species that migrate to the ocean, and the portion of Puget Sound Chinook salmon that stay in the Sound for their adult life-stage. Other ESA-listed species that reside in the Salish Sea (and therefore are more frequently exposed to effects that occur in the Sound, are SRKW, as well as the two species of rockfish.

All listed species and habitats described in Sections 0 and 2.9 occur within the action area. Critical habitat is designated within portions of the action area for PS Chinook salmon, PS steelhead, PS/GB bocaccio and yelloweye rockfish, SRKW, and humpback whales[14]. The PBFs for these species are shown in Table 7. The baseline conditions of these features are that while they are present, they are degraded in quantity or quality at varying levels throughout the action area. As reflected in Status of Critical Habitat and the description above, features of designated critical habitat are modified anthropogenically, and degraded in several ways, throughout the action area. The past and ongoing anthropogenic impacts described above have impacted ESA-listed species and their critical habitats by reducing the quantity and quality of migratory and rearing habitat, including reduced water quality caused by the introduction of pollutants related to upland development and vessel operations.

[14] The Corps did not request consultation on humpback whale critical habitat, therefore an analysis has not been provided in this opinion.

Table 7. Physical and biological features of designated critical habitat

PBF of Critical Habitat	Species
Water quality	PS Chinook salmon PS steelhead PS/GB bocaccio SRKW
Forage or prey	PS Chinook salmon PS steelhead PS/GB bocaccio SRKW
Substrate	PS/GB bocaccio
Safe migration/passage	PS Chinook salmon PS steelhead SRKW

Portions of the action area and TSS may support the deep-water PBFs of critical habitat for adult rockfish, but adequate substrate and complexity is not widely present in portions of the action area proximate to the Ports. PBFs associated with critical habitat for juvenile PS/GB bocaccio rockfish are present in areas of the Elliott and Shilshole Bay nearshore within in Zone 1 for Port of Seattle. Critical habitat is not mapped in Zones 2 or 3. Critical habitat for juvenile PS/GB bocaccio rockfish near the Port of Tacoma is in the nearshore of Commencement Bay.

Adult rockfish typically utilize deep water areas with large rocks and cover; suitable habitat for adult rockfish is extremely limited in the project area as preferred habitat depths and features such as rugosity are rare. In Puget Sound, most bocaccio are found in the Central Sound (Palsson et al. 2009), south of Tacoma Narrows. Central and south Puget Sound Basins are within their historical range, but data suggest that adult rockfish are scarce throughout the action area. If present, they will likely occupy depths greater than those near the port facilities.

Rockfish rely on nearshore environments during larval and bocaccio also during juvenile life stages. Rockfish larvae are thought to be mostly distributed passively by currents (Love et al. 2002), and may be broadly dispersed from the place of their birth (NMFS 2003). Bocaccio rockfish larvae are typically found in the pelagic zone, often occupying the upper layers of open waters, under floating algae, detached seagrass, and kelp. Larval bocaccio and yelloweye drift for long periods before moving into rockier and deeper habitat once their swimming ability is fully developed. Larval rockfish have been documented at open-water disposal sites near Seattle and Tacoma, respectively (Figure 4; Greene and Godersky 2012; NMFS 2015). In Central Puget Sound (i.e., within the action area), larval rockfish presence during the spawning period peaks once in spring and once in late summer (Figure 5; Greene and Godersky 2012).

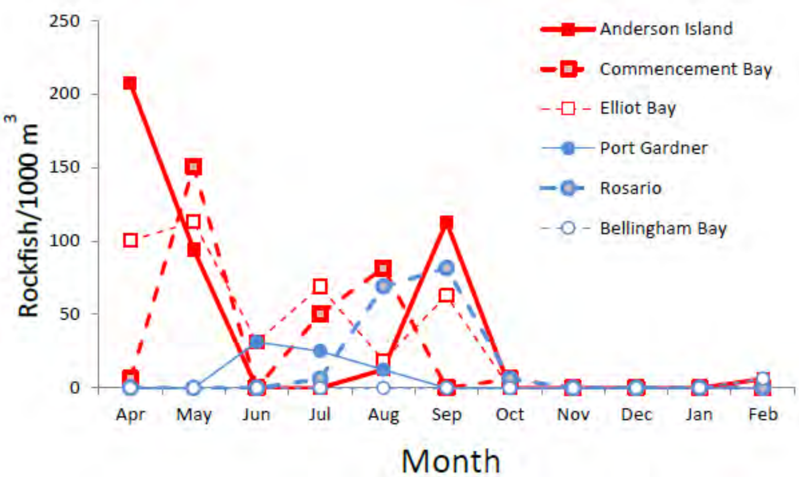

Figure 4. Rockfish larval density (rockfish larvae/1,000 m3) at 6 sediment disposal sites from April 2011 through February 2012. Data from Elliott Bay and Commencement Bay are relevant for the Ports of Seattle and Tacoma, respectively. From Greene and Godersky 2012

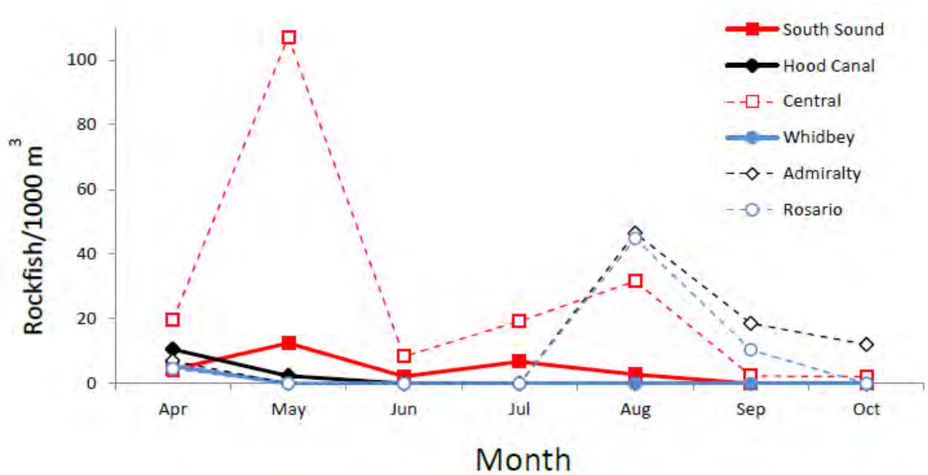

Figure 5. Larval rockfish density at a subset of 16 index sites in 6 oceanographic basins from April through October. Data from Central Puget Sound is relevant for this Opinion. From Greene and Godersky 2012.

The SRKW DPS consists of three pods (J, K, and L) that reside for part of the year in the action area, principally during the late spring, summer, and fall. It is not uncommon for the species to forage in shallower coastal and inland marine waters (NMFS 2008). Critical habitat extends to waters relative to a contiguous shoreline delimited by the line at a depth of 6.1 meters (20 feet) relative to extreme high tide. Thus, critical habitat in the action area include the SJDF and Puget Sound TSS, and waters of Commencement Bay. Within the action area following the TSS, the frequency and timing of SRKW sightings varies. In general, they may be present at some location in the action area at any time.

The Seattle Project Area includes Quadrants 401, 402, 404, 407, 408, 409, 410, 412, and 413. The number of SRKW sightings in each quadrant over the past 23 years are shown in Table 8.

Table 8. Total unique SRKW sightings by month from 1999-2022 within Seattle Project Area Quadrants

Month	J	F	M	A	M	J	J	A	S	O	N	D	Total
Quadrant 401	20	6	8	13	5	6	6	4	34	70	114	69	355
Quadrant 402	15	2	3	4	0	1	2	1	7	36	40	36	147
Quadrant 404	5	1	0	0	0	1	1	1	3	12	19	17	60
Quadrant 407	15	4	5	5	2	0	1	3	11	50	49	52	197
Quadrant 408	20	8	4	1	0	0	1	1	15	34	68	63	215
Quadrant 409	15	3	2	4	0	0	0	3	4	15	11	13	70
Quadrant 410	25	11	2	8	1	4	1	3	8	39	68	59	229
Quadrant 412	16	9	1	2	2	2	1	2	3	10	54	51	153
Quadrant 413	14	6	3	3	0	1	0	3	6	32	54	60	182
Monthly Average[1]	17	6	4	5	2	2	2	3	11	34	53	47	179
Yearly Average[2]	0.74	0.26	0.17	0.22	0.09	0.09	0.09	0.13	0.48	1.48	2.3	2.04	7.78

The Tacoma Project Area includes Quadrants 420 and 421. The number of SRKW sightings in each quadrant over the past 23 years are shown in Table 9.

Table 9. Total unique SRKW sightings by month from 1999-2022 within Tacoma Project Area Quadrants.

Month	J	F	M	A	M	J	J	A	S	O	N	D	Total
Quadrant 420	22	6	1	1	1	1	0	0	1	4	56	61	154
Quadrant 421	7	2	0	1	0	0	0	0	0	1	13	13	37
Monthly Average[1]	15	4	1	1	1	1	0	0	1	3	35	37	96
Yearly Average[2]	0.65	0.17	0.04	0.04	0.04	0.04	0	0	0.04	0.13	1.52	1.61	4.17

1. Yearly average was calculated by dividing the average number of monthly sightings from both Quadrants rounded up to the nearest whole number by the number of years sighting data is available (23 years), and rounding to two digits for ease of reading.

Humpback whales occur in Washington waters mostly from July to September (WDFW 2024), and can occur in the action area. Sightings of humpbacks in the Salish Sea, including the action area, have increased greatly since the mid-2000s, reaching 500 or more annually in 2014 and 2015 (WDFW 2021). Washington Salish Sea sightings have historically been concentrated in the SDJF and near the San Juan Islands, but are increasingly reported throughout Puget Sound (Calambokidis and Steiger 1990, Calambokidis et al. 2017, Palacios et al. 2020).

Sightings of humpbacks in the Salish Sea, including the action area, have increased greatly since the mid-2000s, reaching 500 or more annually in 2014 and 2015 (WDFW 2021). Washington Salish Sea sightings have historically been concentrated in the SDJF and near the San Juan Islands, but are increasingly reported throughout Puget Sound (Calambokidis and Steiger 1990, Calambokidis et al. 2017, Palacios et al. 2020). We expect humpbacks in the action area would be foraging, feeding, or transiting to other feeding areas. Individuals often show fidelity to certain feeding areas, and interchange between feeding areas is relatively uncommon (Sato 2021).

A recent analysis of opportunistic sightings from 1976 to 2019 assessed patterns in whale presence and distribution in the Central Salish Sea (Olson et. al 2024). Results indicate an expansion of humpbacks into additional areas of Puget Sound, including the SDJF, Central Puget Sound, and (to a lesser degree) North Puget Sound within the action area (Olson et. al 2024; Figure 6). Additionally, photo identification studies have shown these whales to be individuals previously observed in offshore waters (Cascadia Research Collective, unpublished data). In 2021 alone, 388 individual humpback whales were photographed during 748 encounters in the Southern British Columbia and Washington region (Cheeseman et al. 2023). Taken together, these results support the renewed use of historical feeding grounds in the Salish Sea as the humpback population recovers to pre-whaling numbers (Olson et. al 2024).

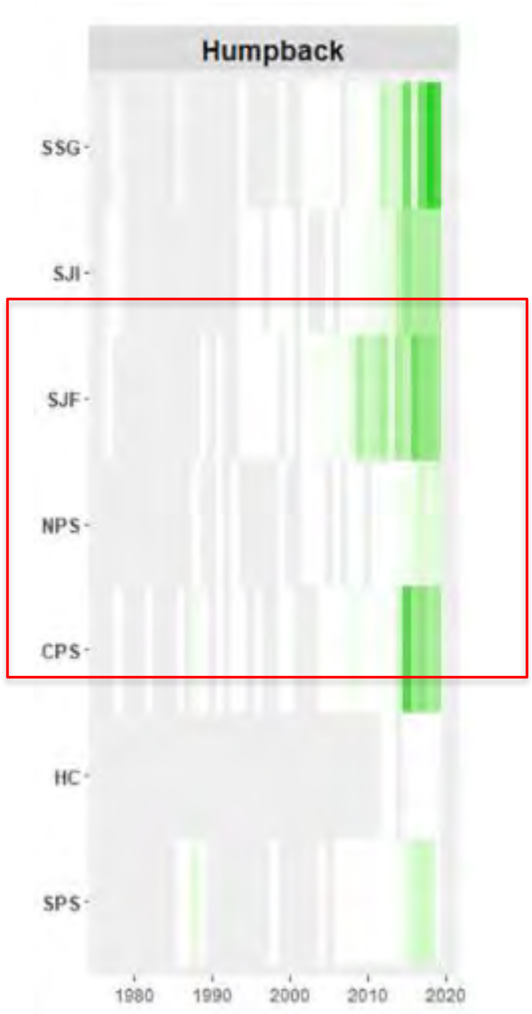

Figure 6. Heat map of sightings in the Salish Sea study area (1976–2019) by region and species. Gray shaded areas represent zero reported sightings. Study areas within the action area are identified by the red boxes. From Olson et. al 2024.

Photo-identification and modeling efforts indicate that a large proportion of humpback whales feeding along the coasts of northern Washington and southern British Columbia are from the Hawaii DPS (63.5 percent), with fewer animals from the Mexico (27.9 percent) and Central America (8.7 percent) DPSs (WDFW 2021; Wade 2017). NMFS assumes that there is a high probability that those humpback whales originate from one of the two listed DPSs, and apply either the 42 percent (CAM DPS) and 58 percent (MEX DPS) proportional values described above for reports off CA/OR. Approximately 20 individual whales have been positively identified using fluke prints in the waters of Commencement Bay adjacent to the Tacoma Project Area (Happy Whale 2024).

While salmonid populations transit broadly in the Salish Sea, several populations have natal streams nearby the Port of Seattle and the Port of Tacoma, which would indicate a greater likelihood of their presence in this portion of the action area in larger numbers, and for longer timeframes. We can describe the baseline conditions with more precision near the ports, including which populations of PS salmonids are most likely to occur.

Seattle Area of Construction Effects.

The work is proposed on and immediately adjacent to Port of Seattle properties within the City of Seattle in King County, Washington (Figure 7). The total area covered by this Program is approximately 11,800 acres.

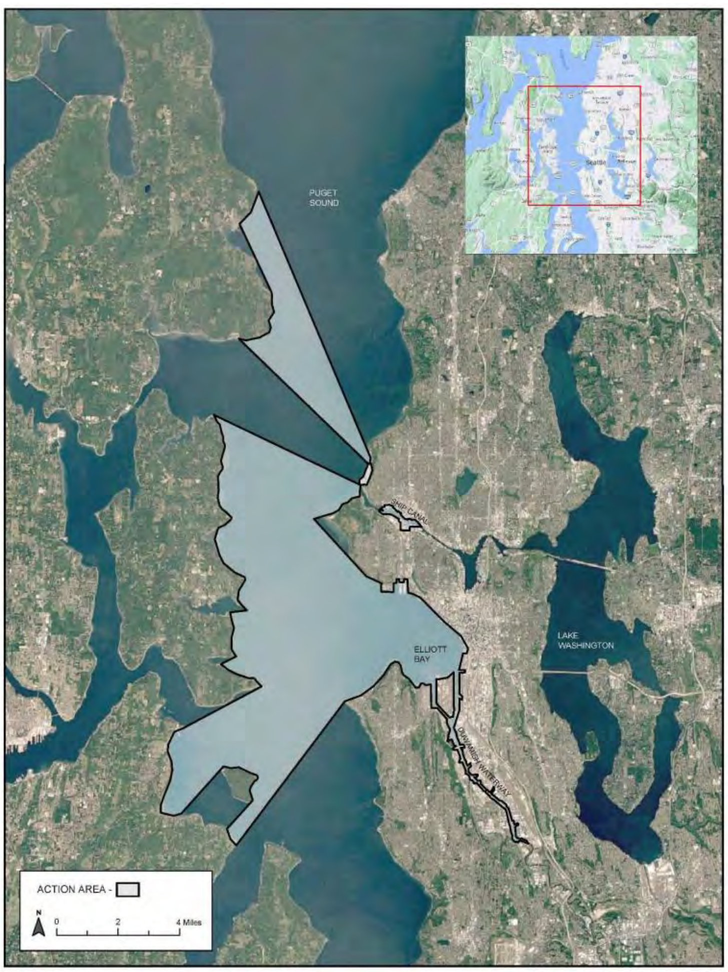

Figure 7. Port of Seattle area of construction impacts, defined by the noise threshold for behavioral harm to marine mammals (Port of Seattle 2024)

The Seattle Program Footprint (i.e., the immediate vicinity where in-water and over-water project activities will occur at discrete Port facilities is shown in the *Figure 8*. Each Seattle facility, its location, and its zone for purposes of this Program are identified in Table 2 of the Seattle BE. The BE (Port of Seattle 2024) describes the proposed action's activities and effects based on 3 geographic zones: Zone 1 – Marine: Elliott Bay & Puget Sound including East and West Waterways; Zone 2 – Estuarine: Tidally- Influenced Duwamish Waterway (River Mile [RM] 0.0 to 5.0 of the Duwamish River), and Zone 3 – Freshwater: Lake Washington Ship Canal.

Figure 8. Seattle Program Footprint (Port of Seattle 2024)

Elliott Bay is about 6 kilometers by 4 kilometers (3.7 by 2.5 miles), covering an area of about 21.4 square kilometers (8.3 square miles; Silcox et al. 1984). With the exception of Duwamish Head extending into the bay from the south, Elliott Bay has a nearly semicircular shoreline. Shoreline elevations range from 0 feet relative to the ordinary high water mark (OHWM) in unarmored areas to about -30 feet (-9 meters) relative to MLLW along the inner shoreline, which is dominated by man-made piers and seawalls. Substrate along the shoreline consists of a mix of shell hash, scattered cobbles and boulders, and silts and clays. The average tidal fluctuation is 11.3 feet (3.4 meters; NOAA 2018). The bathymetry of Elliott Bay is dominated by a submarine canyon in the center of the bay which trends in a northwest-southeast direction and debouches onto the floor of the central basin of Puget Sound (Massoth 1982). The easternmost areas of Elliott Bay are approximately 40 meters (131 feet) deep, gradually reaching depths of 200 meters (656 feet; NOAA 2011). Depths in the inner canyons range from 75 to 150 meters (246 to 492 feet). Circulation in Elliott Bay generally follows a counter-clockwise low velocity circulation pattern. Currents during flood tides tend to flow clockwise and are typically stronger than counterclockwise ebb tide currents (NOAA 2018). The principal source of freshwater is the Duwamish River, which divides into the East and West Waterways before entering the southeast corner of the bay.

Within the Seattle Project Area, the Cedar, Green, and Sammamish River populations of PS Chinook and PS steelhead are expected to be the most prevalent ESA-listed fish populations exposed to project effects (see Section 2.2.1 for additional detail). The Port of Seattle Project area has 3 discrete zones. PS Chinook salmon presence is documented in all 3 zones (WDFW 202

Zone 1 contains portions of Puget Sound and Greater Elliott Bay, including East and West Waterway. Baseline conditions in Zone 1 reflect modifications associated with current and historic commercial uses – it has highly modified maritime industrial areas and urban waterways to support, cargo, cruise, recreational and commercial moorage, as well as other water-dependent or water-related commercial uses. This historic pattern of use has over time eliminated some estuarine habitat areas by filling, deepened some shallow estuarine habitat via dredging, removed native vegetation in most of the riparian area to enable commercial infrastructure, and impaired habitat forming processes by armoring the majority of shoreline.

Elliott Bay is contained within the major urban city of Seattle with over 76 percent impervious surface (WDOE 2023) which contributes stormwater to this portion of the action area. Between the late-1800s and the mid-1900s, the Duwamish Estuary and Elliott Bay were substantially modified to create the East and West Waterway navigation channels and Harbor Island. As described above, this involved dredging navigational channels, filling shallow habitat such as marshes and mudflats, and armoring the shorelines with dikes, levees, bulkheads, and other structures. The manmade waterways have been continually modified over a century of urban and industrial development. The shoreline area is dominated by over-water piers, riprap slopes, constructed seawalls, and bulkheads. Sand, silt, and mud are the dominant substrate types. Subtidal areas are typically dredged to between -15 feet MLLW and -50 feet MLLW.

Decades of urban and industrial use have impaired the sediment, water, and noise levels of aquatic habitat in Zone 1. A WSDOT study found ambient background noise in Seattle to be as high as 141 dB (Laughlin 2015); however, another study by Washington State Ferries reported daytime broadband underwater noise levels of 120 dB in Seattle/Elliott Bay (Laughlin 2020). Therefore, ambient underwater noise near the Port's facilities is conservatively estimated to be approximately 120 dB_{RMS}.

The East and West Waterways are listed under the Comprehensive Environmental Response and Liability Act (CERCLA or Superfund) due to historic practices that caused widespread contamination. Water quality is degraded by sewage discharges from wastewater treatment facilities and numerous other point and non-point stormwater discharges. High levels of bacteria have been documented in nearshore areas of Elliott Bay and Puget Sound, and portions of the action area are identified as impaired by Ecology; these areas occur in and around the Shilshole Marina, along Centennial Park, and north of Terminal 46. Typical sources of noise near the project site include high levels of daily vessel traffic from ocean-going commercial and military vessels, tug boats, commercial fishing boats, tour boats and ferries, and numerous recreational vessels. Strong tidal movement through Admiralty Inlet and Possession Sound is another contributor to ambient noise.

In Zone 1, herring and sand lance spawning is mapped along Elliott Bay's eastern shoreline, and herring and smelt spawning areas are present along the shoreline of Discovery Park (WDFW 2024). Forage fish spawning also occurs on shorelines within the area of underwater noise impacts across Puget Sound. Submerged aquatic vegetation (SAV) is sparse or absent throughout interior Elliott Bay with few exceptions, but eelgrass and Z. japonica are mapped outside of the Seattle Project Footprint on western Alki, Discovery Park, and the outlet of Lake Washington Ship Canal (WA DNR 2024). Less than approximately 4% of the Elliott Bay shoreline includes any sort of marine riparian vegetation (Port of Seattle 2021). In Zone 1, approximately 16% of shoreline functions as intertidal and shallow subtidal habitat despite the presence of artificial structures (Port of Seattle 2021).

Zone 2 includes the RM 0.0 to 5.0 of the Lower Duwamish River (LDR). This portion of the LDR is tidally-influenced and within the saltwater wedge which extends to approximately RM 7.0. Nearly all of the historic tidal marshes, which once predominated in the LDR were filled in the late 19th and early 20th centuries. Historic sources of flow have been greatly diminished compared to their natural rates as a result of the diversion of the White River into the Puyallup River in 1906 and the diversion of the Cedar River into Lake Washington in 1916. The diversion of these rivers reduced the Duwamish/Green drainage basin by 75 percent and its average flow by up to 81 percent. At about the same time, the lower river was dredged to create the Duwamish Waterway, replacing 9 meandering miles (14.4 km) of river with a straight, deep, 5.3-mile-long (8.5 km) navigation channel (City of Seattle 2003).

Water and sediment quality in the LDR has been adversely affected by the history of surrounding high-intensity land use associated with marine transport, as well as municipal stormwater and wastewater outflows. The LDR is on the State's 303(d) list of impaired waterbodies for bacteria, dissolved oxygen, and water temperature. Thirty-three sediment contaminants are also identified on the 303(d) list for the LDR. The LDR was designated a Superfund Site by the EPA in 2001. A Cleanup Plan issued by the EPA in 2014 identified technologies and extent of planned cleanup activities. The river has also been listed for cleanup by Washington State under the Model Toxics Control Act (MTCA).

Green River fall Chinook, and Green River winter and summer run steelhead will enter Zones 1 and 2 of the Seattle Project portions of the action area, through the Duwamish Waterway (WDFW 2019). The population abundance, productivity, diversity and spatial distribution of this population has not improved despite significant investments and large-scale restoration projects, and in some cases has continued to decline (Water Resource Inventory Area [WRIA] 9 2021). Adult Green River PS Chinook salmon migrate through Elliott Bay and the LDR from July to October, depending on water quantity and temperature (WRIA 9 2021). Juvenile Green River PS Chinook salmon outmigrate from February through July (Ruggerone et al. 2006). Juvenile Chinook salmon are present in the in the Elliott Bay nearshore from May through October, with a strong peak in May (Anchor QEA 2019). In Zones 1 and 2, individuals from the winter and summer-run Green River PS steelhead DIP are most likely to be present. The winter and summer-run Green River PS steelhead DIP are which are considered "healthy" and "depressed", respectively. The five-year abundance has increased 95 percent from the previous 5 year interval, and the 15-year mean abundance is slightly negative (-0.01) (Ford 2022). Green River summer-run adults return May through November, and winter-run adults return November through July (Blanton et al. 2011). Juveniles from both runs rear at least 9 to 15 miles upstream in the Green River (WDFW 2023), and outmigrate to the estuary between March and mid-July (Brennan et al. 2004).

Zone 3 includes the Lake Washington Ship Canal. The Ship Canal is a completely artificially constructed waterway, and consequently hydrology and habitat are substantially altered from historic conditions. Lake Washington was lowered by approximately 8 feet through excavation of the Montlake Cut and construction of the Hiram Chittenden Locks. Furthermore, the managed hydroperiod above the Locks is reversed, meaning that the lake level is approximately two feet higher in the summer compared to in the winter. The Ship Canal supports significant marine commercial and industrial activity, with substantial areas of overwater coverage and shoreline armoring. Water quality within the Lake Washington Ship Canal is on Ecology's 303(d) list of impaired waterbodies for lead, pH, aldrin, and bacteria. The Lake Washington portion of the action area contains PBFs 2 (freshwater rearing) and 3 (freshwater migratory corridor) of PS Chinook salmon critical habitat. The re-routing of the Cedar River forced juvenile Chinook to use Lake Washington for rearing and migration. Juvenile Chinook are dependent on shallow nearshore habitat for predator avoidance. The shoreline modifications described above have substantially degraded the function of these PBFs.

Despite poor habitat conditions, ESA-listed species continue to use available areas for forage, migration, and rearing. Salmonid populations identified in Lake Washington include Cedar River and Sammamish River fall Chinook salmon[15], along with Cedar River winter steelhead and North Lake Washington and Lake Sammamish winter steelhead. These PS Chinook salmon populations are largely not meeting abundance, productivity, or diversity goals for WRIA 8 (WRIA 8 2024). Adult PS Chinook salmon from the Cedar and Sammamish River DIPs migrate from Puget Sound through the Ship Canal to Lake Washington and upstream spawning grounds from June through September. The majority of adult Cedar and Sammamish River Chinook

[15] NMFS's 2006 review of Chinook salmon distinct independent populations in Puget Sound determined that of the Chinook salmon utilizing Lake Washington, only the Sammamish and Cedar River Chinook salmon populations were sufficiently distinct. The Sammamish River DIP includes the North Lake Washington Chinook salmon population. Issaquah Creek fall-run Chinook salmon were of Green River stock (NMFS 2006).

salmon traverse the Ballard Locks in August, and are thought to navigate through the Ship Canal in a matter of days (Seattle Public Utilities and Corps 2008). Juvenile PS Chinook salmon from the Lake Washington system typically outmigrate through the Lake Washington Ship Canal from May to August, with peak out-migration from late May to early June (DeVries et al. 2005; 2007; 2008). Juvenile PS Chinook spend a few hours to 1 week or more in Salmon Bay as they outmigrate past the Zone 3 Program Area (Celedonia & Tabor 2010).

In Zone 3, PS steelhead from the winter-run Cedar River DIP and winter-run North Lake Washington and Sammamish DIP are most likely (WDFW 2024). Adult abundances for both of these DIPs is near zero based on fish ladder and redd counts; however, large numbers of resident O. mykiss are found in the Cedar River (Cram et al. 2018). Fifteen-year abundance in the Cedar River is trending very negative (-0.11); data was insufficient to calculate this statistic for the North Lake Washington and Sammamish DIP (Ford 2022). Winter steelhead from Lake Washington return from Puget Sound through the Ship Canal beginning in October (NMFS 2005) and continuing through winter and early spring (SPU & Corps 2008), with most migrating between January and March (Gearin et al. 1988) (WRIA 8 2024). Juvenile steelhead outmigrate to Puget Sound through the Ship Canal during May and June (SPU & Corps 2008 and references therein), potentially through early July (Kerwin 2001). Juveniles and move through the Ballard Locks in only hours or days (SBE 2015).

Within the action area, the Seattle Project Area contains PS steelhead critical habitat in West Waterway (Zone 1; estuarine) and the LDR (Zone 2; riverine).

Adult PS steelhead occupy deep water and do not typically rely on nearshore habitats. The nearshore migration patterns of PS steelhead are not well understood, but it is generally thought that smolts move quickly offshore and make only ephemeral use of nearshore marine waters, unlike most other Pacific salmonids (e.g., PS Chinook salmon). Studies of steelhead migratory behavior strongly suggest that juveniles spend little time in estuarine and nearshore areas and do not favor migration along shorelines. Therefore, unlike for PS Chinook salmon, there are not specific estuarine or nearshore areas within the action area or either Project Area where PBFs essential to PS steelhead conservation are found (78 FR 2726).

We expect adults to migrate through Zones 1, 2, and 3 during the summer, fall, or winter of their upstream spawning migration, coinciding with the IWWW. Juveniles are expected to outmigrate through Zones 1, 2, and 3, from May through early July. We do not expect significant numbers of juvenile PS steelhead to be present in the Seattle Project Area within the IWWW because steelhead smolts tend to move offshore and migrate rapidly though Puget Sound after leaving freshwater (Goetz et al. 2015; Quinn 2018).

A WSDOT study found ambient background noise in Seattle to be as high as 141 dB (Laughlin 2015); however, another study by Washington State Ferries reported daytime broadband underwater noise levels of 120 dB in Seattle/Elliott Bay (Laughlin 2020). Therefore, ambient underwater noise near the Port’s facilities is conservatively estimated to be an approximate minimum of 120 dB.

2.3.1. Tacoma Project Area

Tacoma's proposed work is to occur within the Port of Tacoma in Pierce County, Washington (*Figure 9*). It is located in Water Resource Inventory Area (WRIA) 10 – Puyallup/White and the Puget Sound Hydrologic Unit Code (HUC) #17110019. The Program includes work in and adjacent to Commencement Bay; the adjacent busy industrial shipping channels of Blair Waterway, Hylebos Waterway, Sitcum Waterway, Thea Foss Waterway, and Wheeler-Osgood Waterway; and tidally influenced portions of the Puyallup River, Hylebos Creek, and Wapato Creek.

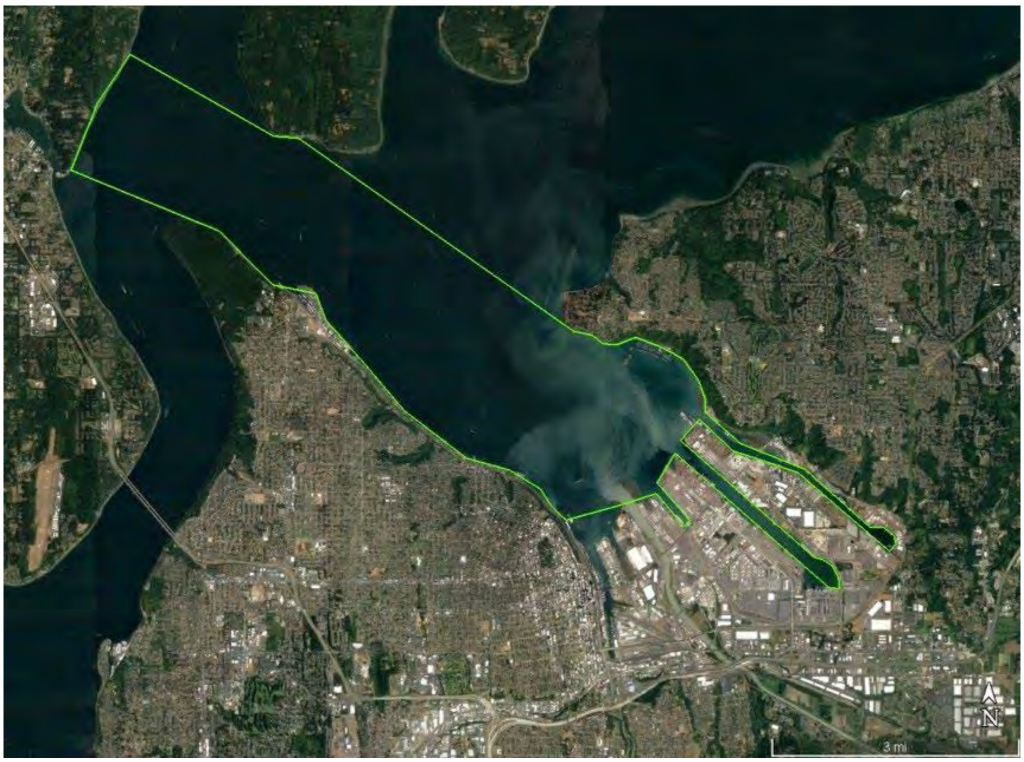

Figure 9. Tacoma Project Area (Port of Tacoma 2024a)

The Tacoma Program Footprint (i.e., the immediate vicinity where in-water and over-water project activities will occur at discrete Port facilities shown in *Figure 10*. The Program encompasses activities at 34 discrete properties owned by the Port in Tacoma, Pierce County, Washington. Facilities considered in this BE include portions of Sections 22, 26, 27, 28, 33, 34, 35 and 36 of Township 20N and Range 03E, and Sections 01, 02, and 04 of Township 20N and Range 03E. Mitigation opportunities exist throughout Commencement Bay.

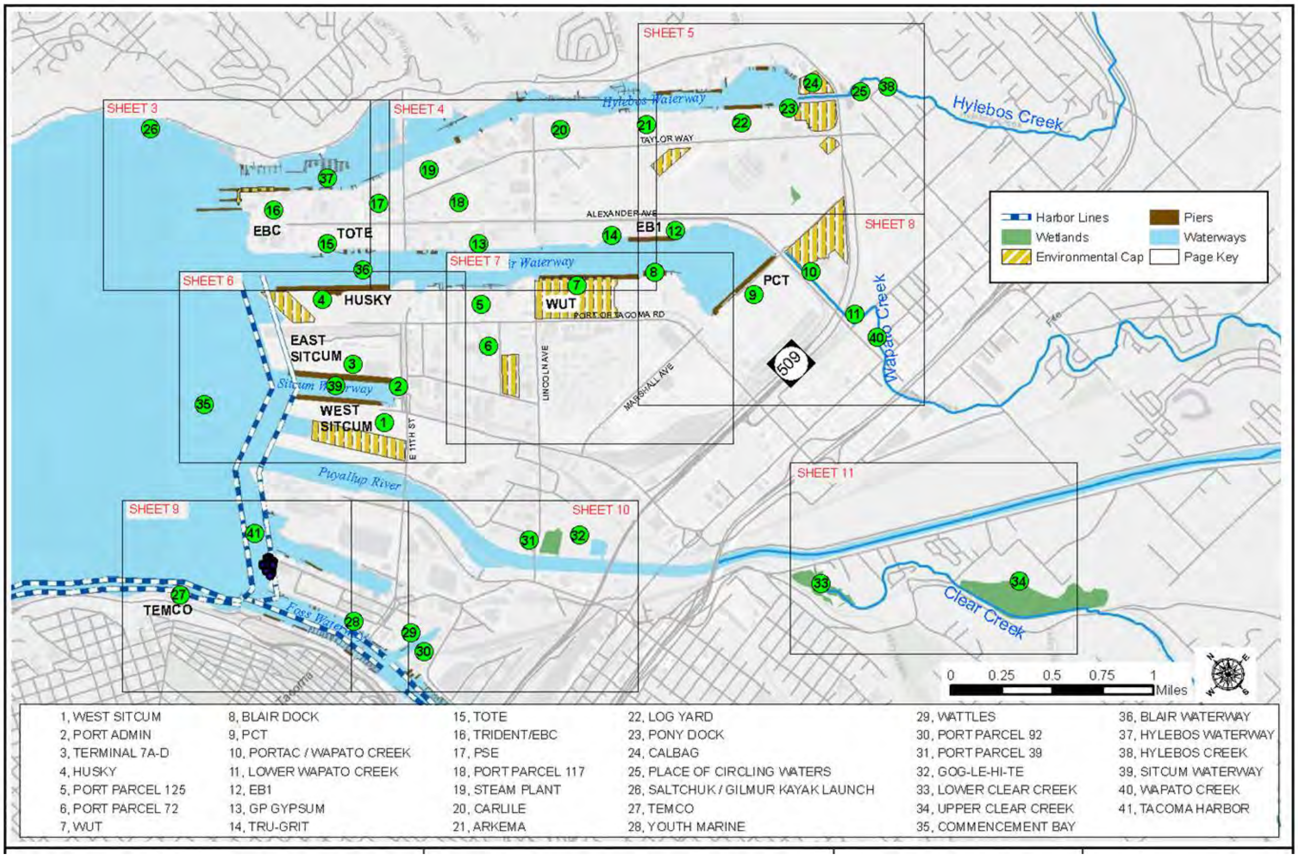

Figure 10. Map of Port of Tacoma Facilities (Port of Tacoma 2024b)

Commencement Bay is located in southern Puget Sound. The depth of sea floor in most of Commencement Bay ranges between 98 and 330 feet, but maximum depths can reach over 600 feet (Corps 2019). Tides in Commencement Bay are mixed semidiurnal type; the mean diurnal tidal range published by the National Ocean Survey is 8.06 feet, and the great diurnal tidal range is 11.77 feet (Corps 2019).

The outlet of the Puyallup River and the industrial waterways are located in the southern and easternmost extent of Commencement Bay within the Tacoma Tideflats. The present-day outlet of the Puyallup River is situated between the Middle and Sitcum Waterways. The Lower Puyallup River is defined in this document as the area between RM X and X, within the salt water wedge and area of tidal influence. This area of the Puyallup River was channelized and diked by USACE in 19XX. The Puyallup River discharges sediment into Commencement Bay at an estimated rate of 1,000,000 tons per year (Czuba and others, 2010).

Presently the Hylebos, Blair, Sitcum, St. Paul, Middle, and Thea Foss Waterways cut through tideflats from north to south. Each of these waterways are oriented from the southeast to the northwest, with the mouths of each waterway terminating in Commencement Bay. Additionally, the Wheeler-Osgood Waterway is connected to the east side of the Thea Foss Waterway at approximately its midpoint, and runs east-west (EPA 2020). In Table 10, we summarize information on the waterways from EPA's CBNT 5-year review (2020), Port bathymetry records, and other sources as noted.

Table 10. Summary of the industrial waterways within the Tacoma Project Area.

Waterway	Approximate Length	Approximate Width (feet)	Current Depth (feet MLLW)	Authorized Depth (feet MLLW)	Habitat Notes
Hylebos	3 miles	300 to 600 feet	-27.1 to -28.3	-30.0	
Blair	2.75 miles	330 to 1300	-49.3 to -49.6	-51.0	
Sitcum**	3,000 feet	750	-37.1 to -46.6	-51.0	
St. Paul	2,000 feet	500	-10 to -30	N/A	
Middle	3,500 feet	300	-10 to -33	N/A	The waterway is shallow, with nearly the entire inner (southern) half composed of intertidal mudflats. Two mudflat, saltmarsh, and riparian zone remediation projects have been constructed in the inner portions of the waterway Hart Crowser 2003.
Thea Foss	1.5 miles	394 to 745	-10 to -36	N/A	Hart Crowser 2003
Wheeler-Osgood	0.3 miles	225	0 to -6 ***	N/A	Hart Crowser 2003

*The current depths are adapted from the NWSA Bathymetric Survey and Puget Sound Pilots 9/15/2020 Least Depth Summary. The information here may not reflect current conditions due to the dynamic nature of underwater topography.
**EPA ESD Sitcum
*** NOAA ENC chart

Within the Tacoma Project Area, the Puyallup and White River distinct independent populations (DIPs) of PS Chinook and PS steelhead are expected to be the most prevalent ESA-listed fish populations exposed to project effects (see Section 2.2.1 for additional detail).

Commencement Bay, Port Waterways, and Lower Puyallup River

Similarly, over the past 120 years, human development has replaced almost all the natural habitat in the Tacoma Project Area. The present environmental baseline conditions of the Project Area are impacted by urban growth and railroad, shipping, logging, agriculture, and other industrial development.

The growth and development of Tacoma, its port, and the surrounding region, has subjected the Project Area to dramatic environmental changes, primarily from dredging and filling the estuarine delta of the Puyallup River. The Port waterways were constructed by filling and dredging channels through the tidal marsh that had developed on the shelf of the Puyallup River Delta beginning in 1874 (Corps 2022), and continuing through the late and early 1900s (Corps et al. 1993). Continuing habitat alterations such as dredging, relocation, and diking of the Puyallup

River; dredging/construction of the waterways for purposes of navigation and commerce; steepening and hardening formerly sloping and/or soft shorelines with a variety of material; and the ongoing development of the Port of Tacoma and other entities, has resulted in substantial habitat loss (Sherwood et al. 1990; Simenstad et al. 1993). Historically, intertidal mudflats covered an estimated 2,100 acres of Commencement Bay. In 1992, approximately 180 acres remained (Corps et al. 1993). In this region, over 98 percent of the historical Puyallup River estuary wetlands, and 70 percent of estuarine wetlands, have been lost over the past 125 years (Graeber 1999).

Intertidal habitat along the shorelines has been limited and fragmented by shoreline armoring, shoreline modification, and overwater structures. Nearly all of the Project Area shorelines have been highly altered to provide bank protection using riprap and other materials (Ecology 2024; Figure 11). The majority of shorelines are more than 81 percent modified (Ecology 2024; Figure 12). Overwater structures are prevalent, particularly within the waterways where large piers for ship loading dominate the intertidal area. Based on shoreline surveys and aerial photo interpretation of the area, approximately 5 miles (20 percent) of the Commencement Bay shoreline is covered by wide over-water structures (Kerwin 1999).

Figure 11. Shoreline armoring in the Tacoma Project Area (Ecology 2024).

Chemical contamination has also compromised intertidal and subtidal habitat suitability in the Project Area (Corps et al. 1993; USFWS & NOAA 1997; Collier et al. 1998). In 1983, the EPA listed the Commencement Bay/Near Shore/Tideflats (CB/NT) site on the federal Superfund National Priorities List Superfund due to widespread contamination of the water, sediments, and upland areas (EPA 2024). As a result of this, the cleanup of contaminants has been a high priority. As a result of significant dredging, capping, and monitoring of contaminated sediment, the EPA has partially deleted the Blair Waterway and St. Paul Waterway from the NPL; the Thea Foss Waterway, Middle Waterway, and Olympic View Resource Area are ready to be partially deleted from the NPL (EPA 2024). Areas still requiring remedial activities include the Hylebos Waterway and Sitcum Waterway. Source control actions have been completed for the Blair Waterway and St. Paul Waterway, and are tentatively complete in the Thea Foss Waterway, Middle Waterway, and Sitcum Waterway; source control actions need to be completed in the Hylebos Waterway at the Arkema and Occidental Sites (EPA 2024). Remedial activity continues at the Tacoma Tar Pits, and the Asarco Smelter, Off-property, Groundwater and Sediment, and Demolition Operable Units (EPA 2024). Although there are long-term benefits to remedial action, the presence of construction over many years has further temporarily fragmented the area of available habitat.

The majority of remaining mudflat habitat is located near the mouth of the Puyallup River, within the Hylebos, Middle, Milwaukee, St. Paul, and Wheeler-Osgood Waterways (Corps et al. 1993; USFWS & NOAA 1997).

With the exception of relic areas and constructed habitat sites, habitat along the waterway shorelines is highly limited and fragmented. The historical migration routes of anadromous salmonids into off-channel distributary channels and sloughs have largely been eliminated, and historical saltwater transition zones are lacking (Kerwin 1999). Shorelines are nearly all armored with artificial side slopes of 2H:1V, and little to no nearshore riparian vegetation is present to support water quality or forage. Industrial overwater structures that inhibit migration and impervious surfaces that produce stormwater runoff are prevalent in the waterway uplands.

Despite extensive alterations and impacts to the Tacoma Project Area, some species use the remaining intertidal and subtidal habitat (USFWS & NOAA 1997). Rearing and foraging by juvenile salmonids occurs along the limited shoreline areas that are shallow or retain natural structural diversity. Juvenile salmonids may use the nearshore reaches and Commencement Bay to transition into marine waters. Returning adult salmon typically congregate at the mouth of the Puyallup River prior to upstream migration. Some estuarine and marine fish and subtidal marine invertebrates inhabit and feed at deeper subtidal elevations within the Tacoma Project Area. However, the depths of the constructed waterways are not commonly habitat that salmonids select for feeding or refuge. Additionally, invertebrates found to inhabit the substrate of the Blair Waterway, such as polychaet and nematode worms, do not contribute significantly to the salmonid food chain (Hiss and Boomer 1986).

The populations of ESA-listed salmonids most likely to occur in The Tacoma Project Area /be exposed in greater numbers or for more duration than other populations are Puyallup, White, and Carbon Rivers Winter steelhead, along with Puyallup River fall Chinook salmon, and White River spring Chinook salmon. This portion of the action area includes riverine critical habitat for PS steelhead at the outlets of Hylebos and Wapato Creeks and in the Puyallup River. These areas are unsuitable for spawning due to saltwater intrusion and tidal influence, so no PBFs for spawning are present in the action area (Table 1). Commencement Bay is a documented rearing and migration corridor for chinook salmon (PIE 1999; WDFW and VVW'TIT 1994; Duker et al.1989; Simenstad et al. 1982; Simenstad 2000).

Adult Chinook salmon returning to spawning grounds would typically be oriented to the outflow of the Puyallup River. Chinook salmon use of the Blair Waterway is up to three times greater near the mouth of the waterway than near the head, where they are found in very low numbers (Duker et al. 1989); this preference is likely true for each of the waterways within the Tacoma Project Area. We expect adult PS Chinook fall-run salmon to occur in Commencement Bay and in the deep, open-water areas around the heads of the waterways during the winter of their upstream spawning migration, and that they would be present in the waterways temporarily and in small numbers. Juvenile Chinook salmon typically use shallow water marine habitats to rear, grow, and feed; however, habitat features that support these uses in the Tacoma Project Area were largely eliminated during industrial development of the estuary, thus juveniles are not expected to spend significant time within the waterways, though they could potentially rear within the nearshore waters of Commencement Bay. PS Chinook salmon have also been documented in Hylebos Creek (via Hylebos Waterway) (SalmonScape[16]).

Both the fall-run Puyallup River and the spring-run White River Chinook salmon populations are small, with historical total annual abundance fluctuating around 1,400 to 1,800 fish (Ford 2022). Since the late 1990's, natural origin spawner abundance has declined for both MPGs, meaning that populations are highly reliant on hatchery supplementation. The 15-year abundance trends are is negative for both the fall-run Puyallup River and White River DIPs (-0.06 and -0.02, respectively; Ford 2022). Productivity does not meet replacement levels goals for either population, and has dropped consistently since the late 1980s. White River spring Chinook salmon are critical to the ESU as they are the only remaining spring stock in the south/central Puget Sound region (Marks et al. 2018, Ruckelshaus et al. 2002, NWFSC 2015, Ford 2022).

Adult spring Chinook salmon migrate through Commencement Bay to spawning habitat in the headwaters of the Puyallup River Basin from April (sometimes even March) and hold in the river through the summer, while adult fall Chinook salmon generally enter the Puyallup River from June through early November (Marks et al. 2022).

Adult steelhead most likely use the waterways as holding areas before they enter migration corridors, and would be oriented to the outflow of the Puyallup River. Adult steelhead are expected to occur in the deep, open-water areas of Commencement Bay and the waterways during the winter of their upstream spawning migration. Mainstem spawning occurs as low as RM 10 in the Puyallup River and RM 3 on the Carbon River (Pierce County 2013). Juvenile PS steelhead are not anticipated to be in the nearshore zone of the Tacoma Project Area in large numbers, because the majority of steelhead smolts migrate directly to the open ocean and do not rear extensively in the estuarine or coastal environments (Burgner et al. 1992; Goetz et al. 2015). In addition to the Puyallup River and Commencement Bay, PS steelhead have been documented in Wapato Creek (via the Blair Waterway) and Hylebos Creek (via Hylebos Waterway) (SalmonScape[17]).

Three distinct PS steelhead populations occur in the Puyallup River Basin local to the Tacoma Project Area: winter-run Carbon, Puyallup, and White River steelhead (Ford 2022; WDFW

[16] http://apps.wdfw.wa.gov/salmonscape/
[17] http://apps.wdfw.wa.gov/salmonscape/

2024) (Hard et al. 2015; WDFW 2015). PS Steelhead in this basin are generally exhibiting positive increases in abundance. The Carbon Puyallup River and DIPs exhibited 153 and 136 percent increases in 5-year abundances, respectively, while the White River DIP abundance decreased by 12 percent (Ford 2022). Fifteen-year abundance trends and recent productivity is also predominately positive for all 3 DIPs. Abundances for the White and Puyallup River winter-run DIPs remain in the low hundreds and continue to be at some demographic risk, although estimates include counts from only portions of the DIPs. Further, abundances for the Puyallup/Carbon River DIP include data series for the Puyallup and Carbon Rivers that could not be combined due to differences in survey protocols.

Adult PS steelhead typically are most likely to be in the Tacoma Project Area January to April. They enter the river in January and then hold until moving to spawning grounds between March and June (NMFS 2005b). The work window avoids most adult steelhead presence, but does not avoid all exposure to migrating individuals between January and February 15.

Juvenile steelhead outmigration in the Puyallup River system generally occurs between April and July (Berger et al. 2011). However, steelhead smolts have been found in low abundances in the marine nearshore, outside of their natal estuary, between May and August (Brennan et al. 2004), and rearing juveniles could be present in Commencement Bay or adjacent waters of Puget Sound at any time of the year in low numbers. The work window would minimize overlap of temporary construction effects with the presence of juvenile PS steelhead in the Tacoma Project Area, but would not avoid all exposure to a small number of individuals that may be present.

2.4. Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action but that are not part of the action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.02).

The effects of those activities that are described as unlimited in Tables 2 and 3 in the Proposed Action section above, all fall within the categories of effects discussed below but are not expected to be meaningful in scope or scale, even in the aggregate. For this reason, the effects of these activities will not be separately discussed but have nevertheless been factored into our ESA analysis and conclusions.

The proposed action anticipates that there may be minor alterations to project activities or to avoidance and minimization methods, or to best management practices. Such alterations can only be made in circumstances where it is infeasible or impracticable to conform with the specifications laid out above and/or if best available science supports an altered approach and/or if the minor alteration was requested by Tribes for consistency with Tribal treaty agreements or cultural resource needs and/or if the work is urgently needed to address unforeseen damage or loss of equipment or infrastructure – and if the minor alteration is consistent with the overall parameters and purpose of the proposed action. Moreover, minor alterations are limited to those that are very small in scope or scale, and do not represent a significant change to what is otherwise set out in this proposed action – and must be verified by NMFS. Accordingly, as a general matter, NMFS does not anticipate that effects from any minor alterations to be significant. Nevertheless, in analyzing the effects of the action, NMFS has taken into account the possibility of such minor alterations.

2.4.1 Temporary Effects

Temporary effects are typically associated with construction of maintenance activities and repair or replacement activities. Despite the use of avoidance and minimization measures in design and construction, effects are likely to include (a) water quality reductions; (b) increased noise in the aquatic environment; (c) reduction of prey/forage (benthic prey, forage fish, prey fishes) and (d) shade. The duration of these effects is typically co-occuring with the activity, and ceasing either with the activity (as in the case of noise) or promptly there after (e.g. hours for suspended sediment, weeks to months for prey reductions). Additionally, dredging activities can entrain fish.

Proposed In-Water Work Window

Both Ports propose to conduct the majority of in-water construction inside the marine and freshwater in-water-work windows (IWWW), described in WAC 220-660-330[18] and WAC 220-660-110[19]. Minor modifications of in-water work up to two weeks outside the work window for specific projects may occur, with NMFS' review.

Activities that may occur year-round, not limited to the IWWWs, would not occur in the water, or would have extremely limited in-water construction effects with proposed BMPs.

Any work exceeding the in-water work window as outlined in the Minor Alterations section of the proposed action (1.3.4) would require verification by NMFS prior to construction. Such IWWW extension will avoid and minimize exposure through use of additional marine mammal and fish monitoring as needed on a site-specific basis. Coordination with a NMFS biologist will ensure that effects to species and critical habitat will be avoided or insignificant.

All temporary (construction) effects to critical habitat and listed species analyzed below would be constrained to the IWWW, subject to any authorized two-week modifications. Long-term effects of the proposed action would endure in critical habitat and affect all life stages of each species present in the action area regardless of an IWWW for construction.

Though the IWWW limits exposure to construction effects, it does not avoid effects to species. Tables below summarize when listed species and life stages are likely to be present in the action area, relative to the proposed IWWWs.
We expect PS Chinook salmon to be present within the Seattle Project Area during the time periods identified

[18] https://app.leg.wa.gov/WAC/default.aspx?cite=220-660-330
[19] https://app.leg.wa.gov/WAC/default.aspx?cite=220-660-110

Table 11. In some cases, peak presence of PS Chinook salmon are expected to be coincident with the designated in-water work window (IWWW) for activities conducted under the proposed action. The lifestages of local distinct population segments likely to be present (described above) are most likely to be exposed to effects of Seattle's proposed action during this time period.

The work window avoids adult spring Chinook salmon presence, but does not avoid all exposure to migrating adult fall Chinook salmon between July and November. Puyallup Tribal Fisheries Department have observed juvenile Chinook salmon emigrating from the lower Puyallup River (RM 10.6) as early as January and as late as August, with outmigration peaking strongly in late May (Marks et al. 2018). Marks et al. (2018) suggests that Chinook salmon fry and sub-yearlings that out-migrate past the Puyallup River before June spend more time in the lower Puyallup River to become acclimated to the salinity. Historic (1980 to 1995) beach seine sampling in the Blair Waterway generally captured juvenile Chinook salmon after mid-February and before mid-August, with a peak around the end of May (Pacific International Engineering 1999). Consequently, proposed activities in January and February have limited overlap with early-migrating juvenile Chinook salmon, because many would still be rearing in the lower Puyallup River. Therefore, we expect the work window restriction minimizes the overlap of temporary construction effects with most out-migrating and rearing juvenile Chinook salmon in Commencement Bay and waterways, but does not avoid all exposure to late-migrating individuals between July 15 and mid-August. A summary of PS Chinook salmon presence within the Tacoma Project Area and coincidence with the IWWW is provided in Table 12, below.

The IWWW avoids the earliest and largest density peaks of rockfish in May, but overlaps with the second rockfish spawning event in August or September. Given the duration of time larvae drift, it is possible that larval rockfish of either species will be present during construction.

Table 11 Expected peak PS Chinook salmon presence in Seattle Project Area compared to IWWW restrictions

IWWW Zone	Adult	Juvenile	Work Window	Presence of PS Chinook during IWWW
Marine (Elliott Bay, Puget Sound) including the East and West Duwamish Waterways	June - October	Any	August 1 - February 15, except for dredging, which is September 1 - February 15	Avoids peak juvenile outmigration Does not avoid juveniles foraging or holding in Elliott Bay, or migrating adults between August and October
Tidally influenced portions of the Duwamish River (RM 0.0 to RM 5.0)	June - October	February - July	August 1 - February 15, except for dredging, which is October 16 - February 15	Avoids peak juvenile outmigration Does not avoid migrating adults between August and October
Freshwater (Salmon Bay and Lake Washington Ship Canal)	June - September	May - August	October 1 - April 15	Peak exposure is not expected

Table 12 Expected peak PS Chinook salmon presence in Tacoma Project Area compared to IWWW restrictions

Adult	Juvenile	Work Window	Presence of PS Chinook during IWWW
Fall run: June - October Spring run: April - May	Mid-February to mid-August, with a strong peak around the end of May	July 15 - February 15	Avoids adult spring Chinook salmon Does not avoid all exposure to migrating adult fall Chinook salmon between July and November, or exposure to late-migrating juveniles between July 15 and mid-August.

Table 13. Summary of species and life stages most likely present in the Seattle Project Area, X= likely present

Month	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Marine IWWW	**X**	**X**					**X**	**X**	**X**	**X**	**X**	**X**
Fall run Green River Chinook salmon - Adult						*x*	**X**	**X**	**X**	**X**		
Fall run Green River Chinook salmon - Juvenile		**X**	*x*	*x*	*x*	*x*	**X**	**X**	**X**	**X**		
Fall run Cedar and Sammamish Chinook salmon - Adult						*x*	**X**	**X**	**X**			
Fall run Cedar and Sammamish Chinook salmon - Juvenile			*x*	*x*	*x*	*x*	**X**	**X**				
Winter Green River steelhead - Adult	**X**	**X**	*x*									**X**
Winter Green River steelhead - Juvenile			*x*	*x*	*x*	*x*	**X**					
Summer Green River steelhead - Adult								**X**	**X**	**X**	**X**	**X**
Summer Green River steelhead - Juvenile			*x*	*x*	*x*	*x*	**X**	**X**				
Winter Cedar River, North Lake Washington, Sammamish steelhead - Adult	**X**	**X**	*x*							**X**	**X**	**X**
Winter Cedar River, North Lake Washington, Sammamish steelhead - Juvenile					*x*	*x*						
Rockfish - Adult	**X**	**X**	*x*	*x*	*x*	*x*	**X**	**X**	**X**	**X**	**X**	**X**
Rockfish - Juvenile				*x*	*x*	*x*	**X**	**X**	**X**	**X**		
SRKW	**X**	**X**	*x*	*x*	*x*	*x*	**X**	**X**	**X**	**X**	**X**	**X**
Humpback Whale	**X**	**X**	*x*	*x*	*x*	*x*	**X**	**X**	**X**	**X**	**X**	**X**

Table 14. Summary of species and life stages most likely present in the Tacoma Project Area

Month	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
IWWW	**X**	**X**					**X**	**X**	**X**	**X**	**X**	**X**
Spring White River Chinook salmon - Adult				*x*	*x*							
Spring White River Chinook salmon - Juvenile	**X**	**X**	*x*	*x*	*x*	*x*	**X**	**X**				
Fall Puyallup Chinook salmon - Adult						*x*	**X**	**X**	**X**	**X**	**X**	
Fall Puyallup Chinook salmon - Juvenile	**X**	**X**	*x*	*x*	*x*	*x*	**X**	**X**				
Winter Carbon, Puyallup, and White River Steelhead - Adult	**X**	**X**	*x*	*x*								
Winter Carbon, Puyallup, and White River Steelhead - Juvenile			*x*	*x*	*x*	*x*	**X**	**X**				
Rockfish - Adult	**X**	**X**	*x*	*x*	*x*	*x*	**X**	**X**	**X**	**X**	**X**	**X**
Rockfish - Juvenile				*x*	*x*	*x*	**X**	**X**	**X**	**X**		
SRKW	**X**	**X**	*x*	*x*	*x*	*x*	**X**	**X**	**X**	**X**	**X**	**X**
Humpback Whale	**X**	**X**	*x*	*x*	*x*	*x*	**X**	**X**	**X**	**X**	**X**	**X**

2.4.2 Enduring and Intermittent Operational Effects

Enduring and Intermittent effects include ongoing activities and structures with the potential to impact protected critical habitat and/or species that are reasonably likely to occur as a result of the additional life span and operation of Port facilities, and would not occur but-for the proposed action. Enduring effects, or long-term effects, are a function of exposure and response to physical, chemical, or biological changes associated with the proposed action on the environmental baseline that are likely to last for months, years or decades.

The proposed action includes repair and replacement, and maintenance of dredged areas for vessel ingress, egress, docking, and berthing. In- and overwater structures and nearshore structures influence habitat functions and processes for the duration of the time they are present in habitat areas. The effects include: (a) altered predator/prey dynamics; (b) disrupted migration; and (c) modified estuarine habitat processes from bank armoring. These effects are chronic, persistent, and co-extensive with the life of the structures.

Port structures support varying levels of water dependent industrial and commercial activities, producing several types of episodic habitat effects, which will occur while the structures are present in the environment: (a) water quality reductions from vessel use and discharge of stormwater from pollution generating impervious surfaces; (b) noise from vessel operation; (c) scour from vessel operation. Each are episodic and persistent effects, coextensive with the respective design lives of the expanded[20], repaired or replaced wharfs, piers, docks, floats, and structures.

Figure 12 illustrates how NMFS interprets the long-term effects of repair and replacement of structures on habitat under the proposed action in highly modified industrial areas. The Port of Tacoma and Seattle exist within highly modified estuarine port environments that are degraded by industrial infrastructure with long design lives. The effect of this port-wide degradation is illustrated as the difference in habitat condition (Y-axis) between the modified maximum site potential and the fully functioning habitat. The modified maximum site potential is the habitat condition in the immediate area of the structure if it were removed. The maximum site potential is generally lower than fully functional habitat because the surrounding port-wide degradation slows site-specific recovery within the foreseeable[21] future. The modified maximum site potential is used to help determine the modified actual site potential[22]. We based impact determinations of long-term effects of repair and replacement on the modified actual site potential which describes the habitat condition that likely develops within the foreseeable future with the structure degrading in place.

We visualize the effect of the action in the orange box. It shows how both the existing structure and the surrounding degraded condition limit recovery in the foreseeable future to the level of the actual site potential. The area in the box represents the effect of delaying the onset of habitat-forming processes caused by the proposed action.

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[20] Limited to 1 percent.
[21] For the Port Calculator, the foreseeable future is 300 years, see Appendix A.
[22] For details see Appendix A

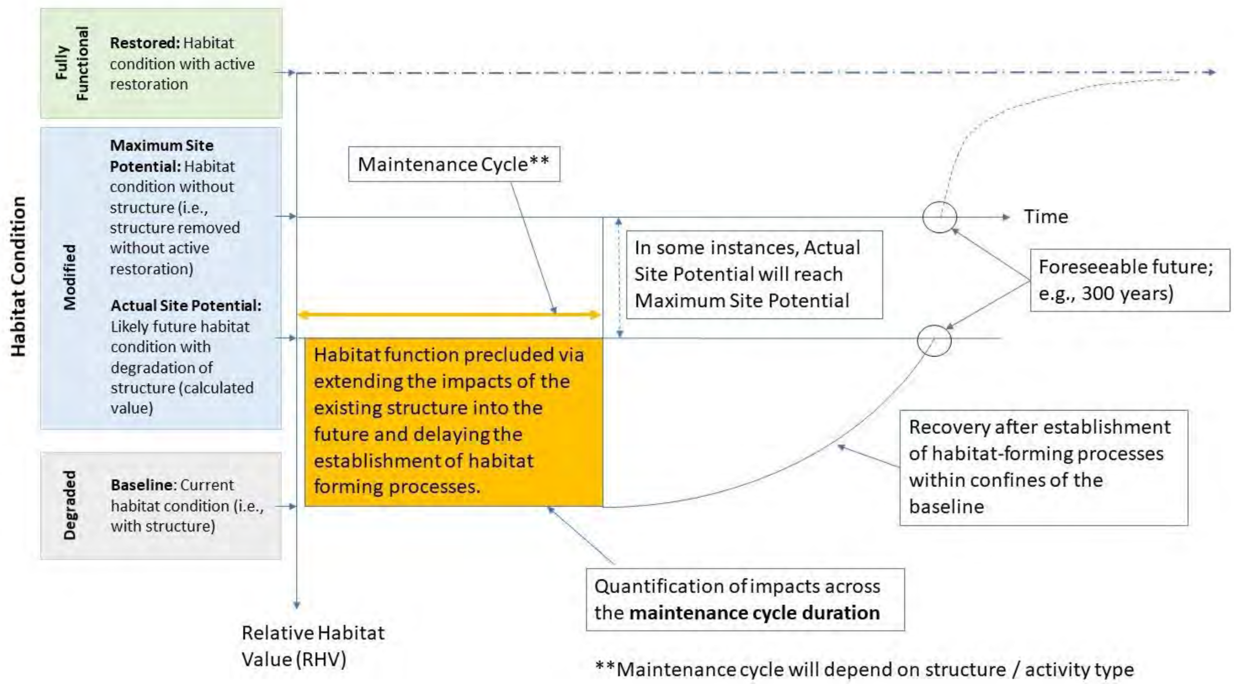

Figure 12. Illustration of the effects of the proposed action in a highly modified environment. Note difference between the fully functional line (top) and the maximum site potential below it.

2.4.3 Effects on Critical Habitat

Critical habitat for PS Chinook salmon, PS steelhead, PS/GB bocaccio, and SRKW, all occur within the action area. NMFS reviews effects on critical habitat affected by a proposed action by examining how the PBFs of critical habitat will be altered, and the duration of such changes, and the influence of these changes on the potential for the habitat to serve its functional role to the species.

In the action area for the proposed actions for both Ports, the features of designated habitat common to each of the species area:

1. water quality
2. forage or prey.

Features of designated critical habitat common to PS Chinook salmon, PS steelhead, and SRKW are:

1. safe migration/unobstructed migratory corridor

Features of designated critical habitat common to PS Chinook salmon, and juvenile PS/GB bocaccio:

1. conditions supporting juvenile growth and maturation (G&M)

Other features of critical habitat for these species are not affected by the proposed action.

In this section, we evaluate the effect pathways of the proposed action identified above in terms of the function of critical habitat on the conservation role of habitat. NMFS reviews effects on critical habitat by examining how the PBFs of critical habitat will be altered, 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. The features of the designated critical habitat in estuaries are particularly important to support growth, physiological transition, and maturation of salmonids.

Table 15. Effect pathways affecting PBFs common to all designated critical habitats

Effect Pathway	**(1) Water Quality** (all species)	**(2) Prey** (all species)	**(3) Passage/Safe Migration and G&M** (PS Chinook salmon, PS steelhead, SRKW)
a) Noise	X	X	X
b) Shade/ALAN		X	X
c) Water quality	X	X	X
d) Loss of habitat	X	X	X
e) Habitat Improvements	X	X	X

G&M: growth and maturation

The USACE's issuance of permits will authorize a suite of activities with effects on critical habitat ranging from temporary (typically related to the impacts of construction activity), to persistent and intermittent (from the use or operation of the permitted structures, including impacts from associated vessel use), to enduring (from effects of the structures on the environment and their impacts on habitat features that might be diminished). Table 16 summarizes the activities and the effects that will result.

Table 16. Actions and Effects pathways (T= temporary, I = Intermittent, E = enduring)

Proposed Activity	**a) Noise**	**b) Shade or night time light**	**c) Water Quality**	**d) Loss of Habitat**	**e) Forage Reduction**
Pile replacement	T	E	T	E	I
Pile repair	T	E	T	E	I
Replace/repair minor pile accessories (including pile jackets)	T	E	T	E	I
Fender systems and rub strips		E			
Cathodic protection systems			I		I
Overwater coverage replace/repair		E		E	
Marina piers, ramps (gangways), and float assemblages		E			E
Boathouses and covered moorage		E			E
Safety platforms		E			
Safety ladders and fencing		E			
Shoreline stabilization repair/replacement			T	E	E

Proposed Activity	a) Noise	b) Shade or night time light	c) Water Quality	d) Loss of Habitat	e) Forage Reduction
Maintenance dredging	T		T	I	T
Sediment/geotechnical sampling	T		T		T
Outfall and tide gate repair or replacement			T		E
Outfall and tide gate cleaning/maintenance			T		
Boat ramps				E	E
Navigational aids		E			X
Under-pier utilities					
Subtidal utility cables			T	T	T
Bollards/cleats/walers/ berthing hardware					
Bull rails					
Crane rails					
Existing paved/impervious surfaces			I		
Exterior building repair					
Light poles		E		E	
Navigation lights		E		E	
Safety and security equipment (incl. fencing)		E			
Utilities					
Construction barges (two barges and two tugs)	T	T			
Vessel traffic	I	I			E
Stormwater effluent generation			I		I
Alternative (soft or hybrid) bankline stabilization			T		T
Beneficial overwater structure removal		T	T		T
Beneficial pile removal	T		T		T
Beneficial debris removal			T		T
Other beneficial activities (see section 1.3.1)			T		T

The USACE permits will ensure the appropriate design criteria to avoid and minimize effects are incorporated into all phases of design for each authorized project under the action categories above. Following the receipt of their respective comprehensive permits, the Ports will provide NMFS information on specific activities as they occur annually. This will include a quantification of long-term habitat effects (positive and negative) using the Ports' Calculator as described in the proposed action including the Credit Savings Instrument (Appendix B). The verification step ensures projects meet all the applicable design criteria and general construction measures, that metrics identified in the take statement at the section 3 of this document are not exceeded, and that the activities that proceed under the USACE's permits reduce long-term net loss of habitat features, quality, or quantity, and thus will not appreciably reduce the of conservation value for listed species and critical habitat.

The intention to offset long-term impacts on the quality of nearshore habitat in Ports' respective environments is an element of their respective proposed actions. All project types proposed, maintenance, repair, replacement, scientific sampling, and habitat improvement, are likely to have adverse temporary effects and many of the proposed activities will have intermittent and long term adverse effects to species and critical habitat. All of the activities intended to achieve habitat improvement are designed to have long-term beneficial effects to species and critical habitat. Habitat improvement activities are reasonably certain to lead to some degree of ecological recovery, including the establishment or restoration of environmental conditions associated with functional estuarine and nearshore habitat. The effects of proposed offsetting habitat improvements on listed fish and their habitat are discussed in detail below, but as a general matter:

- The removal of over-water structures reduces shade and decreases predation on juvenile salmonids.
- Removal of in-water structures such as treated-wood piles also removes habitat for piscine predators and eliminates persistent sources of contaminants.
- The removal of bank armor and replacement with hybrid or soft armor re-establishes access to prey and cover.
- The purchases of conservation bank credits will lead to improved habitat quality, but in some cases, the improvement may be off-site or out-of-kind.
- Similarly, contributions to in-lieu fee programs generally result in habitat improvements but the improvement can be delayed and are typically carried out off-site.
- Applicant responsible case-by-case compensatory mitigation for rare impacts in freshwater will address similar habitat features.
- At the Port of Tacoma, use of advance mitigation from the POCW offset the same features impacted.

a) Noise

Short-term noise during construction and long-term intermittent noise caused by vessel use would decrease the quality of critical habitat via impacts to forage and safe migration.

The Programs propose numerous in-water activities that include sound emissions that would impact PBFs of critical habitat. Noise is expected to reduce the quality of critical habitat during pile replacement (i.e., installation and removal), maintenance dredging, and geotechnical sediment sampling activities, and by activities that require a construction vessel (see tables below). Underwater noise will also be generated on an ongoing basis as a result of Activities that cause vessel traffic.

The proposed activities include BMPs to reduce temporary sound impacts (Section 1.3), including general construction measures such as preference for vibratory installation, working in the dry to the highest degree possible, use of sound attenuation on all steel impact driving, and monitoring for marine mammals during both vibratory and impact driving when sound would travel into open water (not in some locations in the LDW and Tacoma Narrows). The use of a confined or unconfined bubble curtain results in a 5-10dB reduction

During maintenance dredging, noise will be generated by the dredge bucket contacting the sediment. Dredging would generate noise levels lower than 120 dB_{RMS}, below the behavior threshold for marine mammals and fish[23], and thus is not discussed below.

Barges and tug vessels used for maintenance, repair, or replacement of overwater structures and are expected to have adverse effects. A maximum of two barges and two tugs will increase the amount of noise in an area surrounding each construction site and their transit paths

Water Quality - While aquatic habitat is disrupted by vibrations caused by noise, water is not chemically altered, and temperature is not modified by noise.

Prey - for PS Chinook salmon, forage fish may respond to elevated noise during pile replacement, maintenance dredging, or sediment sampling. Response may range from avoidance, to injury and death, depending on the size and lifestage of the prey fishes exposed. Benthic prey are not expected to be notably affected by noise. Noise could result in a temporary loss of foraging quality.

For SRKW, we expect construction noise could adversely affect a small number of juvenile PS Chinook salmon. However, the majority of effects would be sublethal to this prey source, and are not of a magnitude that will measurably affect the SRKW forage base, which is of adult salmon, among other fishes. Salmonids are known to detect and react to vessel noise, but most responses are behavioral. Noise from vessels are not expected to an observable reduction of prey for SRKW, but it does affect foraging behavior of this SRKW, and this is addressed in the effects on species section of this document.

Safe Passage/Migration - Temporary and ongoing noise may impact the migration value for species. For fish, there is some evidence that fish school less coherently in noisy environments and avoid areas where man-made noise levels are high (Slabbekoorn e al. 2010). The presence of sound could keep fish away from preferred spawning sites and change their migration routes (van der Knaap et al. 2022). The operation of construction equipment could cause PS Chinook and PS steelhead to avoid the area around the sound device which could constitute a temporary loss of foraging habitat and could temporarily affect migration patterns and access to breeding sites.

For fish, we expect temporary disruption of free passage for all species during elevated underwater sound levels produced by pile removal and installation. Because passage is obstructed by noise during the work window only, and even within that timeframe is not continuous but is interrupted by breaks in work, the values of critical habitat for all species are only slightly diminished by underwater noise, which will be small, localized, and intermittent. Geotechnical sediment sampling, dredging, and construction vessels will produce lower-level intermittent noise of short durations also temporarily and intermittently increase noise levels while operating at a construction site, and may result in avoidance but are not likely to significantly obstruct a migratory corridor for fish.

[23] The behavioral disturbance threshold for fish is 150 dB (NOAA Fisheries January 2023. National Marine Fisheries Service: Summary of Endangered Species Act Acoustic Thresholds (Marine Mammals, Fishes, and Sea Turtles))

PS steelhead estuarine designated critical habitat is located in Seattle Zone 1, and riverine designated critical habitat is located in Seattle Zone 2 and in freshwater areas of the Tacoma Project Area. Based on the site types and proposed activities in these locations, we expect construction noise to temporarily impact PS steelhead critical habitat as a result of Seattle's proposed action. Habitat reductions from noise are not expected to reach areas of PS Steelhead designated critical habitat as a result of Tacoma's proposed action.

Long Term Vessel Noise: Ongoing elevated underwater noise would occur year-round for the duration of the COE permits as a result of vessel traffic throughout the action area. The proposed action of maintaining both Port's facilities enables incoming and outgoing vessel traffic. Vessels used for a variety of purposes (commercial shipping, military, recreation, fishing, whale watching and public transportation) occur in inland waters of Puget Sound. Based on prior vessel noise studies in Admiralty Inlet (Bassett et al. 2012), vessel noise while transiting to and from the terminal will be detectable within the line of sight of each vessel in Puget Sound proper until it mixes with other vessel noise to reach ambient conditions. Travel in the action area is expected to be slow and to adhere to established USCG vessel traffic regulations, which is expected to minimize the noise. Vessel traffic is expected to be intermittent, and, as the Programs do not propose expansion to allow a greater number of vessels to call at any given time, an increase in the frequency or volume of noise from vessels is not anticipated in the project or action area. Many commercial vessels transiting to the Ports are adopting "Quiet Sound" guidelines that include increased slowdown and installation of quieter motors (Washington Maritime Blue 2022). This protocol may reduce noise from vessels using the Ports or contribute to minor reductions of the ambient commercial vessel noise level in the action area, but would likely be a very minor improvement. We expect vessels and listed species within the action area will be temporally and spatially dispersed to the degree that the perpetuation of noise attributable to these proposed actions are not measurable.

Vessel noise contributes to total effects on passage conditions in SRKW critical habitat, in particular. Data on commercial vessels reveals that in the Haro Strait, which runs between Vancouver Island and the San Juan Islands, container ships produce the highest underwater source levels at 178 underwater dB. Other ship types with source levels greater than 173 underwater dB include vehicle carriers, cargo ships, tankers, and bulk carriers (Viers et al. 2016). The average length of container and cargo ships traveling to inner Puget Sound ports is approximately 900 feet (COE 2022), so the noise levels the proposed action perpetuates are likely below those measured in this study. Current U.S. and Canadian SRKW management plans include measures to reduce disturbance from anthropogenic noise, such as mandatory minimum distances between vessels and killer whales. However, vessel speed, not distance, is the most important predictor of noise levels received by the whales (Holt et al. 2017; Houghton et al. 2015). For many ships in the Salish Sea, a 1 knot reduction in speed results in a 1 dB reduction in broadband source level (Viers et al. 2016). Williams et al. (2019b) found a 3dB noise reduction in Haro Strait could be met by enforcing a speed limit of 11.8 knots on container ships, vehicle carriers, passenger (cruise) and cargo ships, tankers, bulk carriers, and pleasure crafts. Vessels speeds and lanes are governed by the United States Coast Guard, which is not a party to this consultation. We expect that SRKW critical habitat will be episodically, and intermittently exposed to vessel noise as a result of the proposed action.

Construction Noise: Elevated underwater noise will occur during construction activities, including construction barge use, maintenance dredging, geotechnical sediment sampling, pile removal, and pile driving.

Construction barges and tugs will cause noise when in use. Tugboats have a dominant frequency range of 100-500Hz with a peak output at 170d$_{BRMS.}$ While performing construction activities, vessel movement will likely be infrequent, and consist of small adjustments in order to facilitate equipment access as work progresses. Noise will cease after construction is complete, and be limited to the IWWW. Due to their frequent movement, we do not expect any concern for impacts to fish from accumulated sound energy.

Geotechnical borings drill a small solid tube into the sediment, and may also hammer the sample tube into the sediment. Each boring is anticipated to take 15 to 30 minutes total. The number of blows needed for the tube to penetrate a fixed depth relates to the hardness of the ground (Erbe and McPherson 2017, p.142). Little acoustic data is available for in-water geotechnical test boring. NMFS has estimated noise levels from geotechnical sampling based on a review of geotechnical sampling at the Mukilteo Ferry Terminal (Table 17) and information presented in Erbe and McPherson (2017); the actual distance depends on the specific sample collection method, bathymetry, geology, and background noise levels at the test site.

Table 17. Underwater Sound Measurements from Shawn Gilbertson. December 2007. Sound-Level Measurements for Over-Water Geotechnical Test Boring Activities WSDOT Acoustics

Table 1. Summary of Underwater Sound Measurement Results

Measurement	Time	Activity	Drill Depth, ft	# of strikes	Peak, dB[1]	Peak Average, dB	RMS, dB	SEL, dB[1]
Underwater 1	11:08 a.m.	Ambient	n/a	n/a	n/a	n/a	141	n/a
Underwater 2	11:09 a.m.	Hammering	32	49	181	178	158[2]	148
Underwater 3	11:26 a.m.	Drilling	37	n/a	152	151	143	n/a
Underwater 4	11:38 a.m.	Hammering	37	26	180	177	158[2]	148
Underwater 5	11:53 a.m.	Hammering	42	20	177	174	154[2]	147

* - Underwater noise levels are reported as dB referenced to 1uPa.

1 - Highest strike measured.

2 – Average of all strikes.

n/a – not applicable

Note: Comparatively; the WSDOT acoustics group measured a 36" steel pile in 2006 at this same general location which generated a peak value of 206 dB, an average RMS value of 195 dB, and a Sound Exposure Level (SEL) of 180 dB.

b) Shade and Artificial Light at Night (ALAN)

Shade is cast by in-water and overwater structures that will be repaired and replaced as part of the proposed action (e.g. piles, piers, boathouses, covered moorage, floats, docks, wharfs, gangways, cranes, aids to navigation, etc.). Shading caused by enduring structures is associated with the total square feet of overwater structures that will be replaced as part of the proposed action. The Port of Seattle and Tacoma (together) could replace up to 500,000 sqft of overwater cover over the life of their permits. Shading will affect PBFs of designated critical habitat for ESA-listed fish and for SRKW:

Shade producing structures that are repaired or replaced have coinciding proposed offsetting measures through the use of the Port's Calculator. Artificial light and at night (ALAN) has no proposed offsetting measures.

Shade:

Overwater structures (OWSs) adversely affect SAV, if present, and inhibit the establishment of SAV where absent, by creating enduringly shaded areas. (Kelty and Bliven 2003). Decreased ambient light typically results in lower overall productivity, which is ultimately reflected in lower shoot density and biomass (Shafer 1999; 2002).

Fresh et al. (2006a) researched the effects of grating in residential floats on eelgrass. They reported a statistically significant decline in eelgrass shoot density underneath six of the eleven studied floats in northern Puget Sound. However, the physiological pathways that result in the reduction in shoot density and biomass from shading applies to all SAV. Thus, it is reasonable to assume that shading from OWS adversely affects all SAV.

The proposed action also includes the replacement and maintenance of lighting structures, including navigation lights/buoys. The action includes both upland and overwater lighting structures. The Ports operate 24 hours a day, so nighttime light pollution is associated with their facilities. The proposed action would extend the effects of artificial lighting on listed species and habitat into the future. Artificial light at night (ALAN) is a form of ecological light pollution

Water Quality - Studies on the water quality benefits of riparian vegetation show that shade is important for the regulation of water temperature, that can influence important biological processes in estuaries, including organismal growth, survival, and habitat use (Gross et. al 2023). This is likely to become increasingly important as warming of surface waters of estuaries and streams continues. However, water temperature in estuaries is a complex, dynamic system, impacted by numerous factors including configuration, type, location, solar radiation, temperatures of the river, air and the ocean, and changes in river discharge and wind stress (Brown 2016). We expect shade to alter the temperate regimes and decrease primary production in critical habitat below structures that are repaired and replaced. Water quality is not expected to be affected by night time light (also referred to as ALAN, for artificial light at night).

Temporary shade caused by construction barges: Barges are similar to over-water structures when positioned/anchored at the same location after a few hours. Barges obscure 100 percent of natural light and may draw several feet of water. They occupy space in the water column and create overwater cover. This may lead to a temporary impediment to fish passage and an increase in cover for piscivorous fish that may consume listed salmonids. Barges can also serve as attractive loafing/roosting habitat for avian predators of juvenile salmonids. The intensity of effects, in all of these cases is associated with barge size, in addition to the moorage depth, and moorage location relative to the shoreline.

Prey/Forage - Decreased ambient light typically results in reduced benthic productivity (Carrasquero 2001), and a reduced macrofauna diversity and density of epibenthic forage

(Cordell et al. 2017; Haas et al. 2002[24]; Lambert et al. 2021; Munsch et al. 2017; Nightingale and Simenstad 2001). Shade also limits inhibits SAV establishment (Kelty and Bliven 2003), and lowers SAV shoot density and biomass (Shafer 1999; 2002). This, in turn, reduces benthic forage opportunities from epibenthos (Haas et al. 2002) and forage fish sources, as SAV is a spawning substrate for herring and forage fish species (a food source for juvenile Chinook salmon and other fishes). Rooted SAV and forage fish spawning are sparse near Port's facilities. Low primary production interconnected with the continued use of the action area for port activities. Repair and replacement of shade-causing structures continues to suppress SAV and forage for species within critical habitat. Shading would reduce the food sources for nearshore-dependent juvenile PS Chinook and juvenile PS/GB bocaccio. This is particularly important for smoltified juvenile PS Chinook salmon entering the estuarine nearshore areas which the port facilities occupy. Here, juvenile salmon require abundant prey for growth, maturation and fitness for their marine life history stage.

Forage reductions are not expected in PS steelhead designated critical habitat in freshwater/upstream areas of the proposed action. Tacoma's proposed shade producing elements in steelhead critical habitat are very small. Seattle's Shade-producing structures repaired and replaced within PS steelhead designated critical habitat in Seattle's Zones 1 and 2 would be similar to construction in other areas throughout the Seattle Project Area, and shade impacts on prey are more likely impactful as a result of Seattle's Program.

Safe Passage/Migration: Overwater structures can provide shelter and perching opportunities for predators, such as birds or larger fish. This can lead to increased predation pressure on prey species, especially in areas where they may have previously, or typically, found refuge. This would most likely impact juvenile PS Chinook salmon.

Shade has been shown to impact migratory pathways for nearshore-dependent fish species, and may diminish the safe passage/migration PBF for PS Chinook salmon. Fishes rely on visual cues for spatial orientation, prey capture, schooling, predator avoidance, and migration. The sharp light/dark contrast between non-shaded waters and shaded water under structures affects the behavior of smaller juvenile salmon in the nearshore in two ways: 1) migrating juvenile salmon in the nearshore will avoid shaded areas and may mill along the edge, move to deeper waters, or delay migration until the light/dark contrast is reduced, 2) movement into deeper waters may increase susceptibility to predation. There is an increased risk of juvenile salmonid predation by other fish or avian predators when they leave the relative safety of shallow water (Willette 2001; Willette et al. 2001), or hesitate when encountering shaded areas.

Additionally, SAV provides cover for some species where they may avoid predators, and lack a of SAV as cover for listed fish (primarily juveniles) may make them more vulnerable to predators. Bax et al. (1978) determined the abundance of chum fry was positively correlated with the size of shallow nearshore zones, and sublittoral eelgrass beds have been considered to be the principal habitat utilized by the smaller salmonids. Fresh et al. (2006) researched the effects of grating in residential floats on eelgrass, a substrate for herring spawning, and a Chinook salmon

[24] In Haas et al 2002, while the reduction in light and SAV were likely a cause for the reduction in epibenthos, changes in grain size due to boat action and current alteration also may have contributed.

forage species. They reported a statistically significant decline in eelgrass shoot density underneath six of the 11 studied floats in northern Puget Sound. However, the physiological pathways that result in the reduction in shoot density and biomass from shading applies to all SAV. Thus, it is reasonable to assume that shading from overwater structures adversely affects all SAV. Shade that inhibits establishment of SAV beds is likely to incrementally reduce cover for juvenile PS Chinook.

An extension of shade impacts into the future will occur in the estuaries of the Duwamish and Green Rivers. The effect from repairing or replacing existing overwater structures (maximum 25,000 SF per year for each Port) will be to extend into the future forage reductions within the footprint of each structure. We expect that shade-producing structures will perpetuate the depression of the prey/forage PBF and prevent natural recovery with the action area, to the maximum site potential. At the end of a shade-causing structure's design life, without its replacement, some level of recovery would occur. However, as illustrated in Figure 12 , there is a level of habitat degradation in the highly modified ports environment that, even in the absence of the structure itself, limits the recovery of habitat to the maximum site potential.

Beneficial offsetting activities, including removal of in- and overwater structures, are likely to reduce shading and therefore improve prey/forage in other areas (Section □). When accounting for both beneficial and detrimental activities under the proposed action, we expect critical habitat to be largely retained and that long-term habitat impacts from in- and overwater structures will be partially offset by the beneficial activities required under the proposed action, as quantified through the use of the Port Calculator.

Temporary and ongoing minor increases in shade caused by sedimentation in propeller wash and vessel mooring are also expected as a result of these proposed actions. These losses are limited in duration and footprint, and do not aggregate in space or time. The majority of propeller wash and vessel mooring will take place within navigation channels), where the dredge depth limits potential SAV colonization. Given the degraded condition of the Green and Duwamish estuaries, shade from temporary and ongoing vessel activity will continue to marginally reduce benthic and epibenthic production in the action area for the 10-year life of the permits.

As stated above, shade effects from the replacement and repair of overwater structures will be mostly offset through beneficial actions in the action area so that the migration value for juvenile PS Chinook salmon is largely, maintained. Temporary/ongoing minor shade increases from moored vessels and vessel propwash would be transitory and intermittent, spatially dispersed, and confined to deep-water berth areas of the industrial waterways, which has little value for juvenile PS Chinook salmon migration.

Artificial Light at Night (ALAN):

The Ports propose to each replace, repair, and/or maintain up to 6 navigation lights and 10 light poles each year (a maximum of 320 lighting structures over the course of the year). Utility work is unlimited to both Ports and this could include replacement of bulbs.

ALAN can disrupt predator/prey dynamics (Nelson et al. 2022) and in some areas increases the duration of foraging time by daytime predatory species, increasing competition with night time foragers which could result in trophic imbalance (Weschke et al. 2024). Furthermore, because natural light drives primary production and trophic interactions (e.g., grazing, predation), ALAN may alter estuarine communities, with ramifications for food-web structure, nutrient cycling, and ecosystem functioning (Zapata et al. 2019).

Safe Passage/Migration -ALAN has been shown to decrease safe passage/migration values for salmonids. As early as 2000, Yurk and Trites (2000) found that harbor seals (*Phoca vitulina)* congregated under artificial lights to eat juvenile salmonids as they migrated downstream. Turning the lights off reduced predation levels. Recent modeling by Beauchamp et al. (2020) shows that predation risk caused by ALAN is 6-times higher for juvenile salmon and forage fish in urbanized nearshore habitat than in non-urbanized nearshore habitats. In offshore habitats, increased skyglow extended at least 6 km from urbanized shorelines and imposed nearly 2-fold higher risk than offshore habitats in non-urbanized regions.

ALAN can have broad sweeping effects on other fish species as well, including rockfish. NMFS is not aware of any studies on the effects of ALAN on species in the order Perciformes (that of yelloweye and boccacio rockfish). However, we are aware of studies on other fishes that also rely on intertidal habitat. Pulgar et al. (2023) found that ALAN altered movements of a common intertidal rockfish in South America. *Girella laevisifrons* altered its movements into or out of shaded areas based on ALAN exposure. Prior ALAN exposure seemed to disorient or reduce the ability of rockfish to choose dark conditions, deemed the safest for small fish facing predators or other potential threats. In another study, Pulgar et al. (2019) found individuals exposed to ALAN exhibited increased oxygen consumption and activity when compared with control animals. Fish exposed to ALAN stopped displaying the natural (circatidal and circadian) activity cycles observed in control fish. Larval yelloweye and bocaccio rockfish and juvenile yelloweye rockfish may be affected by ALAN in a similar manner when in the intertidal environment, but not as the species mature and move to deeper, darker, waters.

SRKW mostly hunt during the day, but can also hunt at night. ALAN could make it easier for SRKWs to capture disoriented prey, similar to harbor seals (see above). However, SRKWs typically follow large aggregations of adult Chinook in the Puget Sound, which are likely not as affected as juvenile Chinook by ALAN. NMFS is unable to determine if ALAN will have negative effects on SRKW or rockfish critical habitat.

c) Water Quality

Water quality- will be impaired during construction activities occurring during the IWWW, ongoing vessel use at both Ports and in the action area where vessels travel in/out of the Puget Sound, and caused by stormwater runoff from up to 184 total acres of untreated, replaced PGIS associated with the proposed action (9.2 acres of PGIS to be repaired per Port, per year, totaling 92 acres per port over the 10-year term of the permit). Water quality impacts to critical habitat include increased turbidity, decreased DO, contaminants contributed in stormwater runoff, mobilization or resuspension of contaminants during construction, dredging, and by propwash from vessels.

Water quality will be diminished temporarily during construction. Under the proposed action, erosion control measures will be applied to any project that involves near or in-water construction. These measures constrain and secure the site against erosion and inundation during high flow events. This minimizes the amount of fine sediments entering nearshore marine areas, estuaries, and river (up to the salt wedge). The selection of properly sized heavy and equipped heavy machinery also minimizes soil disturbance.

Despite the use of BMPs during in-water work, in-water sediment-disturbing activities are expected to cause short-term and localized increases in turbid conditions, decreased dissolved oxygen, and suspension of contaminated materials at each project area during the IWWW. Increased turbidity is expected to be intermittent during in-water work and return to baseline within hours after work ceases. In estuaries, aquatic life use criteria (WAC 173-201A-210) establish a point of compliance at a 150-foot radius from the activity for aquatic life turbidity criteria. Accordingly, the extent of suspended sediment and turbidity levels will vary within, but are not anticipated to extend more than 150 feet from project work. Impacts to water quality are expected temporarily during pile removal and installation activities, dredging/excavation, material placement, sediment sampling, and by construction vessel spudding and propwash.

Water quality would be impaired intermittently by stormwater effluent for the life of the permits through the replacement and repair of PGIS – caused by vehicle use of the impervious. Installation of ACZA treated wood will also cause short term and localized increases in copper, zinc, and arsenic where such materials are used. Vessel-associated water quality degradation will occur throughout the action area.

An increase in total suspended solids can result in increased turbidity, and a contemporaneous reduction in dissolved oxygen (DO) within the same affected area. Suspension of anoxic sediment compounds during in water work can result in reduced DO in the water column within the mixing zone area as the sediments oxidize. Based on a review of six studies on the effects of suspended sediment 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 will be minimal. Reduced DO from suspended sediments from project impacts is not expected to exceed the established mixing zone. For non-dredging activities, as with suspended sediments, reduced DO is not expected to exceed the established mixing zone of 200 feet plus the depth of water over the discharge port(s) as measured during mean lower low water.

Incidental Discharge of Contaminants - Barges and tugs will be used to construct many of the projects as well as some work associated with the actions to achieve conservation offsets. Significant discharge of hydraulic fluid, oils, or fuels from construction equipment would constitute an unlawful discharge and are not considered here. However, the operation of these vessels at each location are likely to have small incidental discharges caused by drippage from engines, which will introduce very small amounts of fuels, oils, or lubricants into the water. Incidental discharge of oils or fuels, and polycyclic aromatic hydrocarbons (PAHs) may also result from exhaust from these kinds of construction vessels, or from accidental introduction of oils or fuels from equipment in contact with water. These incidental discharges are likely at any site where such vessels are used to stage construction equipment or materials. We expect these PAHs and other contaminants to be introduced into the water column during and immediately following the proposed activity. Because these materials can disperse quickly, they can become quite widespread at very low concentration. PAHs from the exhaust of these vessels have a similar pattern of dispersal. The environmental fate of each type of PAH depends on its molecular weight. In surface water, PAHs can volatilize, photolyze, oxidize, biodegrade, bind to suspended particles or sediments, or accumulate in aquatic organisms, with bioconcentration factors often in the 10-10,000 range.

Re-suspended Contaminants - In some project locations, in-water work is likely to include resuspension of contaminated sediments, including the incidental discharge of contaminated materials when creosote treated wood materials are being removed. Creosote-treated piles contaminate the surrounding sediment up to two meters away with PAHs (Evans et al. 2009). The removal of the creosote-treated piles mobilizes these PAHs into the surrounding water and 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 any of the 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 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 contaminated an adjacent sediment cap. For some projects, removal of creosote timber piles will reduce leaching of chemical compounds into nearshore and marine sediments, which can cause toxic conditions for organisms that use these areas (DNR 2014). The proposed action includes specific measures in general construction measures 9 and 10, designed to minimize the introduction of contaminants from plie removal.

For non-dredging activities, as with suspended sediments, re-suspended contaminants are not expected to be detectable beyond background levels beyond the established mixing zone of 200 feet plus the depth of water over the discharge port(s) as measured during mean lower low water.

Beneficial activities, including the removal of creosote timber piles will reduce leaching of chemical compounds into nearshore waters and marine sediments (WDNR 2014).Temporary mobilization of PAHs is expected during removal of creosote treated timber structures (Parametrix 2011; Smith 2008). Smith (2008) reported concentrations of total PAHs of 101.8 micrograms per liter (µg/L) 30 seconds after creosote-pile removal and 22.7 µg/L 60 seconds after removal, while Weston Solutions (2006) found PAH concentrations of over 134 µg/L were observed 5 minutes following pile removal, and concentrations in samples did not always go down at 5 minutes after removal. PAHs do not easily dissolve in water, and those that are released into surface water rapidly settle out and dilute. The environmental fate and toxicity of PAHs in the water column depends on the molecular weight, pH, hardness, and the variables of organic decay (Santore et al. 2001). The majority of PAH compounds bind to suspended particulate or accumulate in aquatic organisms, with bioconcentration factors often in the 10-10,000 range. However, PAH levels in the sediment can remain high for 6 months or more (Smith 2008). In sediments, PAHs can biodegrade or accumulate in aquatic organisms or non-living organic matter. Some evaporate into the air from surface waters, but most stick to solid particles and settle into sediments.

The Port and Port tenants are required to meet the requirements of the Clean Water Act as mandated through the National Pollutant Discharge Elimination System (NPDES) permits. The Port is identified as a secondary permittee under the Phase I Municipal Stormwater permit for municipal separate storm sewer systems (MS4). Portions of Port properties are also covered under the Industrial Stormwater General Permit (ISGP).

Stormwater construction BMPs apply to all construction activities included as part of the proposed action[25]. Activities will be performed in accordance with the applicable existing NPDES, MS4, and ISGP stormwater permits using BMPs described in the Port's Stormwater Management Program Plan (SWMP; 2024) and Stormwater BMP Playbook (2021), which meet or exceed the minimum requirements outlined in Ecology's Stormwater Manual for Western Washington (Stormwater Manual; Ecology 2019). These documents detail the operational and structural BMPs to be implemented during construction, post-construction, operations and maintenance, and/or source control, that have been designed to meet or exceed applicable treatment benchmarks and reduce non-point pollution in runoff.

Replacement of impervious surfaces that are driven on by vehicles (pollution generating impervious surfaces), including docks, piers, and floats, will cause stormwater discharge. Each Port is subject to various existing NPDES, MS4, and ISGP stormwater permits, and is beholden to an array of BMPs and treatment requirements designed to meet or exceed the minimum requirements outlined in Ecology's Stormwater Manual (Ecology 2019; Seattle 2020; Tacoma 2021 and 2024). Activities would be performed in accordance with the applicable existing NPDES, MS4, and ISGP stormwater permits using BMPs described in the Port's Stormwater Management Program Plan (SWMP; 2024) (Tacoma), Stromwater Management Guidance Manual (Tacoma), Stormwater BMP Playbook (2021) (Tacoma), Stormwater Management Program Plan for Maritime Phase I Propertes (2024) (Seattle). These plans were developed to meet or exceed the minimum requirements outlined in Ecology's Stormwater Manual for Western Washington (Stormwater Manual; Ecology 2019).

NMFS reviewed these stormwater manuals and the Port's Biological Assessments and found no reference, obligation, or commitment to add stormwater treatment to areas repaired or replaced that currently discharge untreated stormwater. The runoff itself comes from rainfall or snowmelt moving over these surfaces, where it picks up and carries away natural and anthropogenic pollutants, finally depositing them into coastal waters, (Dressing et al. 2016). We therefore expect a that, when replacing these surfaces, the action allows for the continuation of untreated discharge from infrastructure repaired, replaced, or maintained as part of these Programs. We expect that untreated or insufficiently treated PGIS will continue as structures are repaired and replaced. Even in areas that currently receive stormwater treatment, no treatment aside from full infiltration fully removes all contaminants, effluent will continue to be a chronic source of episodic physical and chemical loading to Puget Sound when repairing or replacing PGIS. Current treatment levels are part of the baseline for both ports, and while dilution will greatly reduce contaminant concentrations, we expect the continuation of discharge input of untreated stormwater caused by the repair and replacement of structures will cause chronic behavioral or health effects that could reduce the water quality PBF of critical habitat for PS Chinook salmon, PS steelhead, PS/GB bocaccio, and SRKW.

[25] The following actions do not require any post-construction stormwater management: 1. Removing marine debris or marine life from existing outfalls, 2. Replacing outfall flap gates or flow control devices, 3. Minor repairs or non-structural pavement preservation, such as installation or repair of guard rails, patching, chip seal, grind/inlay, overlay; removal or plugging of scuppers in a way that benefits stormwater treatment.

Pollutants in post-construction stormwater runoff typically include:

- Excess fertilizers, herbicides, insecticides and sediment from landscaping areas;
- Oil, grease, PAHs and other toxic chemicals from roads and parking areas used by motor vehicles;
- Bacteria and nutrients from pet wastes and faulty septic systems;
- Metals (arsenic, copper, chromium, lead, mercury, and nickel) and other pollutants from the decay of building and other infrastructure;
- Atmospheric deposition from surrounding land uses; and
- Erosion of sediment and attached pollutants due to hydromodification.

(Buckler and Granato 1999; Colman et al. 2001; Driscoll et al. 1990; Kayhanian et al. 2003; Van Metre et al. 2005). Pollutants will become more concentrated on impervious surfaces until they either degrade in place or are transported by wind, precipitation, or active site management. Although stormwater discharge from most proposed projects will be small in comparison to the flow of the nearby waterways, it will have an incremental impact on pollutant levels within the action area. The adverse effects of stormwater runoff from the proposed action will occur primarily at the basin scale due to persistent additions of pollutants or the compounding effects of many environmental processes.

The following brief summaries from toxicological profiles (ATSDR 1995; ATSDR 2004a; ATSDR 2004b; ATSDR 2005; ATSDR 2007) show how the environmental fate of each contaminant and the subsequent exposure of listed species and critical habitats varies widely, depending on the transport and partitioning mechanisms affecting that contaminant, and the impossibility of linking a particular discharge to specific water body impairment (NRC 2009):

- DDT and its metabolites, dichlorodiphenyldichloroethylene (DDE) and dichlorodiphenyltrichloroethane (DDD) (all collectively referred to as DDx) may be transported from one medium to another by the processes of solubilization, adsorption, remobilization, bioaccumulation, and volatilization. In addition, DDx can be transported within a medium by currents, wind, and diffusion. These chemicals are only slightly soluble in water, therefore loss of these compounds in runoff is primarily due to transport of particulate matter to which these compounds are bound. For example, DDx have been found to fractionate and concentrate on the organic material that is transported with the clay fraction of the wash load in runoff. Sediment is the sink for DDx released into water where it can remain available for ingestion by organisms, such as bottom feeders, for many years.
- PAHs: The environmental fate of each type of PAH depends on its molecular weight. In surface water, PAHs can volatilize, photolyze, oxidize, biodegrade, bind to suspended particles or sediments, or accumulate in aquatic organisms, with bioconcentration factors often in the 10-10,000 range. In sediments, PAHs can biodegrade or accumulate in aquatic organisms or non-living organic matter. Some evaporate into the air from the surface but most do not easily dissolve in water, some evaporate into the air from surface waters, but most stick to solid particles and settle into sediments. Changes in pH and hardness may increase or decrease the toxicity of PAHs, and the variables of organic decay further complicate their environmental pathway (Santore et al. 2001).

- PCBs are globally transported and present in all media. Atmospheric transport is the most important mechanism for global dispersion of PCBs. PCBs are physically removed from the atmosphere by wet deposition (i.e., rain and snow scavenging of vapors and aerosols); by dry deposition of aerosols; and by vapor adsorption at the air-water, air-soil, and air-plant interfaces. The dominant source of PCBs to surface waters is atmospheric deposition; however, redissolution of sediment-bound PCBs also accounts for water concentrations. PCBs in water are transported by diffusion and currents. PCBs are removed from the water column by sorption to suspended solids and sediments as well as from volatilization from water surfaces. Higher chlorinated congeners are more likely to sorb, while lower chlorinated congeners are more likely to volatilize. PCBs also leave the water column by concentrating in biota. PCBs accumulate more in higher trophic levels through the consumption of contaminated food.
- Copper: Due to analytical limitations, investigators rarely identify the form of a metal present in the environment. Nonetheless, much of the copper discharged into waterways is in particulate matter that settles out. In the water column and in sediments, copper adsorbs to organic matter, hydrous iron and manganese oxides, and clay. In the water column, a significant fraction of the copper is adsorbed within the first hour of introduction, and in most cases, equilibrium is obtained within 24 hours.
- For zinc, sorption onto hydrous iron and manganese oxides, clay minerals, and organic material is the dominant reaction, resulting in the enrichment of zinc in suspended and bed sediments. The efficiency of these materials in removing zinc from solution varies according to their concentrations, pH, redox potential, salinity, nature and concentrations of complexing ligands, cation exchange capacity, and the concentration of zinc. Precipitation of soluble zinc compounds appears to be significant only under reducing conditions in highly polluted water.
- Lead: A significant fraction of lead carried by river water occurs in an undissolved form, which can consist of colloidal particles or larger undissolved particles of lead carbonate, lead oxide, lead hydroxide, or other lead compounds incorporated in other components of surface particulate matter from runoff. Lead may occur either adsorbed ions or surface coatings on sediment mineral particles, or it may be carried as a part of suspended living or nonliving organic matter in water. The ratio of lead in suspended solids to lead in dissolved form has been found to vary from 4:1 in rural streams to 27:1 in urban streams. Sorption of lead to polar particulate matter in freshwater and estuarine environments is an important process for the removal of lead from these surface waters.

Recent studies have shown that coho salmon show high rates of pre-spawning mortality when exposed to chemicals (6PPD-quinone) that leach from tires (Lane et al. 2024, Lo et al, 2023, French et al., 2022, McIntyre et al. 2015). Researchers have recently identified a tire rubber antioxidant as the cause (Tian et al. 2020). Although Chinook did not experience the same level of mortality, tire leachate is still a concern for all salmonids. Traffic residue also contains many unregulated toxic chemicals such as pharmaceuticals, polycyclic aromatic hydrocarbons (PAHs), fire retardants, and emissions that have been linked to deformities, injury and/or death of salmonids and other fish (Trudeau 2017; Young et al. 2018).

Pollutants travel long distances when in solution, adsorbed to suspended particles, or they are retained in sediments, particularly clay and silt, which can only be deposited in areas of reduced water velocity until they are mobilized and transported by future sediment moving flows (Alpers et al. 2000a; Alpers et al. 2000b; Anderson et al. 1996). Santore et al. (2001) indicates that the presence of natural organic matter and changes in pH and hardness affect the potential for toxicity (both increase and decrease). Additionally, organics (living and dead) can adsorb and absorb other pollutants such as PAHs. The variables of organic decay further complicate the path and cycle of pollutants.

Water quality can also be affected by the materials used in marine structures. While the Port of Seattle has reduced the amount of treated wood in the majority of its structures, the Port of Tacoma intends to use inorganic arsenical pressure-treated wood piles ammoniacal copper zinc arsenate (ACZA) in some inwater and overwater structures. They will ensure that such treated wood is cured in a manner to reducing leaching of these metals into the marine environment. Despite such curing pesticide-treated wood structure placed in water, or which comes into contact with precipitation or other flowing water, will leach the preserving metals (Hingston et al. 2001; Kelly and Bliven 2003; Poston 2001; Weis and Weis 1996). Copper and other toxic chemicals, such as zinc, arsenic, chromium, leach from pesticide-treated wood.

An evaluation of the level of metal leachate from ACZA-treated wood indicates that levels remain very low, well below standards after the initial 2 weeks post-placement (Brooks 2004).

	Marine water quality criteria	
Metal	USEPA acute (µg/L)	US EPA chronic (µg/L)
Copper	4.8	3.1
Arsenic	69.0	36.0
Zinc	84.6	76.6

Figure 13. Acute and Chronic Marine water quality criteria for copper, arsenic, and zinc

Seawater concentrations of copper, arsenic and zinc were collected at slack tide during a light rain and analyzed at the Battelle Marine Science Laboratory in Sequim, Washington using ICP/MS with detection limits of 0.1 µg As/L, 0.023 µg Cu/L, and 0.062 µg Zn/L.

Metal	Washington Sediment Quality Criteria (µg/g dry sediment)
Copper	390
Arsenic	57
Zinc	410

Figure 14. Sediment Criteria for copper, arsenic, and zinc.

Sediment concentrations of arsenic varied between 1.56 and 6.7 µg As/g dry sediment at all stations located < 7.5 m from ACZA treated structures and between 0.49 and 6.34 µg/g at the reference stations (Brooks, 2004). However, effects from ACZA treated wood may reach harmful levels when the water body in which they are places has poor flushing, or the water body is contaminated with metals reaching a level that requires 303(d) listing. In these cases, we expect ACZA would be additionally degrading of water quality as a feature of critical habitat, reducing its value for the lifestages of listed species that depend upon it for survival, growth, development, maturation, or migration.

Prey - Elevated levels of suspended sediments and turbidity in the water can smother benthic organisms, clog their feeding structures, and reduce light penetration, which can negatively impact photosynthetic organisms like benthic algae and seagrasses. Many benthic organisms, such as clams, mussels, and certain worms, require sufficient dissolved oxygen in the water for respiration. Low oxygen levels, often caused by excess nutrients or organic matter decomposition, can lead to stress, reduced growth, and even mortality in these organisms.

Reductions in water quality can depress forage as a result of contaminants settling and are bioaccumulating up the aquatic food chain. This may occur as a result of construction activities that disturb sediment, or on an ongoing basis from stormwater managed as part of the replaced infrastructure's impervious surfaces. For these proposed actions, water quality is most impactful on the prey PBF of PS Chinook salmon and PS/GB bocaccio designated critical habitat. These species, specifically at the juvenile lifestage, are most likely exposed to temporary elevated contaminants in the water column since they are shoreline-oriented and spend a greater amount of time within Puget Sound than others.

Aquatic forage species in contaminated habitats are vulnerable to both the short term and delayed effects of toxic exposure (Heintz et al. 2000; Meador 2014; Johnson et al. 2013; Varanasi et al. 1993). Exposure through ingestion of contaminated prey in industrial areas is a dominant and detrimental pathway for aquatic organisms (Johnson et al. 2013, 2014). A measurable accumulation of contaminants in an individual organism is dependent on several factors, including levels of contaminants from the project, exposure of prey to contaminants (where and what life stage), the likelihood of detection of the contaminants in the individual, and if the contaminant bioaccumulates and/or biomagnifies. Contaminants associated with the proposed action include metals, PAHs, and PCBs. These can accumulate and biomagnify in the aquatic food web (Compeau and Bartha 1984; Dorea 2008; Yanagida et al. 2012). Marine invertebrates that are prey species can be affected by stormwater contaminants (Schiff et al., 2002), reducing abundance and diversity in areas near outfalls (Kinsella and Crowe, 2015), PAHs from exhausts and spills from vessels (Honda and Suzuki, 2020).

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. Dietary DDTs, dietary PCBs, and dietary PAHs in fish were elevated relative to the stomach contents from fish upstream of a Superfund site, indicating a general correspondence between site-specific exposures to PCBs, DDTs, and PAHs via the diet and elevated tissue concentrations among sub yearling Chinook that reside in these local habitats to feed, shelter, and grow (Lundin et al. 2021), consistent with earlier findings (Johnson et al. 2007; Yanagida et al. 2012). Resuspended pollutants are absorbed at a lower efficiency by benthic organisms than those bound to particulate organic matter directly from the water column (Charles et al. 2005). We anticipate construction impacts to water quality impacts will be short-lived. We expect contaminant concentrations resuspended during construction are likely minor, but may result in reduced growth and other sublethal outcomes to prey. Ongoing vessel use and stormwater caused by the action are likely more significant contributors to water quality degradation than construction actions.

Scour from vessel motors can also create pulses of turbidity. Scour caused by associated commercial and industrial vessel use at both ports similarly adversely affects submerged aquatic vegetation (SAV) where it is present, and inhibits its recruitment where not present, by frequently churning water and sediment in the shallow water environment, in part because the turbidity from boat propeller wash decreases light levels (Eriksson et al. 2004). Shafer (1999; 2002) provides background information on the light requirements of seagrasses and documents the effects of reduced light availability on seagrass biomass and density, growth, and morphology. Decreased ambient light typically results in lower overall productivity, which is ultimately reflected in lower shoot density and biomass (Shafer 1999; 2002).

Prey is a PBF of SRKW critical habitat, of which adult PS Chinook are their primary food item. Therefore, we evaluate the effects of repeated/chronic exposure of PS Chinook (adults and juveniles). Stressors to successive cohorts results in a diminishment of the forage PBF of SRKW critical habitat. Both quantity and quality of prey will slightly decline as a result of impacts to water quality, through impacts to PS Chinook. Water quality effects to PS Chinook are likely to cause latent health effects that slightly reduce adult abundance and reduce the quality of adult fish that return to spawn.

Safe Passage/Migration - Increased turbidity during construction and ongoing turbidity caused by vessel prop wash results in decreased visibility, which can impair the ability of migratory species to navigate and orient themselves during migration. This can cause all species with this PBF to become disoriented or stray from their intended routes. Temporary disruption limited to the same spatial and temporal scale described above for construction effects, and is therefore unlikely to permanently diminish the conservation value of the habitat.

d) Loss of Aquatic Habitat

The proposed action includes construction actions and replacement and repair of structures directly within critical habitat. While overwater structure creates shade that reduces the quality of aquatic habitat below the structure, inwater structures such as piles, bank armor, and fill actually displace aquatic and benthic habitat. Depending on species being considered, these reductions affect forage areas, rearing areas, spawning areas, and migration areas.

Aquatic habitat is negatively impacted when structures such as piles, ramps, fill, and/or armor that are at the end of their life are replaced. This is caused by the extended time period during which there will be a direct displacement of critical habitat as a result of the life span of the replaced structure or an alteration of critical habitat, such as in dredging. The loss of aquatic habitat occurs when the physical footprint of in- and overwater structures directly displaces existing aquatic or benthic features that provide habitat, such as eelgrass beds, oyster reefs, and rocky substrates. Additionally, in- and overwater structures (i.e., piles, shoreline armoring, boat ramps, maintenance dredging) can alter hydrodynamics and sediment transport patterns, leading to increased sedimentation in some areas and erosion in others. These changes in the physical structure or characteristics of a habitat, such as changes in water flow, temperature, or vegetation cover, can make it less favorable for certain species. The displacement of sediment surface from critical habitat by structures alters the exposed sediment composition for the life of the structure, which can decrease or alter benthic productivity or habitat suitability for some species (e.g. rockfish favor high rugosity more than silty or sandy substrates). As a result of alteration of estuarine habitat by armoring, for example, the environment is less complex and loses capacity to provide forage, food, and cover for species, including salmonids and larval and juvenile rockfishes. Shallow habitat is not supported by armoring due to scour waterward with associated navigation channels. Normally shallow habitat in estuaries provide those benefits listed above. Particularly important are blind channels which have overhanging vegetation, woody debris, and aquatic vegetation. An overall change in land cover extending behind armoring means that insects, which have nutritional value and mostly originate in upland areas, are no longer present and unable to drift/land into the estuary (Davis 2019). The proposed maintenance and repair of those existing in- and overwater structures prolongs the life of these anthropogenic features and thereby lengthens the duration of the habitat loss (see the orange box in Figure 12 at the beginning of this effects of the action section). Along with the impacts to habitat when occupied by structures within designated critical habitat, impacts to aquatic habitat can also refer to temporary or indirect loss caused by species avoidance, when the habitat is unsuitable (such as noise, elevated turbidity, or reduced prey availability – discussed above). During construction, temporary habitat losses through reduced water quality (turbid conditions), deepening, or increased noise would occur. Long term habitat loss would occur due to structure replacement and repair, and dredging.

The proposed action allows for the repair and replacement of hard shoreline stabilization structures (also known as hard armoring) such as rock bulkheads, and revetments, sheet pile stabilization, and wharfs. The effects of these structures on habitat features and functions will persist for the design life of the structures, as extended by the repair and replacement work to rehabilitate and ensure their continued use and existence. The repair and replacement of shoreline armoring is intended to prevent certain natural estuarine processes from occurring (e.g, lateral migration, bank slumping, and sediment recruitment). The affected area includes not just the location of where the protective material (sheet pile, rock armor, etc) is but also areas waterward of the armoring where scour occurs and the area landward of the armoring.

This proposed action would maintain (through maintenance, repair and replacement) armoring and other in and over-water structures such as piles, piers, wharfs, and floats in two of Puget Sound's largest estuaries, the Duwamish/Green River and the Puyallup River. Historically these estuaries had expansive mud flats that were inundated at high tide. Low shrubby and herbaceous vegetation grew on the mud flats and larger vegetation was along the margins of the estuary in higher elevations. Both blind water channels (that dead end) and distributary water channels (that have through-flow) were abundant, which fish could access even at low tide (USGS T-Sheets 1852-1926). Bulkheads, whether new, repaired, or replacement are expected to result in erosion waterward of the armoring from deflected wave energy. This, too, is applicable to estuaries, where mud flats normally dissipate wave energy and retain sediment over vast areas. Armoring leads to scour, lowering and coarsening of substrates, and decreased SAV waterward of the armoring. Overall, repair or replacement of shoreline armoring causes continued negative impacts to primary productivity and invertebrate density within both estuaries (Bilkovic and Roggero 2008; Fresh et al. 2011; Morley et al. 2012; Dethier et al. 2016

Repair and replacement of shoreline armoring causes a simplified and hydromodified estuarine environment for an extended period into the future. It precludes natural cover by inhibiting re-establishment of both intertidal habitats and riparian vegetation. Armoring supports the fill (fast-land) that has been placed on top of historic estuarine marsh, directly precluding the onset of development of critical habitat forming processes, and becoming a source for stormwater to wash contaminants into the estuarine environment.

Finally, dredging routinely alters the estuarine environment by removing the steadily contributed sediments that would otherwise create shallow delta habitat, directly converting it to deeper habitat. Both shore armoring and dredging together allow for the continued vessel use, by retaining depth suitable for navigation, docking, and berthing. These areas in turn, do not support aquatic vegetation. Therefore, the effect of repair and replacement of shoreline structures is the delay in reestablishing estuarine features and habitat areas that would otherwise develop.

Water Quality – Water quality reductions caused by the proposed action renders areas of critical habitat less usable or unusable. Corresponding water quality benefits caused by removal of creosote treated timber increase the functionality of critical habitat. These effects are discussed in more detail in sections above.

Prey – Repair and replacement of structures within critical habitat as well as dredging will negatively impact benthic prey communities in and around the structures. Maintenance dredging also will episodically remove sediment that contains benthic prey, and deepen some areas to the point that they will not replenish with the same prey communities, the abundance of prey may reduce, and the prey may be outside of the preferred forage depths of some species.

During construction, areas where sediment is disturbed by pile driving, pile removal, dredging, or other in-or near water work such as boat ramp or bulkhead construction, repair, or replacement, and shade and scour from vessels in shallow water areas to facilitate construction, will disturb and diminish benthic prey communities. In areas where suspended sediment settles on the bottom, some smothering can occur which also disrupts the benthic communities. The speed of recovery by benthic communities is affected by several factors, including the intensity of the disturbance, with greater disturbance increasing the time to recovery (Dernie et al. 2003). Additionally, the ability of a disturbed site to recolonize is affected by whether or not adjacent benthic communities are nearby that can re-seed the affected area. Thus, recovery can range from several weeks to many months. Barge use and positioning (especially if done by tugboat) can cause also localized scour if operating in shallow water (i.e., <20 feet). Localized scour can result in reduction of benthic aquatic vegetation and macroinvertebrates. These effects are temporary, typically lasting for the duration of barge mooring in a particular location. Effects resulting from scour may last for several months, but habitat retains the capacity to eventually fully recover if perturbation ceases. Finally, water quality diminishments can also result in reduced prey abundance, composition, or quality as contaminants can reduce the condition of or survival of prey species.

Safe Passage/Migration - The loss of marine critical habitat can significantly impact the migration routes of protected species. Habitat loss can lead to a decline in species numbers, particularly affecting large animals that range across vast areas, causing fragmentation of their home ranges and forcing them into unsuitable habitats or managed seascapes. However, the effectiveness of designated critical habitat areas in safeguarding highly migratory species with large geographic ranges can be limited, as these species often move outside the borders of protection during their annual cycles.

Construction disturbance could cause species to avoid areas of critical habitat. Temporary reduction of the function of the safe passage/migration PBF due to water quality or noise and corresponding effects on critical habitat are described in Sections 2.4.1.c) and 0 2.4.1.0 above.

Artificial lighting on Port structures, including in and overwater structures, further expands the area of impacted aquatic habitat. The lights disorient and disturb migrating juvenile salmonids, causing them to alter their migration patterns or become delayed or lost during their journeys (Tabor et al. 2004). Several different types of light will be maintained, including navigation and safety lights, and lights for covered moorage. Lighting in nearshore areas negatively impact the area's value for safe migration by disorienting migrating fish by interfering with their visual cues, sensory perception, or navigation abilities.

Swimming around replaced in- and overwater structures lengthens the migration distance and is correlated with increased mortality in juvenile PS Chinook. Structures can contribute to the fragmentation of aquatic habitats, making it more difficult for migratory fish to access spawning grounds, nursery areas, or feeding grounds along their migration routes.

Additionally, we consider here those losses of aquatic habitat from the precluded development of functional shallow-water habitat for juvenile PS Chinook. In- and overwater structures, maintenance dredging and shoreline armoring, including boat ramps, disrupt sediment transport processes that create shallow water habitat preferred for juvenile salmonid migration, precluding refuge for safe migration. Maintenance of existing infrastructure results in a longer time period where fully functional habitat is prevented from forming, extending the time that refuge for safe migration takes to develop.

Extending the existence of in- and overwater structures will be offset under the Programs through the removal of in- and overwater structures like old creosote piles in another portion of the project area and/or stand-alone restoration actions as detailed in Appendix B.

Summary

We also expect that repair or replacement of in- and overwater structures (including dredged deep-water areas, shoreline armor, and boat ramps) will cause limited prey availability, disrupt migration, and preclude development of more suitable habitat for the design life of the structures. For dredging, long term effects on prey may last up to several years, but will eventually improve as forage species colonize new substrate available in adjacent areas or provided by offsets.

NMFS considers the temporal and spatial losses of designated critical habitat as outlined in the proposed action with certain limits on annual volume and extent of impacting activities as a series of continued losses of designated critical habitat. NMFS believes that this long-term loss of habitat quality, quantified through the use of the Port Calculator, will be offset by the proposed beneficial activities, including purchase and generating offsets as require (see next section). Through these offsets included in the proposed action, critical habitat quality is not expected to be impaired in the aggregate.

Habitat Improvements for Compensatory Mitigation

The proposed action includes beneficial activities within or benefiting[26] critical habitat. These include but are not limited to soft and hybrid shoreline armoring and restoration, reestablishment of native riparian plant communities, removal of debris, removal of creosote treated piles, and the removal of structures within critical habitat. The proposed action also includes compensatory mitigation achieved through advance compensatory mitigation sites, banks, and in-lieu-fee programs, etc.

The beneficial actions would provide habitat lift for critical habitat and are proposed to mitigate long-term habitat impacts associated with the maintenance, repair, and replacement of Ports facilities. The Ports propose to use the Port's Calculator to quantify those beneficial and detrimental actions, whenever possible but otherwise through an individual credit assessment conducted or approved by the Services. Through the use of this tool, and continued process improvements based on best available science, the proposed action would strive to obtain an equal balance of detrimental and beneficial habitat impacts over the life of the permits. NMFS believes that the Port's Calculator, including the revisions added at NMFS' suggestion, achieves this goal. The ecological relevance of the beneficial actions would be quantified by the design of and the mechanisms built into the Ports Calculator (or any other tool deemed equivalent). The tool will be used to determine the relative value both of habitat impacting and habitat improving actions.

Because the proposed activities at each port includes actions to create conservation offsets to compensate for the impacts of structures that modify or armor the habitat features or functions within their respective properties, the 10-year permits are expected to achieve a no-net loss approach to maintaining habitat forming process and nearshore habitat quality.

The intention to offset long-term impacts on the quality of nearshore habitat is a key feature of the proposed actions. The Ports Calculator is the tool proposed to assess the long-term impacts and benefits per project on an ongoing basis throughout the duration of the permit. The Ports Calculator is the main tool that will be used to determine whether the benefits and impacts reach a no net loss outcome.

Habitat improvement can occur through infrastructure redesign, or could be standalone projects taken to achieve conservation offsets by reestablishing or enhancing natural habitat qualities, functions, and processes. Temporary effects associated with establishing improved conditions are described above in section 2.4.1. The long-term habitat improvements are likely to include:

- Water quality improvements from the removal of creosote structures
- Regained aquatic habitat areas from redesign of structures that reduce the number of piles
- Re-established nearshore areas from hard armor removal or softening,
- Improved benthic condition by the removal of manmade debris and rubble, and

[26] Some habitat at Tacoma's POCW is upland riparian habitat and the benefits from non-critical habitat were quantified based on its benefits to critical habitat. For example, we considered how drift insects from riparian woody vegetation enhance the forage function in critical habitat.

- Removal or capping of contaminated sediments (other than required by MATCA or CERCLA).

In addition to these, the Ports may also resolve debits identified via the Port's Calculator through the ways outlined in section III of the Credit Savings Instrument attached as Appendix B, i.e., by withdrawing, or purchasing, conservation bank credits from NOAA-approved banks or in-lieu fee programs that have available credits in the South-Central Puget Sound service area, by generating credits through applicant-responsible restoration projects, providing funding for a local habitat restoration project, or by applying credits from a future advance mitigation site.

The Port of Tacoma also may use credits from their Place of Circling Waters (POCW) advance compensatory mitigation site (ACM) to offset impacts resulting from projects consulted on under this consultation. NOAA found the type of habitat enhancements provided through the POCW ACM appropriate for the types of long-term impacts described in section 2.4 above (see Appendix F). Habitat benefits from the POCW address the same features of critical habitat impacted by the repair and replacement elements of this proposed action. As identified above, those are water quality, forage and prey, safe migratory habitat, and conditions supporting juvenile growth and maturation. Benefits restored at the POCW improve water quality and forage and prey through extensive riparian restoration and creation of intertidal saltmarsh vegetation. The creation of tidal channels and mudflats provides new/additional habitat supporting juvenile growth and maturation.

To ensure that POCW provides appropriate benefits to offset impacts from this proposed action, NMFS reviewed the documents related to design, creation, and monitoring of POCW; habitat evaluation; Cops involvement and review; and previous use of advance credits. NMFS also performed a site visit to verify ongoing functionality (see Appendix F – NMFS Evaluation of POCW and Credit Determination for Limited use with the CMMP Consultation – for details).

<u>Structure removal or redesign</u>

Redesign of overwater structures can include increasing the amount of grating/shade reduction, reducing the number of piles that support the structures, or full removal, which will reduce both shade and habitat displacement. These activities may include removal of creosote structures, which will also result in water quality improvements.

<u>Set-back or removal or softening of shore armor</u>

The effects of setting back or removing existing bulkheads, or other shore armoring increases habitat diversity and complexity, restores shoreline habitat forming processes, and provides refuge for fish and increases sediment recruitment which may reestablish suitable conditions for benthic prey communities

<u>Beach nourishment</u>

Beach nourishment in limited circumstances, can provide improved nursery grounds and other habitat for forage fish species. Improved beach and shoreline habitats will also provide shelter from predators and food for young salmonids. Nourishment does not remove the physical forces that cause erosion but it does help to improve and restore habitats affected by erosion. Because these benefits are not often realized, the use of this activity to create offsets may be limited.

Sediment Remediation

Remediation of contaminated soil or sediment, outside of NRDA, MTCA or CERCLA, may occur in-water within the estuary, or in nearby uplands. For example, sediment remediation may be associated with Creosote removal or debris removal. These activities would remove or isolate contaminants found in soils, sediments, or groundwater so that they cannot interact with ESA listed species or their prey.

Shoreline Softening and Shoreline Restoration

Softening and regrading shorelines to create or mimic more natural beaches would improve PS Chinook salmon estuarine habitat rearing values, juvenile bocaccio habitat values, and SRKW values through forage as Chinook. In many cases, these actions would directly add accessible area to critical habitat by increasing area inundated during high tides.

Reestablishment of native riparian plant communities would increase cover, increased habitat complexity, and increase prey base where these activities occur. Again, these benefits accrue primarily to the designated critical habitat of PS Chinook and juvenile bocaccio.

Debris and Structure Removal

The removal of debris and marine structures will improve benthic conditions, primarily benefiting juvenile bocaccio rearing areas, and also providing some benefit to PS Chinook salmon estuarine designated critical habitat by incrementally improving substrates for prey species.

Removal of in water (piles) and overwater structures will improve water quality by eliminating chronic sources of toxic contamination and associated impacts to nearshore dependent species. Removal will also restore impacted substrates because the shade from in and overwater structure prevents recovery of important freshwater, intertidal, and subtidal habitats. The long-term effects of structure removal, including substrate recovery and reduction of resting areas for piscivorous birds, hiding habitat for aquatic predators, and, in the case of preservative-treated piles, a chronic source of contamination will increase safe migration values, and improve water quality values, both of which enhance PBFs for PS Chinook and juvenile bocaccio.

e) Assessment of the Ports' Calculator and Rationale

Because habitat values, both positive and negative, will be quantified under the proposed action using the Ports' calculator, NMFS has closely reviewed the calculator and rationale to ensure all habitat values that inform the calculator appear well supported by best available science. The proposed actions' no-net loss strategy includes assessment of impacts and benefits using the Ports' Calculator. The Services participated in the conceptual development of and reviewed the Port Maintenance Calculator plus the Port Calculator Rationale. NMFS' review included the development of revisions and additional rational that the ports included in its proposed action (Appendix A).

MFS will work with the COE and the Ports on each project that requires conservation offsets in accordance with the detailed mechanisms and processes set out in the proposed action and the attached Credit Savings Instrument. In particular, the Ports will utilize the Calculator to evaluate project impacts and generate a result presented as debits. This informs the amount of offset that is required per project. Those offsets may be met via credits generated by each Port (which can be saved per the Credit Savings Instrument (Appendix B), or by the withdraw or purchase of an offsetting amount from an NMFS-approved bank (including Port banks) or in lieu fee provider or other means described in the Credit Savings Instrument. The Ports shall ledger all credits and debits to ensure that debits accrued during any one fiscal year of the CMMP are offset by conservation credits during that fiscal year or within the subsequent two fiscal years.

Credits generated or purchased in surplus of the immediate number of debits may be saved for each Port's future use within this program. Some habitat improving activities may occur before impacting work and provide value to listed species life stages until such time as the credits are applied to offset debits, consistent with the Credit Savings Instrument. The proposed action also allows that habitat impacting work may not be fully offset until the three years after the debits[27] are incurred. Therefore, for the purpose of this analysis, NMFS assumes that many projects will have a delay in addressing the calculated habitat impacts.

In summary, the proposed use of the Port's calculator and the Credit Savings Scheme described in the Credit Savings Instrument will offset the enduring effects of the proposed action on critical habitat. While adversely affected, PBFs of this habitat would not be so diminished that we would consider the role of the critical habitat to be significantly impaired. We consider the temporary effects to critical habitat not of sufficient duration, intensity, or spatial extent to impair the conservation role (survival, growth, maturation, fitness) of these species. When the offsetting beneficial actions of the program are then also factored (in an effort to establish "no net loss"), NMFS believes that over the duration of the program, the adverse effects of the activities will slightly impair the conservation values of critical habitat.

Summary of the on salmon critical habitat PBFs:

1. <u>Estuarine areas</u>

    a. Forage – Short-term reduction in forage due to dredging, , and construction activities. Enduring loss of some forage production due to overwater structures and shoreline modification. Loss of forage quality and quantity due to introduction of contaminants from stormwater. Improved production of forage from habitat enhancement activities including wetland restoration and beach nourishment (improved quality forage fish spawning habitat).

    b. Free passage – Improvement of fish passage at culvert and bridge replacement sites. Lengthening of migration pathways in nearshore areas due to the repair, replacement, or construction of new overwater structures. Temporary disruption of free passage due to underwater noise from pile driving and construction.

[27] Same as within the subsequent 2 fiscal years.

c. Natural cover – Loss of natural cover resulting from suppression of SAV due to over- and in-water structures.

d. Salinity – no effect

e. Water quality – Temporary water quality degradation, including increased turbidity, due to construction activities and dredging. Reduced dissolved oxygen and resuspension of contaminated sediments from construction activities. Introduction of contaminants from stormwater. SSNP requirements for treatment of stormwater reduce the amount of contaminants reaching the action area.

f. Water quantity – no effect

2. <u>Estuarine marine areas</u>

a. Forage – Short-term reduction in forage due to dredging, sediment remediation, and construction activities. Enduring loss of some forage production due to overwater structures and shoreline modification. Improved production of forage from habitat enhancement activities including wetland restoration and beach nourishment (improved quality forage fish spawning habitat).

b. Free passage – Improvement of fish passage at culvert and bridge replacement sites. Lengthening of migration pathways in nearshore areas due to the repair, replacement, or construction of new overwater structures. Temporary disruption of free passage due to underwater noise from pile driving and construction. Construction of new or repair and replacement of overwater and in-water structures degrade this PBF by creating migration barriers.

c. Natural cover – Loss of natural cover resulting from suppression of SAV due to over- and in-water structures.

d. Water quantity – no effect

e. Water quality – Temporary water quality degradation, including increased turbidity, due to construction activities and dredging. Reduced dissolved oxygen and resuspension of contaminated sediments from construction activities. Introduction of contaminants from stormwater. SSNP requirements for treatment of stormwater reduce the amount of contaminants reaching the action area.

Summary of the effects of the action on Bocaccio rockfish critical habitat PBFs:

Critical habitat is designated in San Juan/Straits of Juan de Fuca, Whidbey Basin, Main Basin, Hood Canal, and South Puget Sound. In each location, the conservation value is high.

Essential features for juvenile bocaccio include habitats located in the nearshore with substrates such as sand, rock and/or cobble compositions that also support kelp are essential for conservation because these features enable forage opportunities and refuge from predators and enable behavioral and physiological changes needed for juveniles to occupy deeper adult habitats, with:

1. Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities; and
2. Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities.

Nearshore areas are contiguous with the shoreline from the line of extreme high water out to a depth no greater than 30 meters (98 ft) relative to mean lower low water.

Essential features for adult bocaccio rockfish. Benthic habitats and sites deeper than 30 m (98 ft) that possess or are adjacent to areas of complex bathymetry consisting of rock and or highly rugose habitat are essential to conservation because these features support growth, survival, reproduction, and feeding opportunities by providing the structure for rockfish to avoid predation, seek food and persist for decades. Several attributes of these sites determine the quality of the habitat and are useful in considering the conservation value of the associated feature, and whether the feature may require special management considerations or protection. These attributes are also relevant in the evaluation of the effects of a proposed action in an ESA section 7 consultation if the specific area containing the site is designated as critical habitat. These attributes include:

1. Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities;
2. Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities; and
3. The type and amount of structure and rugosity that supports feeding opportunities and predator avoidance.

The proposed action is likely to adversely affect critical habitat for PS/GB. These effects would be concentrated on the nearshore juvenile settlement habitats PBF. NMFS expects that the habitats at sites deeper than 98 feet (30 m) within the range of expected effects from the proposed action though at a lesser degree. The proposed action includes conservation offsets to compensate for the enduring effects on nearshore habitat quality.

a. Quantity, quality, and availability of prey species – The diet of Puget Sound rockfish consists of small prey items such as calanoid copepods, crab larvae, chaetognaths, hyperiid amphipods and siphonophores (Moulton 1977, Miller et al. 1978, in WDFW 2009). The proposed action will cause short-term reduction in invertebrate and fish forage items due to dredging, sediment remediation, and construction activities. Enduing loss of some forage production due to overwater structures. Shoreline modification interrupts natural shoreline habitat forming processes and reduces the abundance of invertebrate and fish forage items. Loss of forage quality and quantity results from introduction of contaminants from stormwater. Improved production of forage from habitat enhancement activities including wetland restoration and beach nourishment (improved quality forage fish spawning habitat).

b. Water quality –Temporary water quality degradation, including increased turbidity, due to construction activities and dredging. Reduced dissolved oxygen and resuspension of contaminated sediments from construction activities. Introduction of contaminants from stormwater. SSNP requirements for treatment of stormwater reduce the amount of contaminants reaching the action area.

c. Structure and rugosity – Loss of natural cover resulting from suppression of SAV due to over- and in-water structures.

Summary of the effects of the action on SRKW critical habitat PBFs

The PBFs of SRKW critical habitat are: (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.

a. Water quality – Temporary water quality degradation, including increased turbidity, due to construction activities and dredging will be spatially constrained. Removal of creosote materials will produce water quality improvements, and this benefit is also most notable within the natal estuaries for Chinook. Water quality will continue to be impaired by operational effects associated with upland activities at the Ports (stormwater) and by exhaust and spills from vessels that transit to and from the Ports. Overall, we expect the baseline condition of this PBF for SRKW to remain largely unchanged by the proposed action.

b. Prey – For SRKW, temporary and intermittent or operational effects 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 will 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.

   Overwater and in-water structures reduce nearshore habitat quality, increase migration time, and increase predation on juvenile salmonids. Likewise, shoreline modification interrupts natural shoreline processes, degrading nearshore habitat. Over time, this reduces the amount of salmon available as forage for SRKWs.

   However, because the proposed action also includes habitat improvement activities for the purpose of retaining overall the current level of habitat features and function, we expect that reductions of PS Chinook associated with the activities covered by the USACE's permits will be largely temporary, lasting typically no more than 3 years.

   Accordingly, we believe that the effects on the prey PBF for SRKW is limited to brief reductions but a long-term stasis in abundance.

Passage conditions – The proposed action has the potential to affect passage conditions in SRKW designated critical habitat. Effects of the proposed action include the potential for exposure to the and sound generated by vessels associated with the proposed action. The vessel presence and sound in SRKW critical habitat caused by the proposed action contribute to total effects on passage conditions. Vessels associated with the proposed action do not target whales and disturbance would likely be transitory, including avoidance movements away from vessels. As discussed above, considering the state and federal regulations in place, the number and spread of vessels is not expected to block movements of the whales in their travel corridors. Lastly, given all projects that include impact or vibratory pile driving will include a Marine Mammal Monitoring Plan (Appendices D and E) that is sufficient to ensure pile driving ceases before marine mammals enter the area where sound will exceed 120 dBRMS, noise from pile driving on SRKW critical habitat is likely minor.

2.4.4 Effects on Listed Species

As described in Section 0, the proposed actions will cause adverse effects on habitat through physical, chemical, or biological changes to the environmental baseline. These habitat reductions, or stressors, may cause adverse effects to individuals of listed species. The effects stressors have on individuals are a function of their exposure to those effects; the proximity, duration, frequency, and intensity of exposure; the life stage at exposure; and their response.

Over the lifetime of these Programs, individuals from multiple cohorts and populations will experience these stressors, including PS Chinook salmon, PS steelhead, PS/GB bocaccio rockfish, PS/GB yelloweye rockfish, SRKW, and humpback whales. As previously discussed, local PS Chinook salmon and PS steelhead fish populations are most likely to experience the full array of effects within each Project Area due to the proximity of their natal streams (with the greatest likelihood of exposure among Green, Sammamish-Cedar, Puyallup, and White River Chinook, and Green River, Puyallup River and Winter Carbon, Puyallup, and White River Steelhead) (See Tables 17 and 18).

Although sunflower sea stars are habitat generalists and present abundance is a fraction of historic level, this species will be present and exposed to some of the adverse effects of the proposed action.

In addition to BMPs and design criteria that minimize effects and corollary exposure to noise, shade, water quality diminishments, and habitat loss, the requirement to offset impacts is expected to compensate for the diminishment of nearshore habitat quality, further reducing the amount of exposure of species to habitat-based effects. Minimization and compensatory elements notwithstanding, effects and exposure will occur, and this analysis is for those effects that occur despite the implementation of BMPs.

In this section, we analyze stressors from each pathway detailed for critical habitat for species effects. Additionally, this section includes an analysis for physical contact with equipment, a pathway of effects on species that is not habitat based. Stressors may be temporary, ongoing, or permanent (lasting for months, years or decades). This analysis is based on stressor extent, the risk of potential exposure to individuals of each species, and, where exposure will occur, the anticipated response of each species.

Table 18. Effects pathways and species likely to be exposed and respond.

Effect Pathway	PS Chinook Salmon	PS Steelhead	PS/GB Bocaccio	PS/GB Yelloweye	SRKW	Humpback Whale	Sunflower Sea Star
a) Physical contact			X				X
b) Noise	X	X	X	X	X	X	
c) Shade/ALAN	X	X	X				X
d) Water quality	X	X	X	X	X	X	X
e) Loss of habitat	X		X				X
f) Prey reductions	X	X	X		X		X
g) Habitat Improvements	X	X	X		X		X

a) Physical Contact

Entrainment

Fish could become entrained during dredging, dewatering of cofferdams, sediment remediation and sediment sampling.

Entrainment refers to the uptake of aquatic organisms by dredge equipment. Mechanical (clamshell) dredges can entrain slow-moving and sessile benthic epifauna along with burrowing infauna that are removed with the sediments. They also entrain algae and aquatic vegetation. Organisms that become entrained or are unable to escape before contact with the substrate are likely to be buried under the sediments. The likelihood of injury or mortality would increase with proximity to the center of the discharge field, where depth and weight of the sediments would be greatest.

Carlson et al. (2001) documented the behavioral responses of salmonids to dredging activities in the Columbia River using hydroacoustics. During dredging operations, out-migrating salmon smolts (*Oncorhynchus* spp., likely fall Chinook salmon and coho salmon [*O. kisutch*]) behavioral responses ranged from (1) salmon orienting to the channel margin move inshore when encountering the dredge, (2) most out-migrating salmon passing inshore moved offshore upon encountering the discharge plume, and (3) out-migrating salmon were observed to assume their prior distribution trends within a short time after encountering both the dredging activity and dredge plume" (Kjelland et al. 2015).

The probability of fish entrainment depends on the likelihood of fish occurring within the dredge prism, dredge depth, fish densities, the entrainment zone (water column of the clamshell impact), location of dredging, type of equipment operations, time of year, and species life stage. In order to be entrained in a clamshell bucket during dredging/excavation, a fish must be directly under the bucket when it drops. Most fish in the vicinity of the dredge at the start of the operation would likely swim away to avoid the noise and activity, and the relative size of the dredge bucket in respect to organism distribution across available habitat make this situation very unlikely.

Further, dredge operations move very slowly, with the barge typically staying in one location for many minutes to several hours, while the bucket is repeatedly lowered and raised within an area limited to the range of the crane arm. As a fish is most likely to move away from the disturbance during barge movement or during the first few bucket cycles, the slow progression further reduces the risk of entrainment.

Entrainment can also occur during material placement, when the sand/rock fall through the water column, and creates a plume that extends from the bottom of the vessel to the seafloor. Fish that are above the point of discharge or are otherwise not directly below a discharge plume are likely to detect the plume and attempt to evade the descending material as a perceived threat. Fish that are below a discharge plume are likely to initially dive and then initiate horizontal evasion, or to simply move laterally if already on or near the bottom.

Sediment sampling via grabs have a similar, method of action as a dredge bucket to remove a much smaller area of sediment surface. Theoretically, this activity could also entrain benthic species. Based on the best available information, NMFS considers it highly unlikely that any of the species considered in this consultation would be struck or entrained by a sediment sampling procedure. To briefly summarize, in order to be entrained by sediment sampling, the fish must be directly under sampling equipment when it drops. The small size of the bucket, compared against the distribution of the organisms across the available habitat make this situation is extremely unlikely, and that likelihood would decrease after the first few bucket cycles because the fish are most likely to move away from the disturbance.

Fish Response to Entrainment

There is little evidence of mechanical dredge entrainment of highly mobile organisms such as fish. If proposed action activities resulted in entrainment, demersal fish (such as sand lance, sculpins, and pricklebacks) would be most likely to be entrained as they reside on or in the bottom substrates with life-history strategies of burrowing or hiding in the bottom substrate (Nightingale and Simenstad 2001). Evidence indicates that the risk of entrainment of any ESA listed fish during the proposed action is extremely low. For example, in the Southeast Region of the U.S., where heavy dredging operations occur, only two live sturgeon (NMFS 2012) and two live sea turtles (NMFS 2011) are known to have been taken by clamshell dredging since 1990. This is likely due to a combination of factors that make entrainment very rare. In order to be entrained in a clamshell bucket, an organism, must be directly under the bucket when it drops. The small size of the bucket, compared against the distribution of the organisms across the available habitat make this situation is very unlikely. Second, is that likelihood would decrease even more, after the first few bucket cycles because mobile organisms are most likely to respond to the disturbance by moving away from the disturbance. Most fish in the vicinity of the project at the start of the operation would likely swim away to avoid the sound and activity. Adult salmonids are of sufficient size and speed to avoid entrainment. Consequently, the risk of entrainment of juvenile ESA-listed salmonids by the dredge is low but not zero. Juvenile bocaccio are unlikely to be present, but given that they settle on the bottom, if present in the location of dredging, their risk of entrainment is higher than that of Chinook or steelhead. Entrainment is likely to result in injury or death among these fish, if it occurs.

Marine Mammal Response to Entrainment

Neither humpbacks nor SRKW are at risk of entrainment during dredging or sediment sampling. While SRKW can enter shallow areas, entrainment of SRKW is extremely unlikely based on their size, migration preferences for deeper open water, and marine mammal monitoring protocols (Appendices D and E).

Sunflower Sea Star Response to Entrainment

While sea star adults and juvenile abundance in Puget Sound has declined, one adult can produce millions of larvae, thus larvae in the water column could be present, and in numbers more plentiful than benthic adults and juveniles. Some larvae may be entrained during sediment removal and, if not detected and moved before sampling, it is possible that an adult sunflower sea star could be entrained by a dredge or sediment grab bucket. This would likely kill any entrained individuals.

Strike

Fish Response to Risk of Strike

While studies are available that show fish response to noise from boat motors, no studies were identified that indicate that fish are physically struck by vessels.

Marine Mammal Response to Risk of Strike

For marine mammals, operating vessels could cause collisions, known as strikes. While strikes, if they occur, can produce injury or death, we expect such strikes to be rare, and unlikely to occur during the operational period of these permits. In 2008, a review of 130 large whale strandings in Puget Sound over a 26-year period found only one possible ship struck humpback, despite concentrations of humpbacks feeding within the shipping lanes (Douglas et al. 2008).

Fatal vessel interactions occur but are infrequent for all killer whales (see Raverty et al. 2020). Necropsy of three SRKW strandings in recent years showed one had died of blunt force trauma associated with vessel strike (Carretta et al. 2021). This represents a significant portion of the population, at the current extreme depressed numbers. While the SRKW Recovery Plan mentions vessel strikes, it does not identify them as a major threat (NMFS 2008b). Strikes from any vessel are a relatively rare occurrence in Puget Sound and have been associated with much faster moving vessels (Rockwood et al. 2017). Vessels utilizing the Ports are primarily slow-moving barges and are expected to comply with SRKW approach regulations. All vessels are subject to Washington state regulations protecting SRKWs, which include prohibition of approaching or failing to disengage transmission within 1,000 yards of a SRKW, or exceeding a speed of seven knots at any point located within one-half of a nautical mile of a SRKW. To further reduce the risk of collision and disturbance, the Ports and Quiet Sound implemented a WhaleReport Alert System that delivers alerts when a commercial vessel is within 10 nautical miles of a verified whale sighting and directs captains to slow down or alter course (B.C. Cetacean Sightings Network 2023). We consider the risk of strike extremely unlikely to occur as a result of the proposed action within the 10 years of the permit duration due to vessel speed, existing regulations, and additional voluntary programs intended to provide further protections.

Members of the Mexico and Central America DPSs of humpback whales are present in Puget Sound. In the past several years, documented humpback whale strikes have occurred in association with large vessels, such as the Bainbridge Island ferry in May 2019 (NWPB 2019), and the Whidbey Island ferry in July 2020 (Cascadia Research Collective 2020). These collisions have resulted in the assumed fatality of the individual. Although these two events show the vessel strikes are possible, the whales' relative low density in the Puget Sound proper and the slow seed at which barges travel to and from the Ports compared to ferries in recent strikes, make vessel strikes unlikely.

Sunflower Sea Star Response to Risk of Strike

We do not expect strikes to occur among this species.

b) Noise

All species will be exposed to noise caused directly or indirectly by the Ports' proposed activities. Noise will occur despite application of the IWWW, BMPs for construction and monitoring, or the adherence to the MMMP.

Based on this assessment of underwater noise generated by Program Activities, we assessed the greatest potential for exposure to listed species and their habitat by evaluating a scenario in which the highest possible elevated noise (i.e., pile installation) occurs to define the distance where construction noise attenuates to threshold values. The impact pile scenario with the greatest isopleth distances are:

- Seattle: impact installation of 8 30-inch diameter steel pile in one day
- Tacoma: impact installation of 5 24-inch diameter steel pile in one day

The following assumptions were used to calculate noise impacts:

- Vibratory pile installation is preferred over impact driving. It will include up to 8 pile per day and take up to 60 minutes per pile.
- Assuming 400 strikes per pile for impact installation
- Impact driving will last less than 30 minutes per day;
- The maximum duration of impact driving any steel pile is expected to last less than 80 minutes per day (for a maximum of 9 hours cumulative) when impact driving occurs
- An attenuation of 9 dB was subtracted from the source values for impact driving to account for implementation of attenuation devices, most likely a bubble curtain.
- The number of pile strikes is estimated per continuous work period between 12-hour breaks.

NMFS uses a Sound Pressure Exposure spreadsheet to calculate the area around an activity where listed organisms would be considered at risk of injury or behavioral disruption. In our analysis, SPLs are presented in decibels (dB) measured as root mean square (RMS) or peak with 1 microPascal (1 µPa) as the reference unit. Multiple strikes from an impact pile driver are assessed by integrating the sound energy across all pile strikes, which is denoted as cumulative SEL (SEL_{cum})[28].

For marine mammals, sound effects in the environment can be either Level A, which is defined as a permanent threshold shift or hearing injury, or it can be Level B, which includes changes in behavior such as migration, breathing, nursing, breeding, feeding, or sheltering. NMFS uses conservative dual broadband peak SPL and frequency- weighted cSEL thresholds for impulsive noise and frequency-weighted cSEL thresholds for non- impulsive noise to identify the onset of PTS for generalized hearing groups of cetaceans (NMFS 2018, Southall et al. 2019). Per the 2024 updated marine mammal auditory guidance (NMFS 2024) SRKW are categorized in the high-frequency cetacean group with a generalized hearing range from 150 Hz to 160 kHz.

The noise thresholds for high-frequency cetaceans are (NMFS 2024):

- Impulsive noise:
  - 230 dB peak unweighted
  - 193 dB cSEL weighted for onset of PTS auditory injury
  - 160 dB rms for behavioral harassment
- Non-impulsive noise:
  - 201 dB weighted cSEL
  - and 120 dB rms for behavioral harassment

Results of the modeling are provided in Table 19 for distances to fish thresholds and Table 20 for distances to marine mammal thresholds. NMFS supplements the pile information provided by the Ports with the underwater noise levels generated by dredging, geotechnical sediment sampling, and construction vessels based on the best available data in our analysis. Of note is the extent of the very large distances to the behavior thresholds are truncated by land depending on site-specific topography surrounding each work area (see Seattle 2024 and Tacoma 2024).

[28] $SEL_{single\ strike} + 10\ log_{10}(N)$, where N is the number of pulses.

Table 19. Distance to fish injury thresholds and behavior guidance criteria in meters (rounded to nearest whole number)

Activity	Pile Type and Size	dB_{PEAK}	dB_{rms}	SEL_{cum}	Distance to Peak Injury (206 dB_{PEAK})	Distance to Cumulative Injury Fish ≥ 2 g (187 SEL_{cum})	Distance to Cumulative Injury Fish < 2 g (183 SEL_{cum})	Distance to Behavior (150 dB_{rms})
Impact pile driving-Seattle	30-inch steel pipe	212	195	186	6	468	631	2,512
Impact pile driving-Tacoma	24-inch steel	198	185	169	1	25	46	541
Vibratory pile driving/removal-Seattle	30-inch steel	196	171	--	--	--	--	251
Vibratory pile driving/removal-Tacoma	24-inch steel sheet	177	163	163	--	--	--	74
Geotechnical sampling	--	181	158	148	0	0	1	34

Table 20. Distance to SRKW (high-frequency cetacean) injury thresholds and behavior guidance criteria in meters (rounded to nearest whole number)

Activity	Pile Type and Size	dB_{PEAK}	dB_{rms}	SEL_{cum}	Distance to Peak Injury: Impulsive (230 dB_{PEAK})	Distance to Injury: Impulsive (193 dB SEL_{cum})	Distance to Behavior: Impulsive (160 dB_{rms})	Distance to Injury: Non-impulsive (201 dB SEL_{cum})	Distance to Behavior: Non-impulsive (120 dB_{rms})
Impact pile driving-Seattle	30-inch steel pipe	212	195	186	12	110	541	--	--
Impact pile driving-Tacoma	24-inch steel	198	185	169	1	6	117	--	--
Vibratory pile driving/removal-Seattle	30-inch steel	196	171	--	--	--	--	66	25,119
Vibratory pile driving/removal-Tacoma	24-inch steel sheet	177	163	163	--	--	--	19	7,356
Geotechnical sampling	--	181	158	148	0	0	2	6	3,415

Fish Response to pile driving noise

The level of injury for fish begins at 183 dB_{RMS} for fish below 2 grams and at 187 dB_{RMS} for fish above 2 grams (Turnpenny and Nedwell 1994; Turnpenny et al. 1994; Popper 2003; Hastings and Popper 2005). Injury or death associated with impact pile driving appears to be positively correlated with the size of the pile (driving larger piles requires more energy than smaller piles and produces higher sound levels) but site-specific geologic conditions also influence sound propagation, as instances of driving 30-inch diameter steel piles have been observed to create higher sound levels than 36-inch diameter steel piles (WSDOT 2020). The type of pile seems to influence the severity of impacts to fishes. All observed fish-kills have been associated with impact driving of hollow steel piles ranging from 24- to 96-inches in diameter. Wood and concrete piles appear to produce lower sound pressures than hollow steel piles of a similar size, although it is not yet clear if the sounds produced by wood or concrete piles are harmful to fishes. Death from barotrauma can be instantaneous or delayed up to several days after exposure.

During Seattle impact driving, the impact driving single-strike injury threshold (206 dB) will be exceeded. The peak isopleth (212 dB) will encompass a radius 6 meters (20 feet) from the strike area. No fish will be present within this distance due to exclusion around the bubble curtain. Impact pile noise will reach SEL_{cum} injury threshold levels for fish less than 2 grams (183 dB) within 631 meters (2,070 feet) of installation and injury threshold levels for fish greater than 2 grams (187 dB) within 468 meters (1,535 feet) of installation for fish greater than 2 grams.

During Tacoma's impact driving, the impact driving single-strike injury threshold (206 dB) will not be reached. The peak isopleth (198 dB) will be reached within 1 meter (3 feet). No fish will be present within this distance due to exclusion around the bubble curtain. Impact pile noise will reach SEL_{cum} injury threshold levels for fish less than 2 grams (183 dB) within 25 meters (82 feet) of installation and injury threshold levels for fish greater than 2 grams (187 dB) within 46 meters (151 feet) of installation for fish greater than 2 grams.

During the in-water work window, all exposed PS Chinook salmon and PS steelhead are expected to be larger than 2 grams, which reduces the likelihood of lethal injury. Adult PS Chinook and adult and juvenile PS steelhead make little use of nearshore habitats, and would likely only be exposed to injurious levels of underwater sound if they were holding in an area long enough to accumulate harmful received levels of impact pile driving noise. However, juvenile PS Chinook salmon have a higher chance of sound exposure due to their extensive use of nearshore habitats and potential to overlap with the in-water work window. Early in the work window, juvenile PS Chinook salmon (weighing more than 2 grams) may seek forage or shelter in armored areas despite vibratory construction noise. If behavior changes from vibratory sound cause disorientation or stress and juvenile PS Chinook salmon are unable exit the waterway, they may be exposed to impact driving causing sublethal injury.

High sound levels can also cause sublethal injuries, and adverse effects on survival and fitness can occur even in the absence of overt injury. Fish suffering damage to hearing organs may suffer equilibrium problems, and may have a reduced ability to detect predators and prey (Turnpenny et al. 1994; Hastings et al. 1996). A temporary shift in hearing sensitivity (referred to as a temporary threshold shift [TTS]) can occur with exposure to SEL_{cum} as low as 184 dB

(Popper et al. 2005). TTS can last hours to days (Turnpenny et al. 1994; Hastings et al. 1996). TTS reduces the survival, growth, and reproduction of the affected fish by impeding migration, increasing the risk of predation, and reducing foraging or spawning success.

Noise at fish behavior threshold levels (150 dB_{RMS}) may cause temporary behavioral changes, including a startle response or other behaviors, which may alter fish behavior in such a way as to delay migration, increase risk of predation, reduce foraging success, or reduce spawning success, indicative of stress. The maximum impact scenario for underwater noise indicates that fish behavior threshold levels (150 dB_{RMS}) will be exceeded in areas within 251 meters (823 feet) of activity during vibratory driving and within 2,512 meters (8,241 feet) of activity during impact driving in Seattle (Table 19). For Tacoma, this threshold will be exceeded in areas within 74 meters (243 feet) of activity during vibratory driving and within 541 meters (1,775 feet) of activity during impact driving (Table 19). While SPLs of this magnitude are unlikely to lead to permanent injury, depending on a variety of factors (e.g., duration of exposure) they can still indirectly result in potentially lethal effects. NMFS' overall synthesis of the best available science leads us to our findings. Studies in which these effects have been studied for salmonids and rockfish include Grette 1985 (on Chinook salmon and sockeye), Ruggerone et al. 2008 (on coho salmon), Popper 2003 (on behavioral responses of fishes), and Pearson et al. 1992, and Skalski et al. 1992 (on rockfish).

Noise can negatively impact reproduction, predator detection, foraging, orientation, or communication in fish (Slabbekoorn et al. 2010; Hawkins and Picciulin 2019). Planktonic reef fishes have been found to use sound to settle into reef habitats, so masking can potentially affect this important environmental clue (see review by Putland et al. 2019). Fish hear at low frequencies (the majority of fish hearing from less than 50 Hz to 500 Hz [Popper and Hawkins 2019]) and most of the sound energy of impact pile driving in concentrated at frequencies (100 to 800 Hz) within their hearing range. However, there is a limited understanding of fish hearing because fish are primarily sensitive to particle motion with a gradient of sensitivity among species to SPL depending on if they have a swim bladder and the degree of anatomical adaptations they have to convert sound pressure into particle motion that is detectable by the inner ear (Putland et al. 2019, p.41). Fish species that lack a swim bladder (such as eulachon and sand lance) have the most limited hearing. Salmon and rockfish have a swim bladder, but little specialization, so they primarily detect particle motion. Pacific herring, an important forage species of salmon, have special anatomical adaptations to their swim bladder and can hear sound pressure up to 5 kHz (Mann et al. 2005). Even at levels far lower than those that might result in mortality, may result in temporary hearing impairment, physiological changes, changes in behavior and the masking of biologically important sounds (Popper et al. 2014; Erbe and McPherson 2017). There may be significant consequences to individuals and populations as a result of changes in behavior, including impairment of spawning (Popper 2019).

While no studies specifically evaluate the effects of vibratory pile driving on salmonids, NMFS extrapolates from other studies to determine that vibratory pile driving can result in noise level sufficient to alter normal behavior patterns in fish. As cited in van der Knapp et al. (2022), when exposed to boat noise, wild Pacific herring and juvenile pink and chum salmon schools showed stereotyped responses that are consistent with classic vigilance behaviors associated with anti-predator tactics (Magurran 1990). During exposure trials (in the presence of boat noise) both fish groups spent more time in behaviors considered to be a response to predators. These composite response findings suggest that salmon and herring respond to boat noise as a non-lethal predator (Beale and Monaghan 2004; Frid and Dill 2002). Flight responses to predators, including perceived predators, are adaptive. Once a predator is detected, schooling behavior decreases any one individual's probability of being eaten (Pitcher 1986). But repeated responses to predation risk can carry costs. If fish are repeatedly replacing foraging activities with vigilance and anti-predator behavior, this can reduce their energetic intake and fitness. Simply living in a "landscape of fear" of predation risk can carry population-level consequences, even in the absence of actual predation (Lima and Dill 1990). In fact, fish exposed to boat noise are responding to both perceived and actual predation risk. In addition to disrupting normal behavior in response to anthropogenic disturbance, juvenile salmon and herring in the Salish Sea face a gauntlet of predators (Chasco et al. 2017).

We assume adult PS/GB bocaccio and juvenile and adult yelloweye, would not be present in the area within the injury threshold because this work will take place within each Port's Project Area, where no deepwater habitats with hard benthic structure for rockfish are present. Adult PS/GB bocaccio and yelloweye are also expected to weigh at least 2 grams during the in-water work window, reducing the likelihood of injury. However, larval and young juvenile PS/GB bocaccio and larval yelloweye will weigh less than 2 grams and have the potential to be closer to the sound source, making them more vulnerable to injury or death.

We expect that over the course of the proposed action (10 years) a small number of juvenile and adult PS Chinook salmon, juvenile and adult PS steelhead, juvenile PS/GB bocaccio and larval lifestages of bocaccio and yelloweye will experience underwater sound at levels inducing sublethal effects, including disruption of normal behavior patterns. We expect a small fraction of juvenile fish that engage in disrupted behavior may have greater likelihood of being preyed upon by other species. Based on the preference for vibratory methods over impact driving, the use of sound attenuation for impact driving, and the relatively small area of effects within working waterways with high ambient noise levels, the likelihood of these effects is small but not zero for these species. We cannot predict the exact number of individual fishes among each year's cohorts that will be exposed, because of high variability in species presence at any given time. Furthermore, not all exposed individuals will experience adverse effects.

Therefore, underwater noise, including noise from vibratory or impact pile driving is expected to result in a range of responses, ranging from masking of communication (juvenile PS/GB bocaccio, SRKW) the inability to detect environmental signals (PS Chinook salmon, PS steelhead, juvenile PS/GB bocaccio, juvenile PS/GB yelloweye, and SRKW), to behavioral changes that constitute harm, and in the case of impact driving, death or injury could result in some exposed fish.

Marine Mammal Response to pile driving noise

The responses of cetaceans to sound sources are often dependent on the perceived motion of the sound source as well as the nature of the sound itself. For a given source level, fin and right whales are more likely to tolerate a stationary source than they are one that is approaching them (Watkins, 1986). Humpback whales are more likely to respond at lower received levels to a stimulus with a sudden onset than to one that is continuously present (Malme et al., 1985). These startle responses are one reason many seismic surveys are required to "ramp up" the signal so fewer animals will experience the startle reaction and so that animals can vacate the area of loudest signals. There is no evidence, however, that this action reduces the disturbance associated with these activities. Responses of animals also vary depending on where the animals are when they encounter a novel sound source.

SRKW and humpback whales are unlikely to be injured or disturbed by elevated sound from construction activities because the Ports have included marine mammal monitoring plans as part of the proposed action intend to use marine mammal monitoring and 'stop work' protocols during construction that produces noise causing sound above behavioral thresholds where marine mammals are more likely to be present (i.e., offshore areas of Elliott Bay and Commencement Bay) (See Appendices D and E). Experienced marine mammal observers will visually monitor the zone where acoustic levels are expected to exceed marine mammal thresholds before, during, and after construction work. Pile work will not start, or will cease, if whales enter the monitoring zones. Based on this protective measure, behavioral effects to SRKW and humpback whales caused by noise are unlikely, but not impossible.

Although construction noise could adversely affect a small number of juvenile PS Chinook salmon, the majority of effects would be sublethal and are not of a magnitude that will measurably affect the SRKW forage base, which is of adult salmon, among other fishes.

Seastar Response to Pile driving Noise

Sunflower sea stars do not have ears or the ability to hear, though they are likely to perceive vibration. Their movement is thought to be guided by olfaction, so they are not expected to respond with modified movement when exposed to sound (Garm 2017).

Fish Response to vessel noise (construction vessels and commercial/industrial vessel traffic)

Adult bocaccio and adult and juvenile yelloweye rockfish are expected to be in deeper areas where the exposure to construction and commercial vessel traffic noise is unlikely. Castellote et al. (2019) found that salmon reaction to a playback of ship noise at source level (160-170 RMS dB) was infrequent with no reaction 85 percent of the time, and that the most frequent of the responses was a minor directional change away from the source of the sound. Moreover, the authors posit that fish are less reactive to structured continuous noise than to sudden onset of noise. We assume juvenile PS Chinook salmon, juvenile outmigration steelhead, larval PB/GB yelloweye, and larval juvenile PS/GB bocaccio will be exposed to construction vessel noise, and other than larvae which do not hear until several months of growth and development, all are likely to respond to episodes of noise with a stress and startle reaction that can diminish both predator and prey detection for a short period of time with each episode. Larval rockfish would not be able to swim away from noise and are unlikely to detect noise until several months old.

Many juvenile Chinook from Strait of Georgia and Puget Sound migrate onto the continental shelf after their first year at sea (Trudel et al. 2009). Accordingly, we expect both juveniles and adult Chinook will be exposed to vessels when migrating in the action area; though it is unclear if or how they respond to this noise.

While NMFS cannot specifically identify fish exposure and response to the vessels that use the Ports, we can provide a generalized presentation of response to ship noise. As described above, fish notice and respond to motorboat noise (Simpson et al. 2016; Voellmy et al. 2014; Whitfield and Becker 2014), and juvenile PS Chinook salmon, PS steelhead, and PS/GB bocaccio that encounter ongoing vessel noise will likely startle and briefly move away from the area. Because perpetuated vessel noise within the action area is dispersed, we expect the exposed ESA-listed fish will likely only respond with minor behavior changes. Based on the previously described research, it can be assumed that juvenile PS Chinook salmon are likely to respond to episodes of boat motor noise with a stress and startle reaction that can diminish both predator and prey detection for a short period of time with each episode. The in-water sound is perceived by fish, and increased in-water sound can have adverse consequences for individual fish. If the effect on individuals is sufficiently adverse, these effects can matter to the populations to which those individuals belong. Although sonar, pile driving and explosions typically are noise sources that are most often considered as adverse, it is reasonable consider that the greater impact on fish could be from less intense sounds that are of longer duration, and more systemically present, and that can potentially affect whole ecosystems.

Marine Mammal Response to vessel noise

The proposed action prolongs the life of marine structures that support commercial vessels. As a result, vessel traffic associated with the authorized structures is a consequence of the proposed action. As noted in the description of the action area for this consultation, these vessels are expected to operate in the Salish Sea; both humpback whales and SRKW will be exposed to this noise.

Noise from vessel traffic has shown to cause variation in humpback whale behavior from changes in surface, foraging, and vocal behavior, displace animals from occupied areas, and produce temporary or permanent hearing damage and physiological stress. Nevertheless, responses by whales can vary depending on localized circumstances, sometimes with no observable reactions recorded.

Williams et al. (2014) found coastal marine noise levels high enough to potentially cause significant communication problems for humpback whales at several locations in British Columbia, including Haro Strait in the Salish Sea adjacent to Washington. Where sound-related impacts are severe, reproduction and survival of animals may be affected (Clark et al. 2009). More specific, Schuler et al. (2019) found that feeding and traveling humpback whales were likely to maintain their behavioral state regardless of vessel presence, while surface active humpback whales were likely to transition to traveling in the presence of vessels. These short-term changes in movement and behavior in response to whale-watching vessels could lead to cumulative, long-term consequences, negatively impacting the health. Sprogis et al. (2020) showed vessel noise as a driver of significant behavioral response in humpback whales while simulating whale watching scenarios. During high noise playbacks on mother/calf pairs, the mother's proportion of time resting decreased by 30 percent, respiration rate doubled, and swim speed increased by 37 percent. However, we note that, based on data available in 2015, the threat of anthropogenic noise received a "low" rating for all DPSs of humpback whales in the recent NMFS Status Review (out of possible ratings of unknown, low, medium, high, and very high; Bettridge et al. 2015). While data from 2015 may be outdated, efforts to reduce vessel related noise in the Salish Sea (while aimed at SRKW these are also effective for humpback whales) have likely kept noise levels from rising rapidly over the last 10 years. Such efforts are described below in section 2.5. However, even if noise levels were still low, NMFS finds it likely that there is some exposure to large vessel noise in the action area resulting from the proposed action – 10-year extension of vessel operation. Further, NMFS finds it reasonably likely that this noise exposure will disturb humpback behaviors including feeding and communication and cumulatively reduce individual fitness. NMFS concludes that the proposed action will result in periodic harm to humpbacks in the action area.

Underwater noise is along with paucity of forage and contamination one of the main threats for SRKW and vessel noise has been shown to interfere with feeding behavior more so than with other activities (Williams et al. 2006, Lusseau et al., 2009). However, exposure to noise from vessels in shipping lanes may have the dual effect of masking communication, as well as the reception of echolocation signals, thus affecting the feeding success and the social interactions of SRKW (Cominelli et al 2018).Cominelli et al (2018) found that “Ferries, Tugboats, Vehicle Carriers, Recreational Vessels, Containers, and Bulkers” caused high levels of exposure ($L_{eq-50}{}^{th}$ > 90 dB re 1 μPa) within SRKW summer core areas. While, summer core areas for SRKW are located north of the action area, exposure in the Puget Sound and Strait of Juan de Fuca portions of the action area is likely. Figru shows likelihood of whale distribution based on reported sightings. Williams et al. (2021) found that foraging behavior was inversely related to boat noise; in other words, boat noise either SRKW stopped feeding or reduced the likelihood to initiate feeding. Thus, NMFS finds it reasonably likely that the extension of large vessel operation in the action area will disturb SRKW feeding and potentially other behaviors. Although the vessel noise associated with the proposed action is not likely to cause direct physical injury (i.e. eardrum damage). NMFS concludes that the proposed action will result in periodic harm to SRKW in the action area. Thus, noise from large vessels is likely to adversely affect individual SRKW over the course of the 10-year program by disrupting their ability to find and obtain prey in known foraging habitat.

3. **Shade/ALAN**

Fish Response

Juvenile salmonids have slow visual response to stark shade/light contrast (M.A. Ali, 1959). This could be the cause of their delay when encountering stark shade lines cast by overwater or inwater structures when migrating. Migratory obstructions from shade caused by in and overwater structures, or vessels, typically result in juvenile salmonid delaying passage or forcing them into deeper water in an attempt to go around the structures, resulting in more vulnerability to predation (Simenstad et al. 1999; Shreffler and Moursund 1999; Southard et al. 2006). Swimming around replaced in-and overwater structures is correlated with increased mortality. Salmonids have slow vision response to shade, and reactions include avoidance, which can result in delayed migration and increased predation risk. There is an increased risk of juvenile salmonid predation by other fish or avian predators when they leave the relative safety of shallow water (Willette 2001; Willette et al. 2001), or hesitate when encountering shaded areas. Juvenile bocaccio, if present in either Port’s project area, may not respond directly to shade, but would need to migrate to areas with higher prey base, as shade impairs benthic productivity.

ALAN has negative effects on a plethora of wildlife, including salmonids (Longcore and Rich 2024). Juvenile and adult salmonids rely on diel light patterns for navigation, predator avoidance, and orientation during migration. Artificial lighting can interfere with their behavioral and physiological processes, ultimately affecting their survival and population dynamics (Yurk and Trites 2000; Tabor et al. 2021; Pulgar et al. 2023). For example, Beauchamp et al. (2020) shows that predation risk caused by ALAN is 6-times higher for juvenile salmon and forage fish in urbanized nearshore habitat than in non-urbanized nearshore habitats. Because juvenile Chinook, particularly, use estuarine areas to grow and develop, artificial lights in estuaries and in the nearshore can cause significant reductions in survival through increased predation.

Marine Mammal Response

Marine mammals will not be directly exposed to shade from either Port's structures.

Sunflower Sea Star

Sunflower sea stars, like other invertebrates, often live in or around areas with aquatic vegetation or algal growth. Overwater shading can degrade these habitats, making them less suitable for starfish and other species. Shading from overwater structures can also alter water temperatures, which can affect the metabolic rates, growth, and development of starfish, especially during sensitive early life stages of starfish. Overwater shading may decrease the abundance of prey species which sunflower sea stars rely on, such as bivalves, small crustaceans, and other invertebrates, potentially leading to food scarcity. However, given that sunflower sea stars are currently in low abundance, reductions in prey are not likely to create conditions of competition, even if prey is reduced. Sunflower sea stars are highly mobile and this makes localized prey reductions less meaningful as individuals from this species are able to seek out prey over relatively broad areas (Hodin et al. 2021).

4. Diminished Water Quality

As described above, water quality will be diminished by turbidity and possibly low DO during construction activities to repair or replace in and overwater structures, during habitat improvement activities, and during maintenance dredging. Episodes of diminished water quality from these sources are likely to be brief, intermittent, and dispersed over a large area between project sites.

During the course of these permits, multiple exposures of individual from multiple cohorts of the populations will occur.

Other water quality effects will include suspended contaminated sediments, and chemicals from stormwater, vessel exhaust and spills, and brief exceedances of metals used in ACZA treated wood.

Fish Response to Turbidity/low DO

The effects of suspended sediment on fish increase in severity with sediment concentration and exposure time and can progressively include behavioral avoidance and/or disorientation, physiological stress (e.g., coughing), gill abrasion, and death—at extremely high concentrations. 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. For the proposed action, exposure to concentrations of suspended sediments expected during the proposed in-water construction activities is expected to elicit sublethal effects such as a short-term reduction in feeding rate or success, or minor physiological stress such as coughing or increased respiration. Juvenile salmon can detect and avoid turbidity and other water quality gradients (Quinn 2005; Simenstad 1988), and larger juvenile salmonids are more tolerant to suspended sediment than smaller juveniles (Servizi and Martens 1991; Newcombe and Jensen 1996). For this reason we expect that for those fish present when dredging or other inwater work occurs to create turbid conditions, most salmonids will respond with this avoidance behavior, limiting the duration and intensity of exposure to those minor physiological effects described above. Juvenile bocaccio could experience reduced swimming speed and increased ventilation rates (C.H. Flannery 2018), and some increased predation vulnerability could result (Davis, et al. 2018), but generally rockfish appear to be resilient to exposure to low DO, with sufficient acclimation time (Davis, et al. 2018).

Turbidity and depressed DO will not affect adult PS/GB bocaccio, nor juvenile and adult PS/GB yelloweye rockfish because they are not expected to be located in or near the respective Port's facilities.

While there is little information regarding the habitat requirements of PS/GB bocaccio rockfish larvae, other marine fish larvae biologically similar to rockfish larvae are vulnerable to low dissolved oxygen levels and elevated suspended sediment levels that can alter feeding rates and cause abrasion to gills (Boehlert 1984; Boehlert and Morgan 1985; Morgan and Levings 1989). Because each work window will overlap with one peak in larval presence, which is a several month pelagic stage without significant capacity for avoidance behavior (larval rockfish can swim at a rate of roughly 2 cm per second (Kashef et al. 2014) but are likely passively distributed with prevailing currents (Kendall and Picquelle 2003)), we can assume that project sites, and that PS/GB bocaccio and yelloweye larvae that are present when project sites have high turbidity will be have reduced fitness and/or survival.

Marine Mammal Response to Turbidity/low DO

Humpback whales are expected to be infrequently exposed to turbidity and DO reductions, and that if exposed the duration of their exposure will be brief either through stop work protocols, or because this species will respond with avoidance. SRKW may be exposed more frequently, but as above, stop work protocols could limit exposure to turbid conditions, and response is likely to be avoidance of the disturbed area.

Sunflower Sea Star to Turbidity/low DO

Increased sedimentation from coastal development, dredging, and other human activities can smother sea star habitats and clog their filtering mechanisms, making it difficult for them to feed and breathe. High levels of turbidity from construction activities and dredging are likely to produce a similar response if individuals of this species are present during construction. The Sunflower Sea Star populations have been significantly impacted by various factors, including changes in DO levels. Research indicates that there has been a long decline in their population sizes, with the decline steepening in recent years, emphasizing the importance of maintaining suitable DO levels for their survival and recovery efforts (Heady et al. 2022). Low oxygen levels could reduce health or fitness of exposed individuals,

Contaminants

Stormwater effluent will be managed as an ongoing effect of the maintained and repaired overwater structures and paved surfaces. Since the proposed action extends the life of these impervious surfaces, discharge of stormwater from those surfaces extended into the future are effects of the proposed actions. The proposed actions would not result in any new areas of pollution generating impervious surface (PGIS), but would replace, repair, and maintain the existing impervious surface and route stormwater runoff through treatment, extending the duration of their effects.

Stormwater will be treated in accordance with each Port's stormwater management programs, with treatment equivalent to Ecology's enhanced treatment for metals. But treatment does not exist on any of the Port's warves and only occurs in certain areas of the Port's managed property. Overall, PGIS replaced or repaired as part of this proposed action does not have stormwater treatment and will not receive treatment. Treatment and compliance with water quality permits is expected to limit overall contaminants concentrations in stormwater effluent from the entirety of Ports' facilities. No method of treatment other than full infiltration will fully remove all contaminants, therefore the proposed action will cause a chronic source of episodic chemical load into Puget Sound.

It is reasonable to assume that SRKW, PS Chinook salmon, PS steelhead, and juvenile PS/GB bocaccio will migrate through the project area over the period of the permits as well as the extended design life of the repaired and replaced structures. During this time, individuals would be exposed to untreated stormwater caused by the replacement of PGIS. Stormwater will contain dispersed concentrations of contaminants while in the water column. Dilution will greatly limit contaminant volumes, we expect the proposed action would cause some low-level, chronic behavioral or health effects that could reduce the fitness of listed fish.

Also, primarily at the Port of Tacoma project area, the use of in and overwater ACZA treated wood means that some of these chemicals will leach into the aquatic environment.

Fish Response to Contaminants

Impervious surfaces above working terminals will be used for frequent industrial transport from large vessels. As a result, stormwater runoff is highly likely to contain several contaminants that have proven damaging to fish, including PAHs and microplastics such as 6PPD/6PPD-q from vehicles regularly operating on the deck. As these contaminants are of particular concern for salmonids, their effects are discussed in greater detail below. The adverse responses to toxic contaminants in stormwater effluent on PS/GB bocaccio and PS/GB yelloweye are expected to be similar, although the magnitude and mechanism of impact may differ based on the individual contaminants present.

1. PAHs

A large and growing body of environmental monitoring analytical chemistry data has established PAHs as a ubiquitous component of stormwater-driven runoff into the Puget Sound. Whether originating from oils 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 compound 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 oils spill and urban stormwater are increasingly converging on a risk framework where certain PAHs (Figure 15) cause a well-described syndrome of involving the abnormal development of the heart, eye and jaw structure, and energy reserves of larval fish (Harding et al. 2020). Over the ensuing 30 years, combined research from NOAA's Alaska Fisheries Science Center (AFSC) and the Northwest Fisheries Science Center (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 no 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; 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.

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 (ΣPAH) levels in the range of 5 to 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 15). 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.

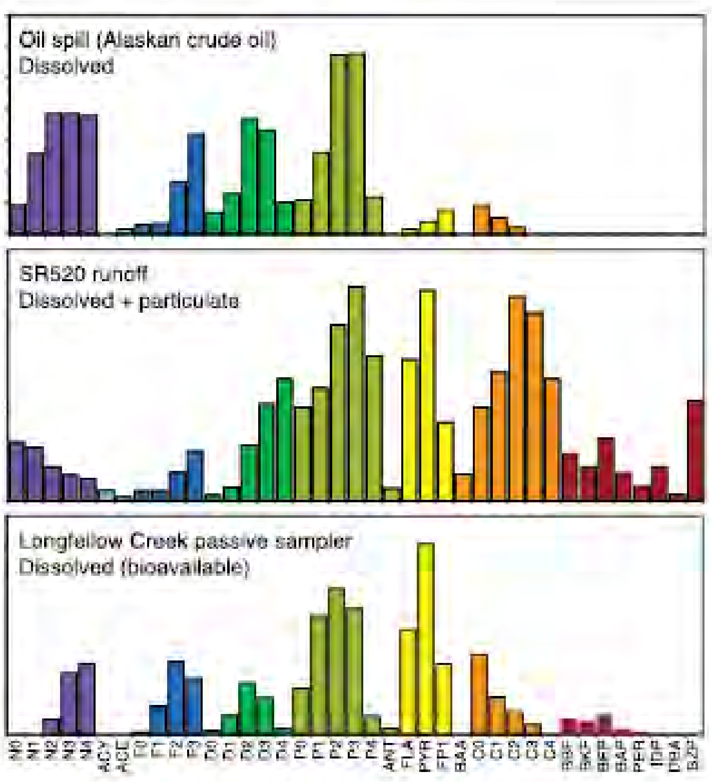

Figure 15. Patterns of PAHs in environmental samples.

In the image above, the top section indicates PAH from effluent in seawater flowing over gravel coated with Alaskan crude oil (source for Exxon Valdez), the middle shows PAHs from runoff from the SR520 highway adjacent to NWFSC. The bottom panel shows PAHs extracted from a polyethylene membrane device (PEMD) incubated 1 week in Longfellow Creek, West Seattle.

The pattern of bioavailable PAHs in the Seattle-area urban streams depicted in Figure 15 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. 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 ΣPAH 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.

2. *6PPD-Quinone*

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 (Lo et al., 2023; French et al. 2022). 6PPD leaches from road dust within a few hours of water exposure (Hiki and Yamamoto 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 and likely longer (McCarthy 2008; Scholz 2011).
- Chinook exposed to road dust with 6PPD-q demonstrate abnormal swimming behavior, hovering close to the surface, tumbling, gasping, loss of equilibrium, and death (Hiki and Yamamoto 2022)
- Samples collected across 15 states showed 6PPD-Q frequently detected in stormwater (57%, N = 90) and from urban impacted sites (45%, N = 276) with concentrations ranging from 0.002 to 0.29 µg/L. The highest concentrations, above the lethal level for coho salmon, occurred during stormwater runoff events (Lane et al. 2024).
- Environmentally realistic levels at ~50 mg/L could result in from leachate concentrations lethally toxic to coho salmon over longer periods of time (Hiki and Yamomoto 20220.
- 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 and Scholz 2011).
- Juvenile coho have been shown to be 3 orders of magnitude more sensitive to 6PPD-quinone compared with juvenile Chinook. Both with a very low lethal concentration. The juvenile coho LC50 was 2.3-fold lower than what was previously reported for 1+-year-old coho (95 ng/L). Both fish species exhibited gasping, increased ventilation, loss of equilibrium, erratic swimming, with fish that were symptomatic generally exhibiting mortality. The LC50 values for juvenile coho are below concentrations that have been measured in salmon-bearing waterways, suggesting the potential for population-level consequences in urban waters. The higher relative LC50 values for Chinook implies potential for population-relevant sublethal effects on juveniles.(Lo et al. 2023)
- 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 and Scholz 2011).
- Coho are extremely sensitive to 6PPD-q, more so than most other known contaminants in stormwater (Scholz et al. 2011; Chow 2019; Tian 2020).
- Coho juveniles appear to be similarly susceptible to the acutely lethal toxicity of 6PPD/6PPD-q (McIntyre et al 2015; Chow 2019).

- 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 et al. 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).

To summarize fish response to long-term stormwater effects, there is a risk that runoff could cause lethal and sublethal toxicity, up to and including delayed mortality, in exposed ESA-listed fish and the prey available to salmon and higher-trophic species. The magnitude of this effect will be somewhat reduced by the installation of basic stormwater treatment proposed for this action, which would likely reduce contaminants to levels below lethal toxicity. However, the standards of basic treatment do not provide evidence that risks from contaminants would be entirely avoided. Thus, adverse sublethal effects from ongoing stormwater effluent discharge are expected for PS Chinook salmon, PS steelhead, PS/GB yelloweye, and PS/GB bocaccio.

3. ACZA Treated Wood

Exposure to ACZA leachate is expected to be somewhat limited, and response depends on the specific chemical and the salinity of the environment. We anticipate that the preserving chemicals are likely to adversely affect juvenile salmon and steelhead, and larval rockfish that are present at the time the wood is placed, and for a period of 2 weeks after placement, when leaching is likely to exceed water quality criteria in the area immediately surrounding the treated wood. Arsenic concentrations in seawater are typically less than **1.5 µg/L** and less than **4 µg/L** in estuaries under natural conditions (Smedley and Kinniburgh, 2002). Concentrations in estuarine and coastal waters vary due to environmental factors such as riverine inputs, salinity gradients, and redox and pH gradients (Smedley and Kinniburgh, 2002). These factors can influence the concentration, which can range in coastal ecosystems (0.14 to 147 µg/l) including estuaries, lagoons and backwaters (Peterson and Carpenter 1983; Martin et al. 1993; Abdullah et al. 1995; Smedley and Kinniburgh 2002).

Among these three metals, copper, zinc, and arsenic, aquatic organisms tend to be most sensitive to the copper (Stook et al., 2004, Stook et al., 2005). For salmonids in particular, while studies have shown that copper impairs the olfactory nervous system and olfactory-mediated behaviors in salmon and steelhead at levels as low as 2.0 pbb in freshwater (Baldwin et al. 2011), in salt water olfaction is protected at a salinity of 10 percent, and also in full seawater. Sublethal concentrations of copper alter the behavior of juvenile Chinook salmon in seawater at environmentally realistic levels, when the fish enter the estuarine environment and transition from freshwater to seawater (Sommers et al. 2016).

Marine Mammal Response to contaminants

SRKW could be exposed to temporary increases of contaminants during construction, and are likely to be exposed to contaminants introduced as stormwater effluent, and from vessel-related pollutants. It is possible that they could be indirectly exposed if juvenile PS Chinook salmon accumulate measurable tissue concentrations that and are subsequently consumed as adults. Predators at the top of the aquatic food chain acquire and bioconcentrate larger amounts of contaminants as a function of age or size (Nichols et al. 1999), and high levels of pollutants have been measured in sample of blubber (Krahn et al. 2007; Krahn et al. 2009; Ross et al. 2000), and feces (Lundin et al. 2015; Lundin et al. 2016). PCBs present in stormwater are a high-risk contaminant for SRKW and are present in stormwater through road paint, building materials, deicer, and other sources. The Puget Sound projection for SRKWs blubber contamination level is expected to remain above the effect threshold (17 mg/kg lipid) until at least 2063 (Hickie 2007). Therefore, NMFS considers toxin accumulation in SRKW a serious concern (NMFS 2008b).

Chronic source input over the design life of repaired or replaced PGIS. The Ports do not propose to add any treatment to PGIS replaced or repaired. Without proposed stormwater treatment, exposure to contaminants is likely to cause some sublethal effects to SRKWs and to all listed species that chronically diminish SRKW prey quality.

We cannot predict the biomagnification of contaminants in prey tissue without site-specific analysis of the chemical composition and bioavailability, and numerous organism-specific biological factors.

Direct exposure of any individual humpbacks to contamination is expected to be infrequent. But exposure through consumption of their prey is expected to be frequent. Their prey is primarily composed of forage fish and crustaceans, of which humpback whales consume up to 2,500 kilograms each day. Through a trophic cascade, contaminants bioaccumulate in predators, including humpback whales. Although there has been substantial research on contaminants on individual whales, including humpbacks, no detectable or sub-lethal impact has been identified in baleen whales (NMFS 2022b). Contaminants were not considered an important threat to the CAM or Mexico DPS in the 2015 NMFS status review of humpback whales (Bettridge et al. 2015). We consider the response to the proposed action insignificant to humpback whales.

Sunflower Sea Star

Little is known about specific effects of water quality on sunflower sea stars, or how stress from exposure to water quality changes affects susceptibility to sea star wasting syndrome. Laboratory challenge tests have exposed larval stages of various marine invertebrates to hydrocarbons, heavy metals, pesticides, and other contaminants commonly found in stormwater runoff. Documented impacts range from developmental abnormalities to behavioral augmentation, and mortality is common at concentrations as low as several parts per million (e.g., Hudspith et al. 2017, de Almeida Rodrigues et. al 2022). For juvenile and adult marine invertebrates, including sea stars and other echinoderms, a variety of sublethal behavioral and physiological effects from these toxic contaminants have been documented, but mortality is also possible. Suspended sediment may also be a concern as stars that become covered by sediment may experience greater risk of wasting disease. Absent species-specific data for the sunflower sea star, ecologically and physiologically similar species can be used as proxies to state that poor water quality is likely to reduce health, fitness or survival of a small number of sunflower sea stars in the action area, having the greatest effects during the larval life history stage.

Species Responses to Diminished Water Quality Summary

We expect that some individual listed fish species would experience sublethal effects from elevated turbidity or low DO. Responses may include such as stress, reduced prey consumption, avoidance behaviors, or injury. We also expect resuspended contaminants and ongoing contaminants from stormwater effluent will adversely affect, PS Chinook salmon and PS steelhead at multiple life stages, SRKWs at all life stages, and juvenile and larval PS/GB yelloweye and bocaccio rockfish.

5. Prey Reductions

Fish response to prey reductions

A reduction to the primary production of SAV beds is likely to incrementally reduce the food sources and cover for juvenile PS Chinook, PS steelhead, and juvenile PS/GB bocaccio. The reduction in food source includes epibenthic prey (Haas et al. 2002) as well as forage fish. Shading can significantly impact benthic communities, and juvenile salmonids in turn have less area with suitable cover, refugia, and forage. Salmonids have slow vision response to shade, and reactions to shade itself includes reduced forage behavior among other reactions (see next section). This may result in some individual salmonids - primarily PS Chinook salmon (with the greatest likelihood of exposure among Green, Sammamish-Cedar, Puyallup, and White River) having reduced growth, fitness, or survival.

When juvenile PS/GB bocaccio rockfish reach sizes of 1 to 3.5 in (3 to 9 cm) or 3 to 6 months old, they settle into shallow, intertidal, nearshore waters in rocky, cobble and sand substrates with or without kelp (Love et al. 1991; Love et al. 2002). This habitat feature offers a beneficial mix of warmer temperatures, food, and refuge from predators (Love et al. 1991). Areas with floating and submerged kelp species support the highest densities of juvenile PS/GB bocaccio rockfish. Therefore, overwater structures reduce prey communities and impair SAV growth, impairing PS/GB bocaccio survival, growth, and fitness. This is not expected to impact enough individuals to cause a population-level effect.

Marine mammal response to prey reductions

Among humpback whales, we do not expect a reduction in available forage, but behavioral response to vessel noise could modify foraging behaviors. We expect humpback whales exposed to vessel noise would have a slight increase in bioenergetic expense as they avoid available prey where vessel noise disturbs them, and seek other areas where prey might be available. Because prey is not identified as limited, we do not expect this behavioral response to produce reduced fitness health or fecundity in humpback whales.

Prey base and foraging behavior are likely to both be affected for SRKW and while it can be difficult to separate the respective outcomes, insufficiency of prey may be the more influential on fitness (Ayres et al. 2012). Most effects associated with the proposed action on SRKW prey communities will occur among Chinook salmon smolts exposed to construction effects. While the number of smolts that are harmed, injured, or killed as a result of project activities at each port could be several tens each year, it is unlikely that these effects would produce a measurable reduction in the abundance of adult PS Chinook, which is the preferred prey. When we consider the very slight prey reduction together with modified foraging behavior of SRKW when exposed to vessel noise, the vessel noise may have the greater effect on foraging, but as noted above the proposed action is not expected to result in an increase of vessel traffic. We anticipate that some SRKW could respond with short periods of nutritional stress, but this is outcome not expected to increase over the current levels of SRKW nutritional condition/individual fitness.

6. Loss of Aquatic Habitat

Loss of aquatic habitat would occur temporarily during construction and long term via the repair and replacement of existing structures that are currently at the end of their design life. Habitat loss is continued when replaced and repaired structures directly displace the water column or sediment, such as displacement caused by in-water piles, fill, and shoreline armoring, and floats for an additional period of time into the future. These enduring habitat modifications represent contemporaneous and long-term losses of habitat features that may be key to a species food base, reproduction, or survival. The proposed actions would temporarily increase noise, result in long term reductions in water quality, would deepen habitat, and continue to alter lighting in the aquatic environment (both shade and nighttime light). When species are exposed to these altered environments created by the proposed action, avoidance behavior is a common response that can, in turn, create consequences for individual fitness and survival.

Fish Response

Salmonids migrate broadly through the Puget Sound. Therefore, any population could be exposed to effects of the proposed action. However, adult and juvenile Chinook and juvenile steelhead must migrate through the highly modified estuaries as they leave or return to their natal streams. The Duwamish/Green River and Puyallup River salmon will incur temporary and permanent habitat loss. The responses will range from behavioral, to reduced fitness and survival.

The presence of in and overwater structure disrupts juvenile salmonid migration (Simenstad 1999; Southard et al. 2006; Toft et al. 2013; Ono 2010) and increases their predation risk (Willette 2001; Willette et al. 2001; Moore et al. 2013). Elevated pinniped predation rates have been documented at major anthropogenic structures that inhibit movement and cause unnaturally large aggregations of salmonid species (Jeffries and Scordino 1997, Keefer et al. 2012, Moore et al. 2013). 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. There is substantial evidence that OWS reduces feeding rates for fish that utilize habitat under overwater structures (Heiser and Finn 1970; Able et al. 1998; Simenstad 1999; Southard et al. 2006; Toft et al. 2007; Moore et al. 2013, Munsch et al. 2014). And, because juvenile salmonids migrate around rather than under OWS, and must migrate around areas where shallow estuarine habitat has been displaced with fill, this lengthens their migration pathway. The lengthened migration distance is correlated with increased mortality (Anderson et al. 2005).

Juvenile PS/GB bocaccio feed on the young of other rockfish, surfperch, and jack mackerel in nearshore areas (Love et al. 1991; Leet et al. 1992). Juveniles also eat all life stages of copepods and euphausiids (MacCall et al. 1999). Because juvenile rockfish are less able to access adjacent areas compared with salmon species, reductions in benthic prey communities in construction areas will reduce available forage for PS/GB bocaccio in their nearshore settlements, reducing growth and fitness of a small number of affected individuals at each location. Larval rockfish of both species—PS/GB bocaccio and PS/GB yelloweye—are affected by the loss of SAV, the change in depth following dredging, and the continued direct habitat loss of estuarine habitat.

These conditions can produce greater bioenergetic response and slower growth as juvenile salmonids seek more favorable habitat, and increase competition for those resources when such areas are found. This combination suggests that some individuals will experience reduced growth, fitness, or survival as a result of decreased carrying capacity

Among bocaccio juveniles, permanent habitat displacement would reduce the availability of suitable nearshore rearing habitat. Because the current abundance of bocaccio is low, we do not expect the habitat reduction to affect many juvenile bocaccio. Larval lifestages could be negatively affected if they drift into the action area where direct modifications and construction occurs. If larvae "settle" near these facilities, rearing habitat would be limited, and mortality would be the likely outcome. We cannot estimate the number of bocaccio or yelloweye that could be affected in this manner because larval rockfish are difficult to distinguish from each other, but we expect the number to be low as adults are not frequently observed in this area and so spawning events are unlikely to cast bocaccio larvae in the vicinity. We also cannot estimate the number of individual juvenile salmonids that will experience migration delays and increased predation risk from the proposed actions but expect that the exposure and response will occur among some individuals of each cohort of the specific populations annually for the foreseeable future.

The proponents' proposed habitat improvement activities are intended to compensate for the losses described above. These will limit the duration of the habitat losses by providing nearby habitat gains. We address this in the section g) below.

Marine Mammal Response

Humpbacks are not expected to be affected by habitat losses in the action area. SRKW, while occurring in shallower waters, are infrequently present in near the Port's facilities. When present, whales are likely there to pursue adult fish on return migration. We do not expect habitat losses associated with fill or structures to inhibit such pursuit of adult salmon. "Loss" of habitat due to noise has been presented above. Marine mammals that avoid foraging areas because of noise may temporarily have increased bioenergetic expenditure and juveniles encountering these circumstances may have reduced growth or fitness.

Sunflower Sea Star Response

This species is not expected to avoid areas affected by temporary effects such a noise, light, or water quality (turbidity) diminishments. Because this species is a generalist in terms of its habitat range (e.g. shallow, deep, sands, silts, rocks are all suitable) we do not expect structural displacement of estuarine habitat to impair individuals of this species, if present. Sunflower sea stars are primarily carnivorous, feeding on mussels, sea urchins, fish, crustaceans (crabs and barnacles), sea cucumbers, clams, gastropods, sand dollars, and occasionally algae and sponges. For most sunflower stars, sea urchins make up 21-98 percent of their diet. In-water work will temporarily reduce the availability of benthic prey items available to individuals present, but because the abundance of this species extremely is low compared with recent historic numbers, reduced prey is not expected to appreciably affect any individuals.

7. Habitat Improvements

Beneficial activities will take place in riparian and nearshore habitat near the Ports of Seattle and Tacoma. Activities carried out to achieve conservation offsets include pile removal (prioritizing creosote-treated timber), overwater coverage removal, debris removal, and alternative shoreline stabilization, all of which may be assisted by construction vessels. During construction, juvenile PS Chinook salmon and PS/GB bocaccio that are exposed will experience the same temporary effects of these activities as when they are performed for repair and maintenance, including:

- Water quality reductions in the form of increased turbidity, reduced DO, and contaminant release
- Decreased forage during the period of sediment benthic recovery (up Behavioral responses to sound from pile removal and construction vessels
- Avoidance of the construction area

While constructing or executing these activities will have temporary adverse effects as described throughout this document, all of those activities are expected to produce long-term beneficial effects on listed species. Benefits expected include:

- reduced in-water structure, resulting in increased prey base and improved safe passage;
- reduced creosote material, improving water quality, sediment quality, and prey base
- reduced overwater structure, improving safe passage, prey base, and rearing areas,
- improved shoreline condition, increasing refuge and forage areas,

- improved benthic conditions from the removal of rubble, enhancing prey base and rearing areas.,

Each of these improvements as well as the improvements achieved through banks, in-lieu-fee sites, and advance compensatory mitigation sites is expected to increase health, fitness, and survival of the listed salmonids, and bocaccio rockfish. Proposed habitat enhancing activities are expected to occur shortly after or be in place before negative long-term impacts of the proposed action occur. These proposed activities, quantified in the Ports Calculator, would create survival, health and fitness benefits. The benefits will accrue to individuals of any salmonid population in the action area near the ports, but will particularly benefit the Green/Duwamish and Puyallup populations. As a result of these proposed beneficial compensatory mitigation actions, we expect the net level of habitat degradation over the term of the 10-year permits to approximate zero.

2.5. Cumulative Effects

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

Some continuing non-federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described earlier in the discussion of environmental baseline (Section 0). Those effects are likely to become more frequent, more intense, and/or more widespread within the action are over time.

Based on the Port's reliance on marine waters, it is unlikely that many activities in the immediate area will lack a federal nexus. This means most future actions and effects will be excluded from this analytical component. But, as the human population continues to grow, land use changes will continue to intensify which will increase wastewater and stormwater inputs, and use of waterways will also increase, creating more opportunities for habitat degradation through vessel noise, water quality impacts, and pollution.

Habitat restoration activities and compensatory mitigation may offset some of the impacts described above. Finally, multiple non-federal activities are reasonably certain to occur that impact SRKW interactions with vessels in the Salish Sea. These additional actions are designed to further reduce impacts from vessels on SRKW by limiting the potential for interactions including:

1. Washington State law (Senate Bill 5577) established a commercial whale watching license program and charged WDFW with administering the licensing program and developing rules for commercial whale watching for inland Washington waters (see RCW 77.65.615 and RCW 77.65.620). The new rules were adopted in December 2020, and became effective May 12, 2021, and include limitations on the time, distance, and

area that SRKW can be viewed within ½ nautical mile, in an effort to reduce vessel and nose disturbance:

   a. The commercial whale watching season is limited to three months/year for viewing SRKW closer than ½ nautical mile, and is limited to four hours per day in the vicinity of SRKW.
   b. Up to three commercial whale watching vessels are allowed within ½ nautical mile of SRKW at a given time, with exclusion from approaching within ½ nautical mile of SRKW groups containing a calf.
   c. Year-round closure of the "no-go" Whale Protection Zone along the western side of San Juan Island to commercial whale watching vessels, excluding a 100-yard corridor along the shoreline for commercial kayak tours.

2. Continued implementation and enforcement of the 2019 restrictions on speed and buffer distance around SRKW for all vessels.
3. Increased effort dedicated to outreach and education programs. This includes educational material for boating regulations, Be Whale Wise guidelines, the voluntary no-go zone, and the adjustment or silencing of sonar in the presence of SRKWs. Outreach content was created in the form of video, online (including social media), and print advertising targeting recreational boaters. On-site efforts include materials distributed at pump out and re-fueling stations along Puget Sound, during Enforcement orca patrols, and signage at WA State Parks and WDFW water access sites. Additionally, State Parks integrated materials on whale watching regulations and guidelines in their boating safety education program to ensure all boaters are aware of current vessel regulations around SRKW.
4. Promotion of the Whale Report Alert System (WRAS) in Puget Sound, developed by the Ocean Wise Research Institute, which uses on-the-water reporting to alert large ships when whales are nearby. Reporting SRKW to WRAS is required for commercial whale watching license holders, and on-the-water staff are also being trained to report their sightings.
5. Piloting a new program ("Quiet Sound") that will have topic-area working groups to lead projects and programs on vessel operations, incentives, innovations, notification, monitoring, evaluation, and adaptive management. This effort was developed with partners including Commerce, WA State Ferries, and the Puget Sound Partnership in collaboration with the Ports, NOAA, and others. Funding is anticipated to be secured in the 2021 state legislative session.
6. Currently WDFW enforcement boats conduct coordinated patrols with the U.S. Coast Guard, NOAA Office of Law Enforcement, San Juan County Sheriff's Office, Sound Watch, and other partners year-round that include monitoring and enforcement of fisheries and Marine Mammal Protection Act requirements related to vessel operation in the presence of marine mammals throughout Puget Sound. Patrols in the marine areas of northern Puget Sound are specifically targeted to enforce regulations related to killer whales. Outreach and enforcement of vessel regulations will reduce the vessel effects (as described in Ferrara et al. (2017)) of recreational and commercial whale watching vessels in U.S. waters of the action area.
7. On March 14, 2018, WA Governor's Executive Order 18-02 was signed and it ordered state agencies to take immediate actions to benefit SRKW and established a Task Force to identify, prioritize, and support the implementation of a longer-term action plan needed for SRKW recovery. The Task Force provided recommendations in a final Year 1 report

in November 2018.29 In 2019, a new state law was signed that increases vessel viewing distances from 200 to 300 yards to the side of the whales and reduces vessel speed within ½ nautical mile of the whales to seven knots over ground. SB 5918 amends RCW 79A.60.630 to require the state's boating safety education program to include information about the Be Whale Wise guidelines, as well as all regulatory measures related to whale watching, which is expected to decrease the effects of vessel activities to whales in state waters.

8. On November 8, 2019, the task force released its Year 2 report30 that assessed progress made on implementing Year 1 recommendations, identified outstanding needs and emerging threats, and developed new recommendations. Some of the progress included increased hatchery production to increase prey availability. In response to recommendations of the Washington State Southern Resident Killer Whale Task Force, the Washington State Legislature provided approximately $13 million in funding "prioritized to increase prey abundance for southern resident orcas" (Engrossed Substitute House Bill 1109) for the 2019-2021 biennium (July 2019 through June 2021)
9. On March 7, 2019, the state passed House Bill 1579 that addresses habitat protection of shorelines and waterways (Chapter 290, Laws of 2019 (2SHB 1579)), and funding was included for salmon habitat restoration programs and to increase technical assistance and enforcement of state water quality, water quantity, and habitat protection laws. Other actions included providing funding to the Washington State Department of Transportation to complete fish barrier corrections. Although these measures won't improve prey availability in 2020/2021, they are designed to improve conditions in the long-term.

Notwithstanding the beneficial effects of ongoing habitat restoration actions, the cumulative effects associated with continued development are reasonably certain to have adverse effects on all the listed species populations addressed in this Opinion. 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. The anticipated cumulative effects, particularly when climate impacts are considered, are likely to continue to be negative over time, with likely detriment to salmonids, bocaccio, yelloweye, SRKW, and Sunflower sea star.

2.6. Integration and Synthesis

The Integration and Synthesis section is the final step in assessing the risk that the proposed action poses to species and critical habitat. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 0), to formulate the

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[29] Available at:
https://www.governor.wa.gov/sites/default/files/OrcaTaskForce_reportandrecommendations_11.16.18.pdf, last visited May 26, 2019.

[30] Available at:
https://www.governor.wa.gov/sites/default/files/OrcaTaskForce_FinalReportandRecommendations_11.07.19.pdf, last visited May 26, 2019.

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.

2.6.1. Critical Habitat

Critical habitats in the action area are impaired primarily by vessel use/noise, and water quality reductions. The baseline condition within the project area portions of the action area is one of habitat that is highly modified by human infrastructure and uses which have converted or eliminated many natural habitat features, including PBFs for PS Chinook salmon, juvenile bocaccio rockfish, and SRKW. Regardless, these areas have high conservation value, for PS Chinook in particular, because of obligate role they serve for salmonid migration to and from spawning areas, and transitions between salt and freshwater. We add to this status and baseline the effects of the port activities which the proposed action will authorize, to determine the degree of impact on the conservation role of the critical habitat for PS Chinook salmon, PS steelhead, PS/GB bocaccio, and SRKWs. The effects on habitat include:

- Short-term but repeated, increases in noise and shade, with contemporaneous decreases in prey, and water quality, which can reduce the critical habitat's ability to support survival, growth, maturation or reproduction of species present where these impacts occur;
- Long-term, overwater structures create shade, suppress submerged aquatic vegetation, negatively impact prey base, interrupt migration of salmon and juvenile bocaccio, and provide cover for predatory fish that eat juvenile salmon. This would extend into the future conditions that limit the habitat's ability to support growth, maturation survival and reproduction of the salmonids (primarily PS Chinook salmon) and bocaccio juveniles.
- Long-term, shoreline armoring, and other modifications such as maintenance dredging would disrupt sediment transport processes that allow shallow nearshore habitat to form, and impede full recruitment of prey species, reducing its quality for rearing habitat designated for PS salmonids and bocaccio juveniles.
  Long-term, habitat improvement through redesign, debris removal, creosote removal, shoreline softening, and stand-alone habitat restoration would improve water quality, increase prey base, reduce safe passage impediments, and improve benthic conditions. NMFS expects these improvements to increase survival, growth, maturation, and fecundity of PS salmonids and bocaccio juveniles in a manner that offset the long-term detrimental impacts listed above, and limit the duration of those impairments when considered holistically. As a result, we find it likely that, as intended with the proposed action, no net loss of PBFs for fishes occurs. This serves to, overall, retain the prey abundance and availability of SRKW.

Therefore, the effects of the proposed action on critical habitat, when added to the baseline, factoring cumulative effects, and considering the status of the critical habitat, will not reduce the conservation role of critical habitat designated in the action area, or at the larger designation scale for PS Chinook salmon, PS steelhead, PS/GB bocaccio, or SRKW.

2.6.2. ESA Listed Species

Each species considered here is threatened with the exception of PS/GB bocaccio and SRKW, which are endangered, and sunflower sea stars, which are a proposed species at this time. We consider each species' status along with the effects of the proposed actions and cumulative effects to the environmental baseline. The effects include exposure to multiple types of temporary and permanent habitat reductions that cause responses ranging from behavioral (startle, avoidance, longer foraging forays, decreased predator detection) to sublethal effects (hearing reduction, reduced foraging success, reduced growth or fitness) to injury or death (barotrauma, entrainment, strike, resulting from a combination of habitat reductions that impair survival, or increased piscivorous predator success).

Salmonids

Both PS Chinook salmon and PS steelhead are listed as threatened, with low productivity, low abundance, declining genetic diversity, and impaired spatial structure. Factors for decline and limiting factors include poor water quality, loss of quantity and quality of freshwater habitat, and for PS Chinook salmon, diminished nearshore and estuarine habitat throughout much of their range including in the action area. We add the effects of the proposed action to this baseline and status. Here, the project effects described above, along with entrainment, are most likely to occur among the juveniles from Green, Sammamish-Cedar, Puyallup, and White River populations of PS Chinook salmon, and the Green River winter and summer runs, and the Cedar River, North Lake Washington, and Sammamish winter run steelhead populations. Of these two species fish from the PS Chinook salmon populations are the more vulnerable to the array of effects and most likely to have the greatest amount of exposure and response because of their smaller size at entering the marine environment and longer nearshore rearing.

The temporary effects on PS Chinook salmon and PS steelhead added to the baseline and considered in light of the status of the species, range from behavioral to injury or death, and will occur among individuals from multiple cohorts of salmonids as the proposed actions will occur annually over a period of 10 years. Prey reductions take longer to ameliorate thus will affect a greater number of individual fish, including past the permit period for up to 3 years. Cedar, Sammamish, Green, White, Puyallup Chinook diversity is poor, but not likely to be affected by the effects of the proposed action. Population abundance for each of these populations is likely to be slightly negatively affected each year, but in the 2022 viability report, all of these populations showed slight increases in abundance relative to the prior reporting period in 2015 suggesting that reductions associated with the temporary effects may not be influential in terms of population productivity overall.

Green River, Carbon River, Puyallup River, and White River, winter-run steelhead populations exhibited 94–187% showed increases in five-year abundances compared to the 2105 reporting period, but Cedar River remains extremely low, and N. Lake Washington tributary population steelhead productivity has not been reported since 1995. Because of steelhead life history patterns, including entering the marine environment as larger fish, with less nearshore dependence, the likely range of effects from temporary activities is expected to occur among fewer individuals in each year and across the 10-year duration of the proposed actions.

Accordingly, we do not consider the viability parameters of these populations to be discernibly altered.

The long-term effects include both reduced fitness and survival among some individuals, but includes several beneficial habitat values that are expected to improve fitness and survival among some individuals of the same cohorts and populations. When added to the baseline, and considered in light of the status of the species, these outcomes on fitness and survival are expected to be largely neutral for salmonids population level demographics, and viability parameters. Accordingly, when considered together, the short term and long-term effects of the proposed action when added to the baseline, and in light of status and cumulative effects, are not expected to reduce viability parameters (productivity, spatial structure or diversity) at the population level.

Rockfish

PS/GB bocaccio are listed as endangered and abundance of this species remains low, with low occurrence in the action area and no recent observations near Seattle or Tacoma. PS/GB yelloweye rockfish are listed as threatened but persist at abundance levels somewhat higher than bocaccio. Juvenile yelloweye rockfish are not typically found in nearshore habitat and adults are found solely in deep water areas of Puget Sound. Larval yelloweye rockfish, like larval bocaccio, are found in nearshore areas and would likely be exposed to the short-term effects of the proposed construction during the 10-year duration of the permit.

The effects of the proposed action over 10 years will occur primarily among the larval life stage of both rockfish species with exposure and response to sound, turbidity or other water quality diminishments. Juvenile bocaccio rockfish, if present in either port's project area, would also experience possible entrainment, modified prey and habitat suitability with dredging, and migration disruption with in water structure. Adults of both species will continue to be exposed to water pollution associated with vessels. The most likely result of these habitat consequences of the proposed action is reduced survival among the larval life stage. When added to the species' status and baseline of poor abundance, productivity, we expect the effects of the action will reduce abundance of bocaccio at an extremely low number, primarily because their presence in either project area is expected to be low. The effect on yelloweye is likely to be somewhat higher because yelloweye are at a higher abundance in Puget Sound, so more opportunity for spawn/larvae to drift into the project area. In both cases, we cannot discern the actual reduction in abundance as larval rockfish species are difficult to distinguish visually from each other. As with salmonids, above, the habitat improvements of the proposed action will ensure that areas within the respective port project areas establish conditions beneficial, though relative to these species the benefits will be primarily to juvenile bocaccio survival. Given the low level of exposure among both species, and the life stage exposed, the reduction in abundance is not expected to produce discernible change in productivity, diversity, or distribution of bocaccio or yelloweye rockfish, even when cumulative impacts are considered.

Marine Mammals

SRKW are listed as endangered, based on an extremely low population size, and low productivity. The population has relatively high mortality and low reproduction, unlike other resident killer whale populations that have generally been increasing since the 1970s (Carretta et al. 2021). Their three subpopulations (pods) are affected by water quality degradation, chronic sound, and insufficient prey (both abundance and poor quality of the prey available, inferred from the high body load of contaminants of SRKW which are an apex predator). Reduced prey availability is a major limiting factor for this species.

To this status and baseline, we add the short-term, operational, and long-term effects of the proposed action. Individuals from this species will experience brief but repeated exposure to pile driving noise, brief and infrequent exposure to stormwater, continued exposure to vessel noise, and a slight reduction of prey associated with construction effects on salmonids. We expect long term habitat improvements at and near port facilities will prevent appreciable declines in SRKW prey communities. Taken together, some SRKW could experience some behavioral responses with episodes of forage avoidance/ bioenergetic expenditure but we do not expect this to result in long term adverse reduction in fitness, survival, or fecundity of any individuals or modify the current level of nutrition in the species overall.

When we consider cumulative effects, as described above, these are driven largely by human population growth and are likely to have an incrementally negative influence over time. However, regulatory protections designed to curtail the influence of vessel interactions with SRKW have recently increased which may yield some contemporaneous protective benefit to the species. We consider the effects of the proposed action, when added to the baseline and in consideration of status and cumulative effects, will not result in a reduction of abundance, productivity, diversity, or spatial structure of SRKW.

The two separate ESA-listed DPSs of humpback whales that occur in the action area are the endangered Central American (CAM) DPS and threatened Mexico DPS. Based on observations of humpback presence and migration patterns in Washington waters, we consider humpback whales migrating or foraging in inland waters of Washington to primarily originate from non-listed Hawaii DPSs, with a smaller proportion being the listed Mexico or CAM humpback whales Wade (2017 and 2021).

Humpbacks enter the Salish Sea as a foraging or rearing opportunity along their migration from summer feeding grounds to winter breeding grounds. Numbers of humpback whales have been growing annually at a rate of 6 to 7.5 percent off the U.S. West Coast (Calambokidis and Barlow 2020; Carretta et al. 2021). With this status in mind, we add the effects of the proposed action. - humpback whale sightings in the Salish Sea have also been increasing since the early 2000s (Calambokidis et al. 2018). Sightings in recent years have most mostly occurred from May through October but occur year-round. Thus, exposure to vessels, vessel noise, and vessel-related water quality impacts is likely in the action area. Presence near Tacoma or Seattle is less frequent but is expected to occur within the 10-year timeframe of the permits, where they could be briefly exposed to sound. We do not expect that behavioral responses to noise will result in injury or death of humpbacks, and that even when cumulative effects are considered, no population level effects will be caused the proposed action.

Sunflower Sea Star

The sunflower sea star is proposed for listing throughout its range due to a precipitous decline in abundance associated with wasting disease. No data exist to suggest anything other than a single, panmictic population of sea stars so, to reach a determination of jeopardy, a proposed action would have to impact range-wide population dynamics. We are not currently aware of any specific habitat types or locations used by sunflower sea stars for mating or spawning; larvae are planktonic, and newly settled juveniles appear in a variety of habitats. Despite multiple pathways of exposure from the proposed action we expect the number of individuals so exposed to be very low, and other than entrainment during dredging, most responses would be behavioral, and would not result in injury or death. We do not expect the effects of this proposed action, even when considered over the duration of the program, and factoring cumulative effects, will impact enough individuals to impair population trends or impede improving productivity.

2.7. Conclusions

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of PS Chinook salmon, PS steelhead, PS/GB bocaccio rockfish, PS/GB yelloweye rockfish, SRKW, or humpback whales We also conclude that the proposed action is not likely to destroy or adversely modify designated critical habitat for PS Chinook salmon, PS steelhead, PS/GB bocaccio rockfish, or SRKW.

NMFS's Conference Opinion concludes that adverse effects to Sunflower Sea Stars are not likely to jeopardize this species. If Sunflower Sea Stars become listed under the Endangered Species Act, The Corps can request that NMFS confirm this Conference Opinion as a biological opinion for this species.

2.8. Incidental Take Statement

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

This ITS provides a take exemption for the action agencies and applicants for any incidental take caused by consequences of the proposed action. This ITS does not include an exemption for any future incidental take of marine mammals caused by third party activities caused by the proposed action, such as increased noise resulting from vessels, for the primary reason that the ESA does not allow NMFS to exempt incidental take of marine mammals where an authorization of the take is required and may be obtained under the MMPA.

2.8.1. Amount or Extent of Take

The amount and extent of take in this ITS serves two functions: (1) it identifies the quantity of incidental take exempted for the action agency and applicant. In the case of a species without 4(d) protective regulations, such as the sunflower sea star, the exemption is not needed because incidental take is not prohibited; and (2) it serves as a check on NMFS's jeopardy analysis. The amount or extent of take identifies the anticipated level of take NMFS considered in reaching its conclusion that the proposed action will not jeopardize the continued existence of a listed species.

The activities carried out under the proposed action will take place above, adjacent to, or within aquatic habitats that are occupied by individuals of the ESA-listed species considered in this opinion (and conference opinion), such that exposure to project effects will result in take of these listed species. The amount of take, particularly among fish cannot be accurately quantified as a number because the highly variable nature of abundance, presence, and response does not allow NMFS to predict, using the best available science, the number of individuals of listed fish that will be exposed at any given time, nor across the 10-year term of the proposed action. When NMFS cannot precisely predict the number of individuals that are reasonably certain to be harmed, captured, or killed, we rely on surrogate measures for take, called an extent of take. The most appropriate surrogates for take are action-related parameters that directly relate to the magnitude and duration of the expected take. In such circumstances, 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. In many instances, these take surrogates are coextensive with the proposed action. However, they are still the best indicator of the extent of expected take because of the causal relationship between the parameters and expected effects, and because the surrogate is readily observable, easily measured, and therefore suffices to trigger reinitiation of consultation if take is exceeded.

For the Port of Seattle Permit, NMFS has determined that incidental take is reasonably certain to occur as follows below. To allow for annual flexibility, take metrics are provided for the 10-year duration of the permit. Progress toward each 10-year limit will be monitored annually during the May meetings and if in any year the 10-year maximum is exceeded, re-initiation would be triggered. 10-year limits are valid reinitation triggers because quantities are readily measurable on an annual basis.:

1. Harm and harassment from noise

    a. from pile driving -The number of piles driven or removed is proportional to the amount of take because the installation or removal of each pile creates sound that could harass, injure, or kill juvenile PS Chinook salmon, juvenile PS steelhead, and larval rockfish or juvenile PS/GB bocaccio from underwater noise. The extent of take is installation (harm) or removal (harassment) of a maximum of 4,000 piles over 10 years (approximately 4000 piles annually).

b. from construction vessels - The extent of take of juvenile PS Chinook salmon, juvenile PS steelhead, and juvenile PS/GB bocaccio from underwater noise produced by construction vessels is the presence of four vessels (two barges and two tugs) at any time during construction.

2. Harm from water quality reductions

a. from turbidity, reduced DO, and suspended contaminants during construction –The extent of take for harm caused by turbidity, reduced DO and suspended contaminants during construction is the 300,000 CY of sediment dredging proposed over the 10-year duration of the permit (approximately 30,000 CY annually). This measure is causally related to harm of juvenile PS Chinook salmon, juvenile PS steelhead, and larval rockfish and juvenile PS/GB bocaccio because the area of increased suspended sediment around sediment-disturbing activities is equivalent to the area where TSS and resuspended contaminants that can harm fish and benthic productivity are most likely to occur.

b. from stormwater effluent – The extent of take of juvenile PS Chinook, juvenile PS steelhead, and larval rockfish, or juvenile PS/GB bocaccio for stormwater effluent is the area of PGIS to be repaved and routed through stormwater treatment systems. The total requested area of repavement per year is 92 acres of PGIS over the 10-year duration of the permit (approximately 9.2 acres annually). This surrogate is related to the amount of take because larger areas of PGIS would contribute a greater load of contaminants.

c. from ACZA treated wood –The extent of take from ACZA treated wood in marine waters is no more than 10 treated wood piles per year installed by the Port of Seattle, where water quality is 303(d) listed for metals.

3. Harm from shade, habitat loss, and migration disruption – The extent of these habitat modification impacts is directly related to the total area (SF) of pile, overwater structures (including marina piers, ramps (gangways), and float assemblages, boathouses and covered moorage, safety platforms, and overwater safety equipment), maintenance dredge areas, boat ramps, shoreline armor, and navigational aids replaced or perpetuated by this Program. Thus, the extent of incidental take of juvenile PS Chinook salmon and PS/GB bocaccio from exposure to in- and overwater structures over the life of the 10-year permit is a maximum of 550,500 SF of overwater structures (marina piers, ramps and floats; boathouses and covered moorage; Overwater safety equipment), 50 navigational aids, 300,000 CY of sediment dredging, and 16,000 LF of shoreline armoring.

4. Harm from night time lighting –incidental take of juvenile PS Chinook salmon and juvenile PS steelhead as a result of night time lighting is directly related to the number of lights in use. Therefore, the extent of take is 100 light poles, and 60 navigation lights over the 10-year life of the permit, which are the numbers included in the proposed action. This number causally related to harm from night time lighting and an increase in this number would expose the listed fish to more night time light than has been analyzed.

5. Harm from prey reductions- the extent of incidental take of juvenile PS chinook, juvenile PS steelhead, and juvenile PS/GB bocaccio would be 300,000 CY of sediment dredging over the life of the permit (approximately 30,000 cy annually). This amount is causally related to the reduction in prey.

6. Capture/injury/death from entrainment – the extent of incidental take of juvenile PS chinook, juvenile PS steelhead, and juvenile PS/GB bocaccio would be 300,00 CY of sediment dredging over the life of the permit. This amount is causally related to the likelihood of entrainment, and is a readily observable metric on an annual basis. Dredging a greater volume increases the likelihood of exposure of these listed fish to the operating dredge equipment, and therefore the risk of entrainment increases.

7. Capture/injury/death from fish handling and exclusion – Fish isolation activity is anticipated to co-occur with cofferdamming to address certain in-water repair activities. The extent of take is the occasions in which such isolation and handling will occur, which is 5 occurrences over the 10-year life of the permit.

The above extents of take for Port of Seattle are also captured here in tabular form (Table 20).

Table 21. Extents of Take for Port of Seattle, by Activity Type

Activity (Replacement, Maintenance, and Repair)	**Estimated Approximate annual Quantity**	**Estimated Maximum Quantity over the 10-years permit duration**	**Unit[1]**
Pile Replacement	400	4,000	EA
Pile Jacket Installation	Unlimited	Unlimited	EA
Marina Piers, Ramps (gangways), and Float Assemblages	5,000	50,000	SF
Boathouses, Covered Moorage	20,000	200,000	SF
Overwater Safety and Security Equipment (platforms, ladders, fencing, etc.)	50	500	SF
Shoreline Stabilization	1,600	16,000	LF
Outfall/tide gate Replacement	15	150	EA

Activity (Replacement, Maintenance, and Repair)	Estimated Approximate annual Quantity	Estimated Maximum Quantity over the 10-years permit duration	Unit[1]
Boat Ramps, Launches (incl. vessel hoists and marine rail track systems)	5,000	50,000	SF
Vessel Berths (maintenance dredging)	30,000	300,000	CY
Navigational Aids	5	50	EA
Existing Paved/Impervious Surfaces	9.2	92	Acres
Fish exclusion and cofferdamming	5	50	EA
Navigation Lights	6	60	EA
Light Poles	10	10	EA

[1] EA = Each; SF = Square feet; LF = Linear feet; N/A = Not applicable

For the Port of Tacoma Permit, NMFS has determined that incidental take is reasonably certain to occur as follows below. To allow for annual flexibility, take metrics are provided for the 10-year duration of the permit. Progress toward each 10-year limit will be monitored annually during the May meetings and if in any year the 10-year maximum is exceeded, re-initiation would be triggered. 10-year limits are valid reinitation triggers because quantities are readily measurable on an annual basis:

1. Harm and harassment from noise caused by

    a. Pile Driving - The number of piles driven or removed is proportional to the amount of take because the installation or removal of each pile creates sound that could harass, injure, or kill fish (PS Chinook salmon, PS steelhead, and PS/GB bocaccio from underwater noise). The extent of take is installation (harm) or removal (harassment) of 2,000 piles no larger than 24 inches in diameter over the 10-year Program lifetime.

    b. Construction Vessel Noise - The extent of take of PS Chinook salmon, PS steelhead, and PS/GB bocaccio from underwater noise from underwater noise produced by construction vessels is the presence of four vessels (two barges and two tugs) at any time during construction.

2. Harm from water quality reductions caused by

    a. turbidity, reduced DO, and suspended contaminants during construction –The extent of take of juvenile PS Chinook salmon and PS/GB bocaccio is 300,000 CY of sediment dredging over the 10-year duration of the permit (approximately 30,000 CY annually). This measure is causally related to harm because the area of increased suspended sediment around sediment-disturbing activities is equivalent to the area where TSS and resuspended contaminants that can harm fish and benthic productivity are most likely to occur.

b. stormwater effluent – The extent of take of PS Chinook salmon, PS steelhead, and PS/GB bocaccio from stormwater effluent is the area of PGIS to be repaved and routed through stormwater treatment systems. The total requested area of repavement is 92 acres of PGIS over the 10-year duration of the permit (approximately 9.2 acres annually). This surrogate is related to the amount of take because larger areas of PGIS would contribute a greater load of contaminants.

3. Harm of from shade, habitat loss, and migration disruption – The extent harm from these habitat modification impacts on juvenile PS Chinook salmon and PS/GB bocaccio is directly related to the total area (SF) of pile, overwater structures (including, safety platforms, and overwater safety equipment), maintenance dredge areas, boat ramps, shoreline armor, and navigational aids replaced or perpetuated by this Program. Thus, the extent of incidental take from exposure to in- and overwater structures is over the 10-year life of the permit a maximum of 250,000 SF of overwater structures, 50 navigational aids, 300,000 CY of sediment dredging, and 16,000 LF of shoreline armoring.

4. Harm from prey reductions- the extent of incidental take of juvenile PS chinook, juvenile PS steelhead, and juvenile PS/GB bocaccio would be 300,000 CY of sediment dredging over the life of the permit. This amount is causally related to the reduction in prey, and is a readily observable metric.

5. Capture/injury/death from entrainment – the extent of incidental take of juvenile PS chinook, juvenile PS steelhead, and juvenile PS/GB bocaccio would be 300,000 CY of sediment dredging over the life of the permit. This amount is causally related to the likelihood of entrainment, and is a readily observable metric. Dredging a greater volume increases the likelihood of exposure of these listed fish to the operating dredge equipment, and therefore the risk of entrainment increases.

The above extents of take for Port of Tacoma are also captured here in tabular form (Table 21).

Table 22. Extents of Take for Tacoma Activities, by Activity Type

Activity (Replacement, Maintenance, and Repair)	Estimated Approximate annual Quantity	Estimated Maximum Quantity over the 10-years permit duration	Unit
Pile Replacement	200	2,000	EA
Pile Repair	Unlimited	Unlimited	EA
Overwater Coverage Replace/Repair	25,000	250,000	SF
Safety Platforms	50	500	SF
Shoreline Stabilization Repair/Replacement	250	2,500	LF
Maintenance Dredging	30,000	300,000	CY

Activity (Replacement, Maintenance, and Repair)	Estimated Approximate annual Quantity	Estimated Maximum Quantity over the 10-years permit duration	Unit
Outfall and Tide Gate Repair or Replacement	15	150	EA
Boat Ramps	5,000	50,000	SF
Existing Paved/Impervious Surfaces	9.2	92	Acres
Light Poles	10	100	EA
Navigation Lights	6	60	EA
Navigational Aids	5	50	EA

SRKW Prey reduction: The proposed action is reasonably certain to harm individual SRKW from prey reductions. The extent of harm to SRKWs is measured by the same extents of take on PS Chinook salmon described above, for the respective ports. These metrics are causal to the harm because each pathway described above is one which impacts PS Chinook salmon, primarily in the juvenile life stage, and over the life of the permit the number of juveniles 'taken' will translate into a small reduction of the adult lifestage of PS Chinook salmon, which is the primary preferred prey of SRKW. If the metrics above for habitat impacts or entrainment of fish increase, we would expect an additional increase of Chinook salmon to be taken.

SRKW and Humpback – Large Vessel Noise: The proposed action is reasonably certain to harm individual SRKW and Humpback whales due to noise from large vessel traffic caused by the proposed action. The best available incidental take surrogate associated with large vessel traffic is the amount of Port maintenance reflected in the take indicators above (particularly those related to structures and dredging). These metrics are causally linked to the incidental take that will occur because the amount of maintenance correlates with the number of vessels that can access and load and unload cargo at the Ports of Seattle and Tacoma. The greater the amount of dredging and work at overwater structures, the more vessel traffic would be able access the ports in the future. These surrogates function as an effective check on the ongoing validity of the jeopardy analysis because they are measurable and reported on an annual basis and thus meet the legal standards as they relate to a reinitiation trigger. As explained in the introduction to this section, this ITS does not include an exemption for any future incidental take of SRKW and Humpback whales caused by third party vessel traffic.

Sunflower Sea Stars

Sea stars, if present, could be killed if entrained during dredging, and harmed during construction or from vessel use due to sediment settling from elevated turbidity and harmed from reduced DO. They could be harmed if in-water structures that they are occupying are removed/replaced. The extent of take for capture/injury/death is 300,000 cy over the course of the 10-year permit (30,000 cy annually) per each port. The extent of take for in-water structure (piles or armor below HTL) modification (jacketing of piles or removal/replacement of piles or armor) is up to 415 structures for Port of Seattle and 225 for Port of Tacoma. These metrics are observable and enforceable. Exceeding any of these extents of take could trigger re-initiation of this consultation.

2.8.2. Effect of the Take

In this 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.

2.8.3. 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 following measures are necessary and appropriate to minimize the impact of incidental take of listed species from the Ports Program proposed action:

1. The USACE, in coordination with the Ports, shall ensure completion of a monitoring and reporting program to confirm this Opinion is minimizing take from permitted activities.
2. The USACE and Ports shall ensure that take associated with pile driving noise is minimized.
3. The USACE and Ports shall ensure that take from water quality reductions is minimized.
4. The USACE and Ports shall minimize take from overwater structures and night time light.
5. The Ports shall reduce take associated with overwater structures causing harm from shade, habitat loss, and migration disruption.

2.8.4. 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 the applicant complies) with the following terms and conditions. The USACE or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. To implement reasonable and prudent measure #1:
    a. The USACE, the permittees, and their contractors shall follow the monitoring and reporting program as detailed in the proposed action and present these at the annual meeting in May:
        i. Habitat Improvement Plans
        ii. Marine Mammal Monitoring
        iii. Noise during pile driving and pile removal
        iv. SAV
        v. Water Quality
        vi. Turbidity
        vii. Contaminated Sediments

b. The USACE shall ensure that amount and extent of incidental take as expressed above is not exceeded by tracking and reporting on the metrics in Table 2 and Table 3, annually.
c. If stop work to avoid exposure of marine mammals occurs, these should be noted for the annual meeting. If fish are noted as injured or killed during work, these incidents should be reported within 24 hours to NMFS.
d. Reports shall be sent to projectreports.wcr@noaa.gov, with a cc to CMMP@noaa.gov.
e. Reports shall include "WCRO-2024-02448 PORTS" in the regarding line.

2. To implement reasonable and prudent measure number 2 (pile driving noise) both Ports, when impact driving is necessary, shall apply all applicable measures to reduce in-water noise, for example, driving at low tide to work outside of the water, utilizing a bubble curtain when work must occur in the water, and employing a wood block between the driver and the pile to dampen the noise profile.

3. To implement reasonable and prudent measure #3 (water quality):

   a. ACZA treated piles shall have coating or wrapping to prevent leaching, if the water body in which they are being used is or becomes 303(d) listed for metals, or has poor flushing.
   b. Suspended Sediment – if turbidity exceeds state regulatory limits, suspend dredging and deploy a bubble curtain.
   c. Stormwater – When the EPA approves new or additional water quality standards that exceed the current NPDES permits, the Ports shall modify stormwater treatment and management, as applicable, at their existing facilities in order to comply with those new standards expediently.
   d. Where pollution generating impervious surfaces (PGIS) do not have stormwater treatment, implement best management practices (BMPs) to reduce oils, grease, and tire wear particles, consistent with the MS4 Phase I Permit and Washington Department of Ecology's stormwater management manual. Examples of BMPs include operational remedies (e.g., sweeping before a rain event, spill prevention), structural remedies (e.g., placing potential sources [e.g., dumpsters, tires] under cover), and/or in situ water quality treatment (e.g., downspout treatment boxes, catch basin inserts). At the annual meeting required by condition 1.a.v, the Ports will update NMFS on their respective stormwater management programs, including plans for emerging contaminants of concern.

4. To implement reasonable and prudent measure #4 (night lighting),
   a. When consistent with Coast Guard, Maritime Administration (MARAD), Federal Aviation Administration, and Occupational Safety and Health Administration (OSHA) regulations:
      i. When Replacing Light Fixtures:

ii. Replace fixtures with those that cast light directly downward (to decrease skyglow).
iii. Install timers that turn lights off when not needed and/or activate with motion.
iv. When replacing bulbs:
v. Use as low lux (watts/lumens/intensity) as possible.
vi. Whenever possible, install timers when replacing bulbs alone (not just when replacing fixtures)
vii. The Ports shall follow but not exceed lux (lumens/watts/intensity) when meeting navigation or site safety requirements for lighting.

b. Affix bird-deterring conical pile caps on all piles extending above OHW, and replace them when lost or damaged. These will deter piscivorous birds from perching on piles.

2.9. "Not Likely to Adversely Affect" Determinations

This assessment was prepared pursuant to section 7(a)(2) of the ESA, implementing regulations at 50 CFR 402 and agency guidance for preparation of letters of concurrence.

When evaluating whether the proposed action is not likely to adversely affect listed species or critical habitat, NMFS considers whether the effects are expected to be completely beneficial, insignificant, or discountable. Completely beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Effects are considered discountable if they are extremely unlikely to occur. The effects analysis in this section relies heavily on the descriptions of the proposed action discussed in Section 1.3 and on the effect pathways analyses presented in Table 15.

PS/GB Yelloweye Rockfish Designated Critical Habitat

Critical habitat was designated for yelloweye rockfish in 2014 (79 Fed. Reg. 68041, November 13, 2014). 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 adult bocaccio. No nearshore component was included in the critical habitat listing for juvenile yelloweye rockfish as they, different from bocaccio, typically are not found in intertidal waters (Love et al. 1991). NMFS identified as essential for their conservation, deepwater sites (>30 meters) that possess or are adjacent to areas of complex bathymetry consisting of rock and or highly rugose habitat with (1) Quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities, (2) water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities, and (3) the type and amount of structure and rugosity that supports feeding opportunities and predator avoidance. (79 FR 68042; 11/13/2014)

The only effects of the proposed action that may extend into these deepwater habitats are noise from construction activities and water quality reductions. Temporary noise, primarily from vibratory pile driving, will become attenuated as it reaches deeper areas, and does not alter water temperature, clarity, or chemical load, is unlikely to affect prey, and will not alter rugosity. The stormwater effluent from both sites will become dispersed so that when it reaches designated habitat contaminants be very diffuse and we anticipate insufficient to degrade the role of the critical habitat. Additionally, while the designation includes areas in or adjacent to the respective ports, these areas don't contain the level of rugosity preferred by rockfish (these features are prevalent in the straits), suggesting that the effects in these locations would not meaningfully alter the conservation role of the PBFS. Therefore, we consider the effects insignificant on any on the designated critical habitat for PS/GB yelloweye rockfish.

2.10. Reinitiation of Consultation

This concludes ESA consultation for the Ports of Seattle and Tacoma's Comprehensive Mitigated Maintenance and Repair Permits (CMMPs).

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

2.11. Conservation Recommendations

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

The USACE should encourage the Ports engagement in beneficial habitat and salmonid recovery activities to include:

1. Leverage the Ports' authority over tenants to require BMPs with maximum protectiveness of aquatic habitat on Port properties, and provide educational outreach to tenants and staff.
2. Establish dedicated funding for salmon enhancement habitat development as a maritime environmental initiative, capitalizing on the Port's financial resources, public visibility, and responsibility to citizens as a special-purpose government.
3. Utilize Port facilities to perform pilot projects benefitting habitat restoration, including exploration of eco-engineering and green technologies.
4. Evaluate green and emerging technologies for contaminant removal in surface and stormwater effluent.
5. Foster a coordinated effort among Puget Sound ports in support of Washington State's pursuit of a healthier Puget Sound.

6. Continue to reduce vessel noise by investing in quiet propeller designs and incentivizing retrofitting of ships.
7. Improve the quality of riparian habitat and submerged aquatic vegetation to increase cover and forage for juvenile migration and rearing.
8. Remove existing in-water structures such as docks, floats, piles, bulkheads, or armoring that are no longer in use. To reduce contaminant loads to ESA-listed species, prioritize permanent removal of remaining creosote timber.
9. Evaluate and prioritize areas for soft shore armoring where existing bulkheads occur.

Please notify NMFS if the USACE or Ports carry out these recommendations so that we will be kept informed of actions that are intended to improve the conservation of listed species or their designated critical habitats.

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 associated physical, chemical, and biological properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects may result from actions occurring within EFH or outside of it and may include direct, indirect, site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH (50 CFR 600.905(b))].

This analysis is based, in part, on the EFH assessment provided by the USACE and descriptions of EFH contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce for Pacific Coast salmon (PFMC 2022a), Pacific Coast groundfish (PFMC 2022b), and coastal pelagic species (PFMC 2023).

3.1. Essential Fish Habitat Affected by the Proposed Actions

The entire action area overlaps with identified EFH for Pacific Coast salmon, Pacific coast groundfish, and coastal pelagic species. Designated EFH for groundfish and coastal pelagic species encompasses all waters along the coasts of Washington, Oregon, and California that are seaward from the mean high water line, including the upriver extent of saltwater intrusion in river mouths to the boundary of the U. S. economic zone, approximately 230 miles (370.4 km) offshore (PFMC 1998a,b). Designated EFH for the Pacific coast salmon fishery within marine water extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone offshore of Washington, Oregon, and California, north of Point Conception to the Canadian border (PFMC 1999). Species within the management groups that have designated EFH in the action area are listed in

Table 23.

Additionally, Puget Sound is a Habitat Area of Particular Concern (HAPC), based on importance of the ecological function provided by the habitat. The environmental effects of the proposed project may adversely affect EFH for Pacific coast groundfish, coastal pelagic species, and Pacific coast salmon in the HAPC for these species.

1. Noise – temporarily elevated underwater noise during construction, and vessel noise.
2. Water quality – temporarily degraded water quality as a result of sound, turbidity, re-suspended contaminants, decreased dissolved oxygen, and other pollutants.
3. Water quality – long term degraded water quality from contaminants (including 6PPD-q) in untreated stormwater runoff associated with replaced PGIS at both Ports.
4. Migratory disruption – continued alteration of outmigration routes of juvenile salmonids, causing them to navigate around the proposed structures and move into deeper water. Juveniles encountering the structure will leave the shallow nearshore, increasing the migration route and increasing the risk of predation. Although the total overwater cover will decrease slightly, we expect this action to continue to impair the quality of the migratory corridor and hinder safe passage.
5. Forage reduction – Designated EFH will experience temporary, episodic, and long-term declines in forage or prey communities as a result of reduced primary production. Contributing project actions include temporary disturbance of benthic communities and long-term perpetuation of shading that prevents growth of submerged aquatic vegetation.

The diminishments of EFH water quality, migration areas, shallow water habitat, forage base, and SAV will continue to incrementally degrade the function of EFH. Some habitat effects will be offset for some species by elements of the proposed action that provide habitat improvement.

Table 23. EFH species in the action area

Groundfish Species			
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
arrowtooth flounder	Atheresthes stomias	rosy rockfish	Sebastes rosaceus
big skate	Raja binoculata	rougheye rockfish	Sebastes aleutianus
black rockfish	Sebastes melanops	sablefish	Anoplopoma fimbria
bocaccio	Sebastes paucispinis	sand sole	Psettichthys melanostictus
brown rockfish	Sebastes auriculatus	sharpchin rockfish	Sebastes zacentrus
butter sole	Isopsetta isolepis	English sole	Parophrys vetulus
cabezon	Scorpaenichthys marmoratus	flathead sole	Hippoglossoides elassodon
California skate	Raja inornata	greenstriped rockfish	Sebastes elongatus
canary rockfish	Sebastes pinniger	hake	Merluccius productus
China rockfish	Sebastes nebulosus	kelp greenling	Hexagrammos decagrammus
copper rockfish	Sebastes caurinus	lingcod	Ophiodon elongatus
curlfin sole	Pleuronichthys decurrens	longnose skate	Raja rhina
darkblotch rockfish	Sebastes crameri	Pacific cod	Gadus macrocephalus
Dover sole	Microstomus pacificus	Pacific ocean perch	Sebastes alutus
Pacific sanddab	Ctlharichthys sordidus	shortspine thornyhe	Sebastolobus alascanus
petrale sole	E opsetta jordani	spiny dogfish	Squalus acanthias
quillback rockfish	Sebastes maliger	splitnose rockfish	Sebastes diploproa
ratfish	Hydrolagus colliei	starry flounder	Platichthys stellatus
redbanded rockfish	Sebastes babcocki	stripetail rockfish	Sebastes saxicola
redstripe rockfish	Sebastes proriger	tiger rockfish	Sebastes nigrocinctus
rex sole	Glyptocephalus zachirus	vermilion rockfish	Sebastes miniatus
rock sole	Lepidopsetta bilineata	yelloweye rockfish	Sebastes ruberrimus
rosethorn rockfish	Sebastes helvomaculatus	yellowtail rockfish	Sebastes llavidus
Coastal Pelagic Species			
Common Name	**Scientific Name**		
market squid	Latigo opalescens		
northern anchovy	Engraulis mordax		
jack mackerel	Trachurus symmetricus		
Pacific mackerel	Scomber japonicus		
Pacific sardine	Sardinops sagax		
Pacific Salmonid Species			
Common Name	**Scientific Name**		
Chinook salmon	Oncorhynchus tshawytscha		
coho salmon	Oncorhynchus kisutch		
pink salmon	Oncorhynchus gorbuscha		

3.2. EFH Conservation Recommendations

NMFS determined that the following conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the adverse effects of the proposed action on EFH. Therefore, NMFS recommends the following to ensure the conservation of EFH and associated marine fishery resources:

1. To minimize suspended sediment during structure removal and construction, implement the best management practices and conservation measures and employ a turbidity monitoring plan. Some conservation measures include:
    a. Remove piles slowly to allow sediment to slough off at, or near, the mudline.

   b. Shake or vibrate the pile to break the bond between the sediment and pile. Doing so causes much of the sediment to slough off the pile at the mudline, thereby minimizing the amount of suspended sediment.
2. To protect water quality in bodies of water receiving discharge from new or replacement PGIS, include source control and/or stormwater treatment at the location of new or replaced PGIS or an equivalent area anywhere under the Ports discretion (up 92 acres for each Port).
   a. Treatment should be designed to remove 6PPD-q and meet Ecology's "Basic" + "Metals" treatment. See more information in Ecology's publication 22-03-020 6PPD in Road Runoff Assessment and Mitigation Strategies available: https://apps.ecology.wa.gov/publications/documents/2203020.pdf
   b. Treatment can be added over the life of the permits.

3. To protect water quality at the Port of Tacoma from contaminants associated with the use of ACZA piles—if the water body becomes listed for metals under CWA section 303(d), cease using unwrapped piles.

3.3. Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, USACE 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.

3.4. Supplemental Consultation

The USACE 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 USACE. Other interested users could include Port of Seattle, Port of Tacoma, the Northwest Seaport Alliance, tribal representatives, citizens of affected areas, or others interested in the conservation of the affected species. Individual copies of this opinion were provided to the USACE. 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 of '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.

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6. APPENDICES A-G

Appendix A. Ports Calculator Rationale

We further propose to update the Port Calculator and rational (Appendix B) with the revisions detailed below. We propose to complete updates prior to using the Port Calculator for projects covered under this consultation. The Services requested these revisions but given the tight timeline, we were not able to incorporate them in a timely manner. Proposed updates:

- Fully Functional Habitat Valuation: Chinook PBF Point Values: Forage/Prey: Riparian: Change value to 3 (proposed as 2)
- Fully Functional Habitat Valuation: Chinook PBF Point Values: Migration/Rearing: Mid-Subtidal and Deep Subtidal for both substrate conditions: Change value to 3 (proposed as 2)
- Modified Maximum Site Potential: Chinook PBF Point Values: Forage/Prey: Riparian: Change value to 2 (proposed as 1)
- Modified Maximum Site Potential: Chinook PBF Point Values: Forage/Prey: Mid- and Deep Subtidal: Large Substrate: Change Value to 1 (proposed as 0)
- Modified Maximum Site Potential: Chinook PBF Point Values: Migration/Rearing: Mid-Subtidal and Deep Subtidal for both substrate conditions: Change Value to 2 (proposed as 1)

Table 1. Summary of Relative Habitat Values, Fully Functional Valuation

Habitat Zone	**Access**	**Chinook PBF Point Values**				**Sum**	**Relative Habitat Value**
		Migration/ Rearing	**Forage/ Prey**	**Cover**	**Water Quality**		
Riparian	0	0	3 (2)*	2	3	1.33	0.47
Upper Intertidal	0.4	3	3	3	2	2.23	0.79
Lower Intertidal	0.94	3	3	3	2	2.77	0.98
Shallow Subtidal	1	3	3	3	2	2.83	1.00
Mid-Subtidal	1	3 (2)	1	1	0	1.83	0.65
Deep Subtidal	1	3 (2)	1	0	0	1.67	0.59

Note: Using the values assigned, the maximum habitat value was 2.83 for the shallow subtidal fully functional condition. This is considered the 1.0 RHV, and all other values were divided by 2.83 to determine the RHV.
* NOAA revised values in red with Port suggested values in parentheses.

Table 2. Modified Maximum Site Potential Fine Substrate Habitat Valuation

Habitat Zone	Access	Chinook PBF Point Values				Sum	Relative Habitat Value
		Migration/ Rearing	Forage/ Prey	Cover	Water Quality		
Riparian	0	0	2 (1)	0	1	0.50	0.18
Upper Intertidal	0.4	2	2	1	1	1.40	0.49
Lower Intertidal	0.94	2	2	1	1	1.94	0.68
Shallow Subtidal	1	2	2	1	1	2.00	0.71
Mid-Subtidal	1	2 (1)	1	0	0	1.50	0.53
Deep Subtidal	1	2 (1)	1	0	0	1.50	0.53

Note: These RHVs are relative to the shallow subtidal fully functional condition.

Table 3. Modified Maximum Site Potential Large Substrate Habitat Valuation

Habitat Zone	Access	Chinook PBF Point Values				Sum	Relative Habitat Value
		Migration/ Rearing	Forage/ Prey	Cover	Water Quality		
Riparian	0	0	2 (1)	0	1	0.50	0.18
Upper Intertidal	0.4	2	1	1	1	1.23	0.44
Lower Intertidal	0.94	2	1	1	1	1.77	0.63
Shallow Subtidal	1	2	1	1	1	1.83	0.65
Mid-Subtidal	1	2 (1)	1 (0)	0	0	1.50	0.53
Deep Subtidal	1	2 (1)	1 (0)	0	0	1.50	0.53

Note: These RHVs are relative to the shallow subtidal fully functional condition.

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Ports of Seattle and Tacoma Comprehensive Repair and Maintenance Programs

Port Calculator Rationale

Prepared for Port of Seattle and Port of Tacoma

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ATTACHMENTS

Attachment 1 Relative Habitat Value Determination
Attachment 2 Subject Matter Expert Qualifications
Attachment 3 Structural Decay and Habitat Recovery Evaluation for Actual Site Potential Factor
Attachment 4 Basis of Shoreline Armoring Affected Area
Attachment 5 Port Calculator User Guide
Attachment 6 Port Calculator

ABBREVIATIONS

ASP	actual site potential
AZCA	ammoniacal copper zinc arsenate
DSAY	discounted service acre year
ESA	Endangered Species Act
GIS	geographic information system
H:V	horizontal to vertical (ratio)
HAT	highest astronomical tide
HEA	Habitat Equivalency Analysis
HFV	habitat function variable
LAT	lowest astronomical tide
MLLW	mean lower low water
mm	millimeter
MOU	Memorandum of Understanding
MSP	maximum site potential
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PBF	physical or biological feature
Ports	Port of Seattle and Port of Tacoma
Port Calculator	proposed calculator for port-specific actions in highly industrialized waterfronts
Programs	proposed programs to conduct routine maintenance and repair activities at wharves/docks and other facilities with shoreline frontage in Seattle and Tacoma, Washington
PSNHC	Puget Sound Nearshore Habitat Conservation
RHV	relative habitat value
RHV_{ASP}	actual site potential
RHV_{MSP}	maximum site potential
SAV	submerged aquatic vegetation
Services	National Marine Fisheries Service and U.S. Fish and Wildlife Service
SME	subject matter expert
SRKW	Southern Resident killer whale
SSNP	Salish Sea Nearshore Programmatic (Biological Opinion)
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
WHI	weighted habitat improvement
WWU	World Without Us

STRUCTURE DEFINITIONS

The following is a glossary to further define and describe the types of structures for entry into the Port Calculator:

- **Rubble-strewn slope:** A shoreline consisting of various discarded materials, such as reinforced concrete and asphalts chunks, tires, slag, and/or other inert material. See Exhibit 1 in Port Structures Photograph Log (Attachment 3).
- **Conventional armored slope – heavy:** A shoreline consisting of large quarry rock, typically greater than 2 to 3 feet in diameter. See Exhibit 2 in Port Structures Photograph Log (Attachment 3).
- **Conventional armored slope – light:** A shoreline consisting of small, angular quarry rock, typically less than 1 foot in diameter. Also referred to as quarry spalls. See Exhibit 3 in Port Structures Photograph Log (Attachment 3).
- **Bulkhead and conventional armored slope:** A vertical wall at the top of a slope, with quarry rock descending downslope. The vertical wall typically consists of sheet pile or timber. See Exhibit 4 in Port Structures Photograph Log (Attachment 3).
- **Bulkhead, toewall, and conventional armored slope:** A vertical wall at the top and bottom of the slope, with quarry rock placed between the two vertical walls. See Exhibits 5 and 6 in Port Structures Photograph Log (Attachment 3).
- **Vertical bulkhead:** A vertical wall located at the top of slope or mid-slope. The vertical wall typically consists of sheet pile or timber. See Exhibit 7 in Port Structures Photograph Log.
- **Pile – timber:** A vertical post made from a single log, typically Douglas fir. Depending on its age, timber pile can be treated with creosote or ammoniacal copper zinc arsenate (ACZA), or wrapped in a high density polyethylene. Generally, 12 to 18 inches in diameter and considered to be a sacrificial structure when used in fender systems. See Exhibit 8 in Port Structures Photograph Log (Attachment 3).
- **Pile – steel:** A vertical post typically made from carbon steel. Steel pile can be formed into sheet pile, pipe pile (hollow in the center), and h-pile. Pipe pile can be up to 36 inches in diameter. See Exhibit 9 in Port Structures Photograph Log (Attachment 3).
- **Pile – concrete:** A vertical post made from reinforced concrete. Concrete pile can be round, octagonal, or square. Generally, up to 36 inches in diameter. See Exhibit 10 in Port Structures Photograph Log (Attachment 3).
- **Stormwater outfall:** A pipe that conveys water runoff to a receiving waterbody. Can be associated with a concrete spillway, a bulkhead, and/or a standalone structure. Depending on its age, stormwater outfalls can be high density polyethylene, concrete, ductile iron, corrugated metal, or other material. In tidally influenced environments, stormwater outfalls may have a tide gate installed to prevent backflushing; tide gates can be hinged flap gates,

duckbills, or in-line check valves. See Exhibit 11 in Port Structures Photograph Log (Attachment 3).

- **Overwater cover – heavy:** A large overwater structure for international and domestic cargo handling, and heavy industrial uses. An industrial pier varies in length and width but generally is over 1,000 feet long, consists of hundreds of piles, and supports large container cranes, buildings, and cargo. See Exhibit 12 in Port Structures Photograph Log (Attachment 3).
- **Overwater cover – medium:** A narrow, elevated pier that can be perpendicular to shore or in the shape of a "T" to accommodate public access viewing or barge moorage. Piles generally consist of timber or concrete, and decking can consist of timber, asphalt, concrete or a combination thereof. These piers generally have load restrictions of some sort. See Exhibit 13 in Port Structures Photograph Log (Attachment 3).
- **Overwater cover – light:** A small, narrow pier, often associated with marinas. Pier generally consists of floats and timber or concrete guide piles with solid or grated decking depending on load requirements and uses. See Exhibit 14 in Port Structures Photograph Log (Attachment 3).

1 Introduction

The Port of Seattle and Port of Tacoma (Ports) each have a proposed program (Programs) to conduct routine maintenance and repair activities at their wharves/docks and other facilities with shoreline frontage in Seattle and Tacoma, Washington, respectively. The Ports, the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS) determined that the Salish Sea Nearshore Programmatic (SSNP) Biological Opinion and the corresponding Puget Sound Nearshore Habitat Conservation (PSNHC) Calculator are not appropriate to evaluate the potential effects of most port projects to species listed under the Endangered Species Act (ESA). Therefore, a calculator for port-specific actions in highly industrialized waterfronts (Port Calculator) has been proposed. The Port Calculator is needed because of the unique characteristics of estuaries where the Ports operate, the current and likely future habitat conditions in the port action areas, and the durability and duration of port-type structures (see glossary for detailed descriptions of structure types) in the environment. Habitat impacts or improvements resulting from the Programs will be calculated using the Port Calculator. Application of the Port Calculator will identify the magnitude of ESA-listed species impacts for each project undertaken within the Programs as well as determine any necessary offsets. In addition, the Port Calculator—like the PSNHC Calculator—includes an algorithm for assessing the “enduring effect” of structures that are being repaired or maintained.

This memorandum describes the basis of development of the Port Calculator. The Port Calculator was developed using best available science, subject matter expert (SME) opinion, knowledge of port infrastructure, a series of simplifying assumptions using best professional judgment, consistency with the PSNHC Calculator to the extent practicable, and collaboration with NMFS and USFWS.

Several large group meetings occurred between the Ports, NMFS, and USFWS throughout 2023 to develop common definitions and agree on the overall approach for quantifying enduring effects. This was followed by several focused technical subgroup meetings in spring 2024 to work through detailed elements of the Port Calculator.

A primary objective of the Port Calculator is to quantify the enduring effects of structures in the environment to ESA-listed species. Repair and maintenance of structures extends their functional life in the environment, delaying the onset of habitat-forming processes and the recovery of the underlying habitat. The scope of the Programs also includes small expansion projects as well as some beneficial activities, predominantly removal of overwater cover and creosote-treated structural components. The Port Calculator has been designed to consider these projects and activities as well as a broad range of repair and maintenance actions common to the Ports. Because the activities covered by both Programs are similar, and the two Ports operate within similar environments, several simplifying assumptions are used to ensure that the Port Calculator is generally applicable to these two ports.[1] All new development projects are outside the scope of the Programs and are subject to an individual ESA consultation, and the most applicable calculator available at the time of permitting will be used.

1.1 Report Organization

This report is organized as follows:

- Section 1 – Introduction
- Section 2 – Framework for Port Calculator
- Section 3 – Project Type
- Section 4 – Port Calculator Inputs
- Section 5 – Adaptive Management
- Section 6 – Summary
- Section 7 – References
- Attachment 1 – Relative Habitat Value Determination
- Attachment 2 – Subject Matter Expert Qualifications
- Attachment 3 – Structural Decay and Habitat Recovery Evaluation for Actual Site Potential Factor
- Attachment 4 – Basis of Shoreline Armoring Affected Area
- Attachment 5 – Port Calculator User Guide
- Attachment 6 – Port Calculator

1.2 Definitions

The following key definitions were developed jointly during discussions with NMFS and USFWS, and they are specific to the Port Calculator:

- **Relative habitat value** (RHV) represents the difference in ecological values provided by different habitat zones and/or conditions relative to the most valuable habitat zone/condition. RHV is determined in a two-step process. Each habitat zone is assigned values for duration of access and the contribution of that zone to each designated critical habitat physical or biological feature (PBF; 0 to 3 for no, low, medium, or high). The RHV is the result of the sum total for each habitat zone divided by the habitat zone with the highest value (i.e., fully functional shallow subtidal). Therefore, RHVs range from a minimum of 0 to a maximum of 1. The Port Calculator uses the approach consistent with a Habitat Equivalency Analysis (HEA) to determine RHVs; see Table 1-1 in Attachment 1).
- **Baseline** is the current habitat condition, which is typically degraded for port environments.

[1] The Services may further evaluate the Port Calculator to determine its suitability for other highly industrialized ports.

- **Modified** is the predicted habitat condition in the foreseeable future (e.g., 300 years) based on the durability of the structure, the rate of its decay, and the corresponding recovery of habitat functions as a result of the structure degradation. The time frame of 300 years was used to determine the site potential for two reasons: 1) The Port Calculator uses HEA for its integration of impacts over time. For HEA, debits and benefits do not change much after 300 years because of HEA's use of a discounting factor; and 2) Engineering estimates of structural decay can be extrapolated to 300 years with moderate certainty. There are two subcategories of this modified habitat condition:
  - **Maximum site potential** (MSP) is the highest RHV possible in a port environment without active restoration (i.e., physically removing the structure but not restoring the underlying habitat). This represents the quantitative acknowledgement that ecological function will not reach "pristine" conditions for the foreseeable future in highly developed port environments without significant, active restoration actions. For example, lateral channel migration does not occur in highly developed estuarine/port settings due to the artificially constructed waterways that create highly constrained channels.
  - **Actual site potential** (ASP) is the likely future RHV that develops when a structure in a highly developed port environment degrades without actively removing the structure. The SMEs conducted a Program-specific evaluation to determine what the most likely future habitat condition will be without intervention (i.e., maintenance).This determination is based on the evaluation of the following: 1) what a structure's decay curve would be irrespective of any action; and 2) how much habitat function would return as a result of the structure's degradation. This approach is consistent with the Memorandum of Understanding (MOU) between the Department of the Army (Civil Works) and the National Oceanic and Atmospheric Administration (NOAA) (Civil Works and NOAA 2022). The MOU summarizes mutual understanding of existing laws and regulations.
- **Enduring effect** is the quantification of the loss in habitat function caused by the delay in habitat-forming processes (recovery) leading to achieving the ASP. The Ports will measure the enduring effect over a specified time frame (e.g., maintenance cycle, except for dredging).
- **Maintenance cycle** is the estimated number of years a structural element will remain fully functional for its intended purpose before needing maintenance or repair actions.
- **Discounted Service Acre Years** (DSAYs) are the debit and credit units generated by the Port Calculator. The PSNHC Calculator includes DSAYs as an output, but it relies on conservation credits as the primary unit. One DSAY is equal to 100 conservation credits.
- **Habitat function variables** are important species-specific habitat features, similar to PBFs but not limited to designated critical habitat.

2 Framework for Port Calculator

The Port Calculator is based on a HEA model. HEA is a model that was developed by NOAA to assess both ecological services lost or gained using the following: 1) the RHV pre- and post-project; 2) the size of the area affected; 3) the time a project will remain in place; 4) the time it takes for the habitat to achieve full function; and 5) discounting for less value of future functions and ecosystem services (NOAA 1995; Ehinger et al. 2015). Ecological services lost (debits) or gained (credits) are expressed in DSAYs, which allows for a service-to-service replacement approach rather than direct habitat replacement (e.g., 1 acre of wetland created to replace 1 acre of wetland impacted). Under this framework, the services and functions a habitat unit provides for a species or group of species are used to offset the services lost by impacts to another habitat unit.

The steps for implementing a HEA are as follows:

1. Determine the pre- and post-project acreages for each habitat zone.
2. Determine the habitat condition in both the pre- and post-project scenario. The Port Calculator includes consideration of dominant substrates for each habitat zone to determine the RHV. These determinations were made at a Program level by valuing each habitat zone for habitat access and PBFs for three habitat conditions (including two conditions for two different substrates) and dividing by the highest scoring habitat zone (the site-specific "gold standard").
3. Determine the project duration: How long will the structure remain functional without maintenance?
4. Determine the time to full function: How long will it take for the different habitat zones to mature and reach the ASP assumed in the post-project assessment?
5. Run these inputs through the HEA model to determine the total present habitat value, which includes a 3% discounting factor[2] for each year after the initial year, to determine the debits or credits as DSAYs.
6. Determine any applicable adjustment factors based on the location of the project.

2.1 Area

Delineating the area affected by the project is the first step in any HEA. All subsequent analyses quantify the change in service value specific to each affected area. The smallest units in which habitat services are determined can be called habitat polygons. Because area (acres) is a primary driver of the DSAY calculation, it is important to establish a replicable method for delineating the habitat areas for each project. First, the project footprint baseline condition will be delineated into separate polygons as a geographic information system (GIS) layer, which differentiates between habitat zones,

[2] To make the losses that occur in different time periods comparable, a discount factor of 3% (the standard used by NMFS) will be applied to both the debits and credits to determine DSAYs in present terms.

submerged aquatic vegetation (SAV) coverage (if applicable, SAV baseline condition will be considered fully functional), dominant substrate types, and habitat condition. This will be informed by aerial photography or existing data (e.g., survey information). Second, the post-project condition will be delineated into separate polygons as a new GIS layer based on habitat zones, dominant substrate types, and habitat condition using project plans/schematics. Third, these two layers will be joined in GIS to create a habitat conversion table, which will serve as the basis for entries in the Port Calculator. Shoreline stabilization includes an affected area landward of the stabilizing structure (see the following section). For all other structures, structure repair affected area will be limited to the repair footprint, unless the repair occurs within 20 feet of an overwater structure's waterward edge (see the following section).

2.1.1 Affected Area

2.1.1.1 Shoreline Stabilization Structures

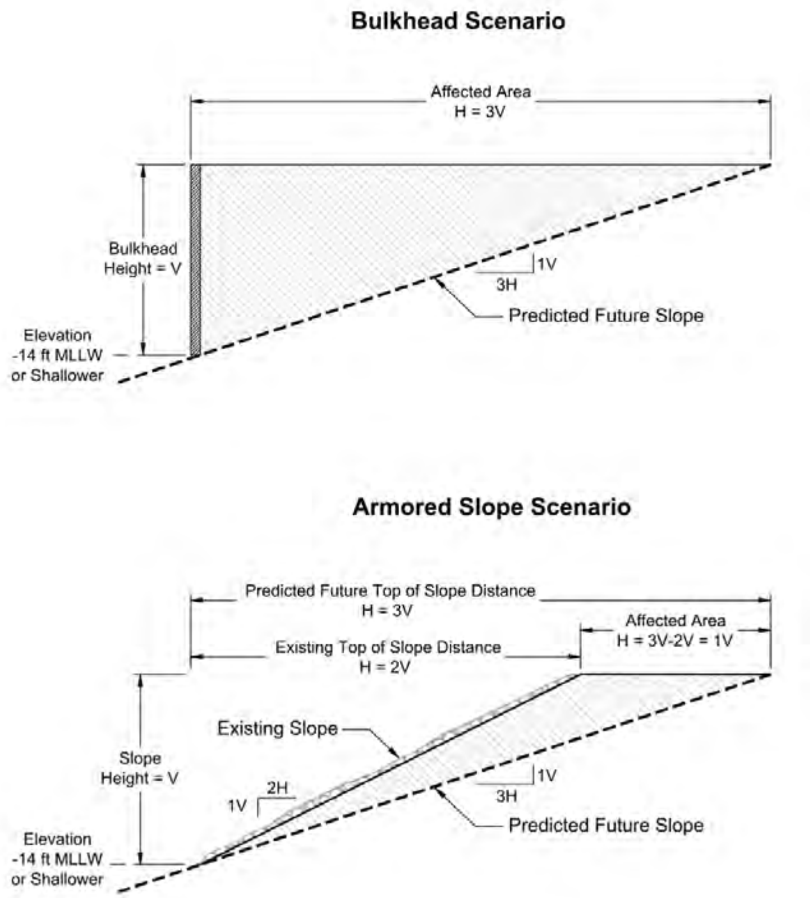
For shoreline stabilization structures, the continued existence of the structure in the environment delays natural shoreline processes that would otherwise re-establish nearshore migratory habitat. As a result, the Port Calculator assumes that any shoreline stabilization project will include an affected area landward of the maintenance or repair area. Many site-specific factors influence the extent of landward area that is impacted by shoreline stabilization structures, including tidal forces, aspect (for wind and wave forces), and upland land uses. As discussed with NMFS and USFWS, simplifying assumptions were used to determine an appropriate affected area for shoreline stabilization structures. Based on the soil type (i.e., fill and dredge spoils) and soil friction properties in the Port's properties and immediately surrounding areas, a predicted future slope angle would achieve a 3 horizontal to 1 vertical (3H:1V) inclination and would be limited on the waterward edge to the lowest extent of wave action (see detailed description in Attachment 4), which is likely to occur no deeper than the shallow subtidal habitat zone. For bulkheaded areas, if the bulkhead were not maintained, a 3H:1V slope would likely develop behind the unmaintained bulkhead over the long term (Figure 1). For armored slopes, a typical armored slope at 2H:1V would likely flatten to a slope angle of 3H:1V (Figure 1).

These assumptions are practically applied as follows:

- **Bulkheads:** The area of extent is the linear length of the bulkhead repair multiplied by three times the bulkhead height from the toe of bulkhead or -14 feet mean lower low water (MLLW), whichever is shallower. This factor of three represents the change between a vertical wall existing to a 3H:1V slope in the long term.
- **Sloped Armor:** The area of extent is the linear length of the slope repair multiplied by one times the height between the toe-of-slope or -14 feet MLLW, whichever is shallower, and the

top of slope. This factor of one represents the change between a 2H:1V slope existing to a 3H:1V slope in the long term.

Figure 1
Shoreline Stabilization Affected Area

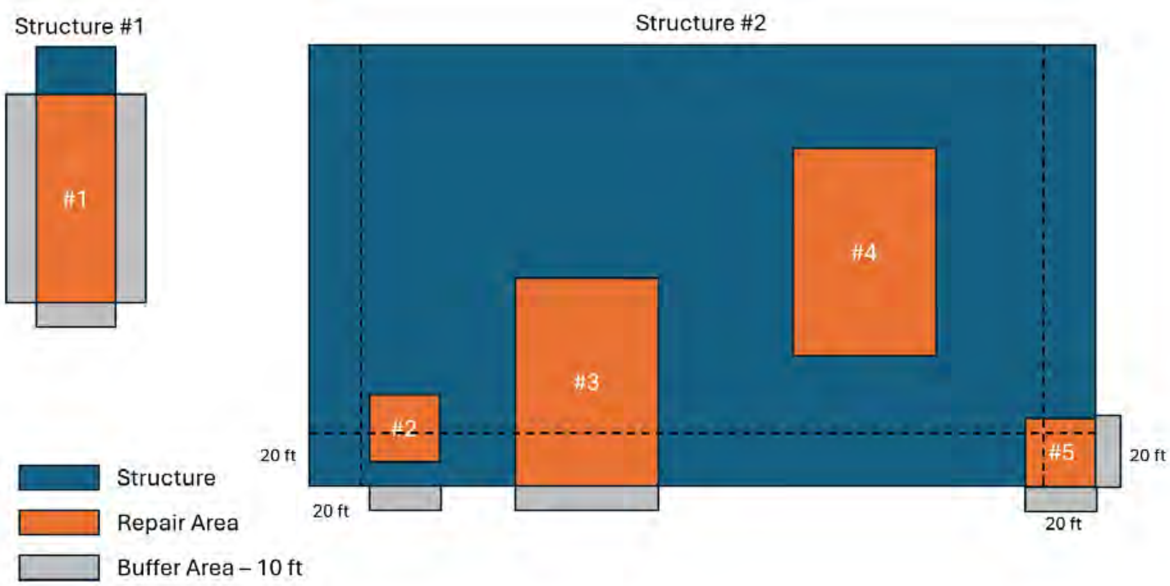


Note:
The shaded area is the predicted migratory corridor area that would become accessible if natural processes were restored through total functional loss of shoreline armoring features.

2.1.1.2 Overwater Structures

For all other structures, the affected area is limited to the footprint of the area being maintained or repaired, with the exception of repairs that occur within 20 feet of an overwater structure's waterward edge (Figure 2). Consistent with the PSNHC Calculator, these repairs will have an additional 10-foot buffer (i.e., affected area) that extends beyond the edge of the structure. This buffer will be calculated at 50% of the structure repair area in the Port Calculator.

Figure 2
Overwater Cover Affected Area



Note:
The gray-shaded area is the predicted additional area of limited shading, migratory, and water quality impacts that will continue to have limited (50%) enduring effects with the structure remaining in the environment.

2.2 Habitat Conditions

For the Port Calculator, a small number of categories capture the differences between notably different habitat conditions that commonly occur in the areas around the Ports. The overall approach to capture effects and effect pathways is to use these habitat condition categories. General characteristics of the three habitat conditions (i.e., fully functional, modified, and degraded) included in the Port Calculator are as follows:

- **Fully functional** indicates habitat that is not impaired on site or adjacent to the site. Fully functional habitat includes a vegetated riparian buffer, no obstructions to migration, abundant forage/prey, presence of cover or refuge (e.g., wrack, SAV or large wood), water filtration through the presence of riparian and intertidal sediments and vegetation, and restored natural processes. For the Ports, this habitat condition is usually limited to the post-project condition for restoration projects, with site protection and monitoring requirements to confirm that these sites are achieving performance standards.
- **Modified** indicates habitat that is impaired by adjacent conditions (i.e., highly urban settings) and historical development (i.e., creation of artificial shipping channels). This category is further defined and valued based on the dominant substrate type: fine substrate (sand/silt)

and large substrate (i.e., more than 20% particles greater than 2 millimeters [mm] in diameter). At any given elevation, sand/silt substrates are assumed to provide more prey organisms consumed by juvenile salmonids and are assigned higher values than structurally complex ones (Anchor QEA 2021; Grette 2022). This habitat condition is generally the post-project condition used for enduring effect and non-restoration crediting project actions (e.g., reduction in footprint) and the baseline condition for expansion actions in the Program.

  - **MSP** indicates habitat that is not impaired by on-site port structures but is located adjacent to industrial structures in a highly developed urban waterfront landscape.
  - **ASP** indicates habitat that no longer has intact physical obstructions, but rather contains remnants from the decay of structures.

- **Degraded** indicates habitats that are severely impacted by physical obstructions (i.e., large overwater structures such as piers, aprons, and buildings; the occurrence of log rafting in intertidal and shallow subtidal areas; and the presence of concentrations of wood wastes). This category is further defined and valued based on the dominant substrate type: fine substrate (sand/silt) and large substrate (i.e., more than 20% particles greater than 2 mm in diameter). At any given elevation, sand/silt substrates are assumed to provide more prey organisms consumed by juvenile salmonids and are assigned higher values than structurally complex ones (Anchor QEA 2021; Grette 2022). This habitat condition is generally the post-project condition for expansion actions in the Programs and the baseline condition for the enduring effect and non-restoration crediting actions.

2.3 Duration

Project duration is an estimate of how long the impact or crediting action is expected to last. This input is used to ensure that all anticipated impacts into the future are accounted for, and mitigated for, adequately. For enduring effect and expansion projects, the duration is the maintenance cycle for the structure because that represents the expected time frame before the structure will need to be permitted for a subsequent activity. For crediting actions, the duration will be determined on a case-by-case basis depending on the potential site protections that can be implemented (e.g., Capital Improvement Plan timelines).

2.4 Time to Full Function

Time to full function is the time it will take for the habitat to transition from the baseline RHV to the ASP habitat value. For enduring effect and expansion projects, the loss of function is effective immediately (i.e., within the first [base] year). For structure removal, the benefits are also effective immediately because they are no longer impacting (e.g., artificial shade or water quality) the environment. For other restoration actions (e.g., marsh restoration), time to full function time frames will be specific to each habitat zone. For intertidal and subtidal habitats, monitoring data from Puget Sound restoration projects demonstrated rapid initial development of diverse and abundant benthic and epibenthic assemblages within 1 to 2 years after construction, with many sites achieving long-term production levels, population structure, and taxa richness comparable with reference areas after 4 years (e.g., Milwaukee Habitat Area [Parametrix 1998]). Therefore, intertidal and subtidal habitat is assumed to establish as a stepwise function over 4 years. For marsh habitats, Strange et al. 1999 (as cited in Iadanza 2001) found that newly created marsh vegetation functions equal to a natural marsh were established within 5 years. However, overall community/ecosystem function (e.g., hydrology, soils, vegetation, nutrients, and animal life) took more than 15 years to establish. Therefore, marsh habitat is assumed to establish as a stepwise function over 15 years. Development rates of vegetated (riparian) buffers in the Puget Sound area were limited, but most monitoring programs for vegetated buffers (riparian, shrub-scrub, and woody vegetation) overseen by U.S. Army Corps of Engineers have success criteria in Washington associated with 60% cover by native shrub species by year 5 (USACE 1999). Ossinger et al. 1999 provided suggested benchmark values for herbaceous vegetation as 80% cover by year 3 and 90% cover by year 5. Therefore, riparian habitat is assumed to establish full coverage for woody/shrub cover in 8 years. The Port Calculator currently does not have that function included because the Program anticipates prioritizing structure removal and creosote removal as the primary crediting activity for the beginning of the Program. The time to full function for restoration actions will be added in a subsequent update of the Port Calculator.

2.5 Discounting

An annual discount factor is applied to years following the initial year of impacts, based on the economic theory that the public places greater value on having resources (e.g., habitat function) available in the present day versus having the benefit of those resources delayed into the future. The result is in an incremental reduction of the ecological impacts (or benefits) over time. Based on the NMFS approach to assess habitat service losses, a standard 3% annual discount factor is applied to calculate DSAYs lost in present value units (NOAA 1999). For example, the loss of 1 acre of the best quality habitat (RHV = 1.0) would result in a loss of 1 DSAY for the first year of impact, 0.97 DSAYs lost in year 2, 0.94 DSAYs lost in year 3, etc. The total DSAYs for each habitat are calculated for each year, and then summed across all years for the life of the project (Equation 1). This is consistent with the PSNHC Calculator.

Equation 1

$$Total\ DSAYs = \sum_{t=1}^{n} Discount\ Factor * Relative\ Habitat\ Value * Acres$$

where:

t = year

n = life of project

The same approach is applied to restoration, where the future value of habitat is discounted annually at 3% to calculate the DSAYs gained in present value units. See Attachment 5 for a step-by-step guide to entering a project into the Port Calculator, which is provided as an Excel file (Attachment 6).

2.6 Adjustment Factors

Credit factors are used with HEA to account specific conditions, like connectivity. The credit factors for the PSNHC Calculator are specific to site conditions (e.g., whether a project location is within 5 miles of a natal Chinook salmon estuary).

HEA allows for the optional use of adjustment factors as the last step in the analysis. Adjustment factors can help quantify special conditions not included or not considered sufficiently in the other elements of the HEA. These factors include landscape-scale conditions, such as the proximity of an affected area to areas of special importance. They also include site-specific adjustment factors, such as impacts to forage fish-spawning habitat. The Port Calculator includes adjustment factors consistent with those outlined in the PSNHC Calculator rationale document (Section 5 in Ehinger et al. 2023).

3 Project Type

Likely effects to ESA-listed species (beneficial or adverse) and maintenance activities resulting in compensatory mitigation requirements will be calculated using the Port Calculator and included in each port's Annual Report with a ledger of conservation offset debits and credits. The following Program activities will require an analysis using the Port Calculator to determine conservation offset credits and debits:

- Pile replacement removal (including horizontal components and attachment hardware)
- Replacement, minor expansion, or removal of overwater structures
- Shoreline stabilization (unless required to isolate upland contamination[3])
- Maintenance dredging
- Beneficial activities

The Program Biological Evaluations include detailed descriptions of the structures and project activities included in the Port Calculator. Additionally, the Port Calculator includes multiple structure options (e.g., different materials, different uses, and different durability) for each of the project activities listed. The Port Calculator is designed to evaluate the following three types of potential outcomes from a project action, each with its own input tab:

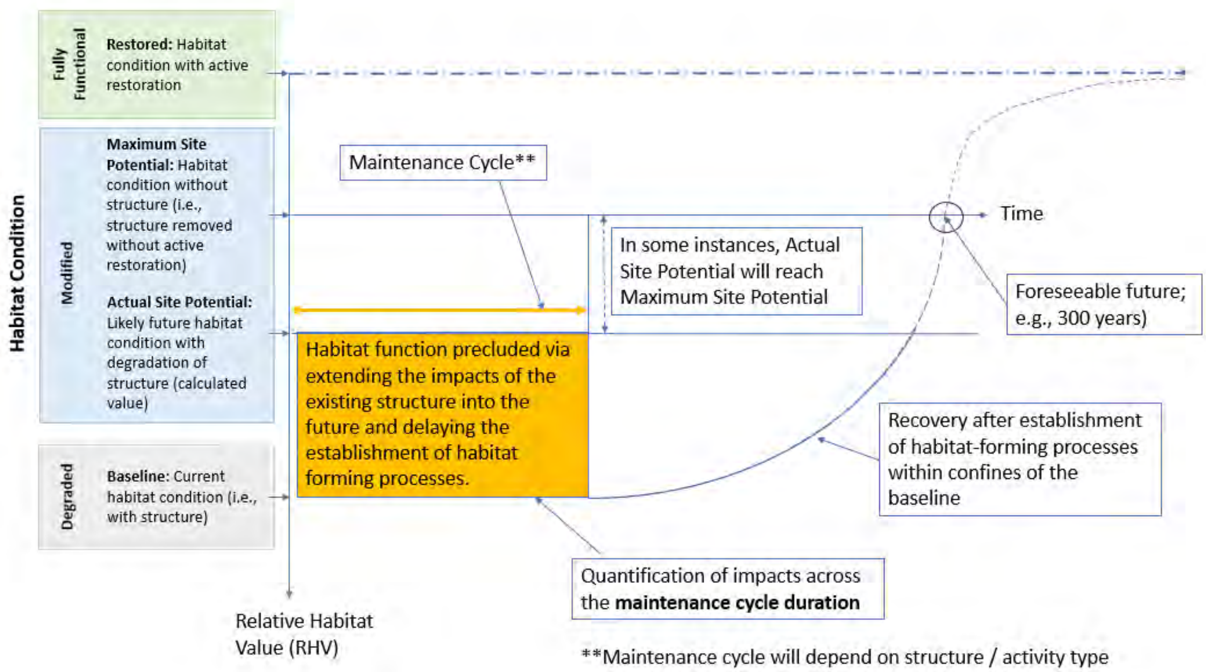
- **Enduring Effect:** The recovery of habitat is delayed by the maintenance and repair actions of an existing structure. This impact is quantified by calculating the delta between the ASP and baseline (both defined previously). That delta is summed over the duration of the maintenance cycle (defined previously). This is represented by the area within the gold box shown in Figure 3. Consistent with the PSNHC Calculator and other HEA models, the value of habitat is discounted into the future at a rate of 3%, which is not depicted in Figure 3 but is further described in the Section 2.5.
- **Expansion:** The Programs generally consist of maintenance and repair conducted within the existing footprint of the facility. However, a small number of projects could require minor expansion or further degrade the habitat condition. For example, a maintenance dredge project may convert mid-subtidal habitat to deep subtidal habitat to return the berth to its design depth. This conversion of habitat zones degrades the habitat condition and will be calculated in the Expansion tab. Additionally, if a structure requires a modification that results in a minor expansion of overwater coverage (e.g., less than 5% of the existing overwater coverage), this would be considered an expansion, and effects would be calculated in the Expansion tab. Activities that disrupt the substrate when SAV is present results in degradation of the habitat and will be considered an expansion project even if the work is limited to

[3] If maintenance of a structure is preventing contamination from entering the aquatic environment, the maintenance is protective of the environment, and the Port Calculator will not be used to determine impacts.

maintenance activities. Consistent with the PSNHC Calculator, these projects represent a new impact on the environment and therefore have an adjustment factor applied that results in two times the enduring effect impacts calculated for existing structures.

- **Credit:** Crediting projects are those that improve habitat condition. The most common crediting projects within the Programs will be removal of overwater cover and creosote-treated structural components (partial or complete). Crediting projects also include habitat improvement projects (e.g., shoreline softening) and active restoration.

Figure 3
Project Effects Illustration



4 Port Calculator Inputs

The framework outlined above informed the architecture for developing the Port Calculator structure, including all of the key elements needed for a HEA model as well additional elements specific to the Programs, such as the affected area and adjustment factors. The next step in calculator development was to define input values for the various elements that support quantification of the magnitude of ESA-listed species impacts, including enduring effects, for each project undertaken within the Programs as well as determine any necessary offsets. The following section describes the specific input values and the supporting rationale used in the Port Calculator.

4.1 Species

The Port Calculator quantifies RHVs for ESA-listed sentinel species that are likely to be affected by projects proposed under the Programs.

4.1.1 Chinook Salmon

Puget Sound Chinook salmon were selected to be the sentinel species for all NMFS ESA-listed species. Puget Sound steelhead, also ESA listed, generally reside longer in freshwater and do not rear extensively in estuaries or nearshore habitats (NMFS 2019). Thus, it is expected that the habitat requirements and susceptibility to the effects of Port maintenance activities do not exceed those of Puget Sound Chinook salmon. Quantification of impacts from Port maintenance activities to Chinook salmon are generally inclusive of steelhead. Further, because Chinook salmon are important prey for Southern Resident killer whales (SRKW), offsets determined for Chinook salmon also apply to SRKW. For USFWS, bull trout and marbled murrelet are included because these are the only two USFWS ESA-listed species in the action areas for each port. If other species (e.g., sunflower sea stars) become listed under the ESA, and NMFS and USFWS (together, the Services) determine reinitiating consultation is warranted, inclusion of a new species into the Port Calculator can be addressed as part of adaptive management.

As such, the Port Calculator was developed to allow for each project activity to be evaluated based on the estimated impacts to each considered species. In practice, the Port Calculator will be run three separate times using the same project activity inputs by simply changing the target species. If the greatest impact to an individual species is fully offset, the operating assumption is that all other species impacts are subsumed.

4.1.2 Bull Trout

Using the Chinook salmon PBFs as a surrogate for bull trout determined that bull trout habitat needs for migration, cover, and water quality are very similar. In select areas (e.g., Water Resource Inventory Area 8), juvenile salmonids make up a significant portion of bull trout diet, so there is likely large habitat overlap with Chinook salmon (Goetz et al. 2004). The most notable difference based on discussions with USFWS is related to prey, because bull trout (age 3 or older) almost exclusively eat fish, with the bulk of their diet coming from forage fish, surf smelt, sand lance, and herring (Goetz et al. 2004). Herring spawn is generally confined to vegetation in the shallow subtidal and lower half of the intertidal zone (Penttila 2007). Surf smelt tend to spawn in the uppermost one-third of the tidal range, from approximately +7 feet MLLW up to extreme high water on sand-gravel (1 to 7 mm range; Penttila 2007). Sand lance tend to spawn between mean higher high water and about +5 feet MLLW in central Puget Sound (Penttila 2007).

After re-evaluating the prey PBF using forage fish as the primary target prey, the bull trout RHVs were the same as Chinook salmon, with the exception of lower RHVs for the riparian zone because terrestrial invertebrates do not constitute a significant portion of bull trout diet (Goetz et al. 2004). Based on this, the Chinook salmon RHVs are protective of bull trout and are used in the Port Calculator (Table 1-6 in Attachment 1). The valuation can be provided upon request.

4.1.3 Marbled Murrelet

Murrelets generally forage in relatively shallow waters within 2 kilometers of the shore in Washington. Prey species mostly include invertebrates and small inshore schooling fish species, such as sand lance, smelt, Pacific herring, capelin, and various other fish (Burkett 1995; Strachan et al. 1995). Other than foraging habits, limited data are available on other aspects of their habitat criteria in Puget Sound, specifically in the areas around the Ports. After discussion with USFWS, the bird assemblage RHVs determined by Iadanza (2001) were deemed consistent with marbled murrelet foraging behavior. For the purposes of that analysis, the value of a particular habitat zone to estuarine birds was assumed to be the same as the habitat value assigned to salmon. However, there is a large disparity when comparing the RHVs for salmonids as described previously and in Iadanza (2001) because of the different approach to assigning habitat values. The Iadanza (2001) RHVs for estuarine birds were notably lower than the values determined for Chinook salmon and bull trout using the approach described in the previous section. Due to lack of specific information to complete the evaluation, the value of habitat zones is assumed to be the same for salmonids and estuarine birds (e.g., marbled murrelets; Table 1-6 in Attachment 1), consistent with the statement in Iadanza (2001). If more data become available, separate marbled murrelet RHVs can be incorporated during the annual updates to the Port Calculator as part of adaptive management.

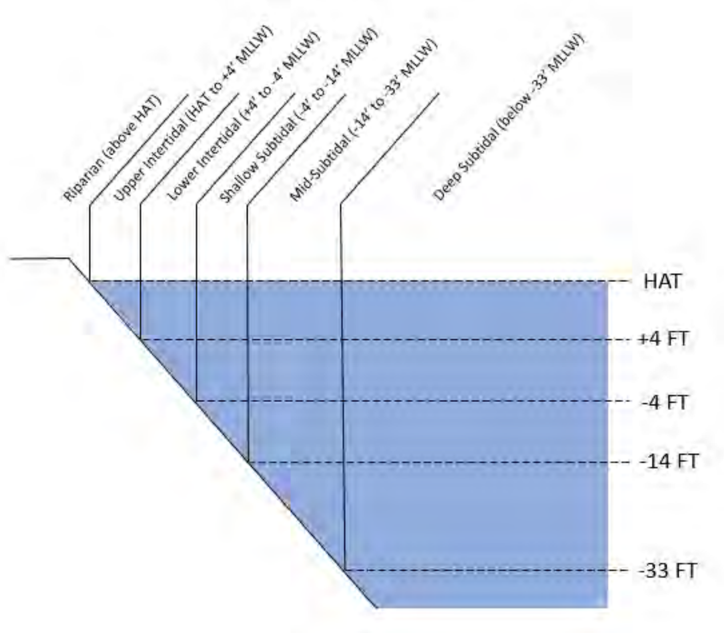
The one difference for marbled murrelets is the ongoing operational impact from noise. Marbled murrelets holding fish preparing to fly inland have been observed swallowing the fish intended for their nestlings in response to disturbance by small boats (Speckman et al. 2004 in Nelson and Fitzgerald 2024). Missing meals due to anthropogenic disturbance have serious nutritional and developmental consequences to individual marbled murrelet chicks (Nelson and Fitzgerald 2024). Specific impacts to marbled murrelets are currently addressed in these Programs using the predicted weighted habitat improvements for the access and noise habitat function variables (see Section 4.4 and Table 3-3 in Attachment 3).

4.2 Habitat Zones

The habitat zones defined in this section and depicted in Figure 4 are largely based on Iadanza (2001) to designate appropriate zones and elevational breaks within an estuary based on the prey assemblage and abundance, the frequency and duration of habitat availability (i.e., inundation), primary productivity, and habitat use. Specific to port infrastructure depths and more recent work documenting SAV, the deep subtidal zone has been split into two subtidal zones to capture the differences in habitat values. The habitat zones are defined as follows:

- **Riparian** (highest astronomical tide [HAT] to 50 feet linear distance): This zone is based on the site potential tree height as the maximum distance a tree would provide shade and organic inputs along a highly modified, urban shoreline.
- **Upper Intertidal** (HAT to +4 feet MLLW): This zone is consistent with Iadanza (2001) and captures periodic tidal inundation with enough horizontal distance to be meaningful in a simplified port environment to the upper extent of eelgrass and correlated with estuarine vegetation.
- **Lower Intertidal** (+4 feet MLLW to -4 feet MLLW): This zone is consistent with Iadanza (2001) and captures more frequent tidal inundation from the upper extent of eelgrass to the lowest astronomical tide (LAT).
- **Shallow Subtidal** (-4 feet MLLW to -14 feet MLLW): This zone is consistent with Iadanza (2001) and captures the lowest extent of eelgrass present. If eelgrass is present below -14 feet MLLW, then the shallow subtidal zone can be modified to include the eelgrass extent.
- **Mid-Subtidal** (-14 feet MLLW to -33 feet MLLW): This zone has been added to capture the diminished habitat value associated with limited light penetration down to the lower extent of the effective photic zone for most species of vascular and algal species in Puget Sound (Lambert et al. 2021).
- **Deep Subtidal** (deeper than -33 feet MLLW): This zone starts at the lower extent of the effective photic zone (Lambert et al. 2021).

Figure 4
Habitat Zones



4.3 Relative Habitat Value

The Port Calculator has defined fixed RHVs for the six habitat zones (Figure 4), the three habitat conditions (i.e., fully functional, modified, and degraded), and the site-specific sediment type (i.e., fine or large substrate). Sediment type is generally not relevant for the riparian zone; therefore, the riparian zone uses presence (or absence) of vegetation and/or types of hardscaping to capture impacts from shoreline stabilization performed in the riparian zone. The 31 RHVs (Table 1-6 in Attachment 1) result from the six riparian habitat conditions plus six habitat and sediment conditions for the five intertidal and subtidal habitat elevations. These 31 unique values adequately categorize the habitat conditions in the highly developed industrial ports of Seattle and Tacoma. Using fixed RHVs increases consistency with implementation of the Port Calculator between users and over the life of the Programs.

To calculate the RHV for each habitat condition and each habitat zone, the first step was to determine the highest value habitat based on Chinook salmon PBFs. Chinook salmon PBFs were used to determine the RHV tables for the Port Calculator because the Ports and the Services agreed that Chinook salmon were the sentinel species; therefore, the RHVs for Chinook salmon would also be protective of USFWS ESA-listed bull trout and marbled murrelet as well as other NMFS ESA-listed species, such as Puget Sound steelhead, bocaccio and yelloweye rockfish, and SRKW.

Chinook salmon PBFs (i.e., migration/rearing, forage/prey, cover, and water quality) were assigned values using a scale of 0 to 3 for no, low, medium, and high value, respectively. The Port Calculator uses the simplifying assumption that each PBF equally contributes to the overall value of a habitat zone rather than weighing one PBF more or less valuable than another.

Habitat accessibility (i.e., proportion of the tidal cycle inundated) was assigned values from 0 to 1. Deep subtidal, mid-subtidal, and shallow subtidal all have a value of 1 because these elevations are inundated 100% of the time. To determine the habitat access value in the intertidal zone, the midpoint of the habitat zone was used because the intertidal zone is not inundated 100% of the time and therefore has some limitations to accessibility. According to O'Neal et al. 2024, water depths between 1.3 to 2.2 feet had the highest densities of stream-type juvenile Chinook salmon. This indicates that outmigrating juvenile Chinook require depths greater than the lowest elevation within the intertidal zone, which was the method used in the PSNHC Calculator (Appendix A in Ehinger et al. 2023). Using the midpoint, the upper intertidal zone is considered accessible approximately 40% of the time, and the lower intertidal zone is accessible approximately 94% of the time. See Attachment 1 for determination of the percent of time at least half of the upper intertidal zone (midpoint is +8.65 feet MLLW) and lower intertidal zone (midpoint is 0 feet MLLW) was inundated between January 1 and December 31, 2023.

Habitat access (i.e., inundation) is one-third of the value, and the sum of the four PBFs is two-thirds of the value. See Attachment 1 for a more detailed description of the valuation.

4.3.1 Fully Functional

NMFS's designation of salmonid critical habitat describes which PBFs support the specific conservation roles of habitat. For estuarine and nearshore marine areas, essential PBFs of habitat for salmon include the following: 1) unobstructed rearing and migration corridors; 2) forage, including aquatic invertebrates and fish; 3) natural cover, such as SAV and large wood; and 4) water quality. General characteristics associated with fully functional habitat include a vegetated riparian buffer, no obstructions to migration, available forage/prey, presence of cover or refuge (e.g., wrack, SAV, or large wood), water filtration through the presence of riparian and intertidal sediments and vegetation, and restored natural processes. See Table 1-1 in Attachment 1 for the individual values, which are described as follows:

- **Habitat Access:** The riparian zone is valued at 0 for habitat access (i.e., no access above HAT) and 1 for all three subtidal zones (i.e., constant inundation). Using the elevation midpoint, the upper intertidal zone is inundated 40% of the tidal cycle (value of 0.40; Figure 1-1 in Attachment 1), and the lower intertidal zone is inundated 94% of the tidal cycle (value of 0.94; Figure 1-2 in Attachment 1).

- **Migration/Rearing:** The upper intertidal, lower intertidal, and shallow subtidal zones are assigned the highest value (3) for migration/rearing for Chinook salmon. The fully functional upper intertidal, lower intertidal, and shallow subtidal habitat zones are free from obstructions for migration and have off-channel areas for rearing. Higher abundances of fish have been observed in shallow nursery habitat compared to deeper elevations (Munsch et al. 2016; Chalifour et al. 2019; Toft et al. 2023). Medium value (2) is assigned to the mid-subtidal and deep subtidal zones because of the preferential use of shallow nursery habitat, and no value (0) is assigned to the riparian zone. The riparian zone does not provide migration or rearing opportunities because there is no access.
- **Forage/Prey:** The upper intertidal, lower intertidal, and shallow subtidal zones are assigned the highest value (3) for forage/prey for Chinook salmon. These zones support higher taxa richness, species diversity, and abundance (Northcote et al. 1976; Simenstad et al. 1983), and invertebrates are strongly associated with wrack, large wood, intertidal vegetation, algal growth, and forage fish spawning (Heerhartz et al. 2016; Munsch et al. 2021; Sobocinski 2003; Toft et al. 2010). The mid- and deep subtidal zones still provide some prey resources via planktonic primary and secondary production but they are overall less valuable (1) to Chinook than the shallower zones (Ehinger et al. 2023).
- **Cover:** The upper intertidal, lower intertidal, and shallow subtidal zones are assigned the highest value (3) for Chinook salmon for cover, or refuge, from piscivorous predation, albeit not always avian predation, that is provided via the shallow water migratory corridor (Willette 2001; Willette et al. 2001) and possibly wrack, and large woody material. Medium value (2) is assigned to the riparian zone providing large wood inputs through natural processes (Brennan 2007; Brennan and Culverwell 2004), and low value (1) is assigned to the mid-subtidal zone for limited cover provided by deep SAV (i.e., kelp). No value (0) is assigned to the deep subtidal zone for cover because no natural cover (i.e., SAV) is expected at these deeper elevations. The photic zone is often shallower than 10 meters (33 feet) MLLW for most vascular plant and algal species in Puget Sound (Lambert et al. 2021).
- **Water Quality:** The riparian zone is assigned the highest value (3) for water quality. Removal of contaminants is most effective through soil filtration in the riparian zone (McIntyre et al. 2015). Filtration of water through intertidal vegetation (e.g., SAV) and sediments can also benefit water quality (Fardel et al. 2020; Wang et al. 2014); therefore, medium value (2) is assigned to the upper intertidal, lower intertidal, shallow subtidal, and mid-subtidal zones for filtration through intertidal sediments and SAV. No evidence is available to support that the deep subtidal zone contributes to water quality function, so no value (0) is assigned.

Based on the evaluation described in this section, the shallow subtidal zone has the maximum habitat value given the constant availability/access to juvenile fish (migration/rearing); the high potential contribution to forage and cover; and the medium value provided for water quality through filtration with SAV (see Table 1-1 in Attachment 1).

With the highest value habitat identified, the second step was to determine the RHV for the other habitat elevations and habitat conditions. The RHV is the sum total of the PBF values and habitat accessibility for each habitat zone divided by the habitat zone with the highest value (i.e., fully functional shallow subtidal). Therefore, RHVs range from a minimum of 0 to a maximum of 1. See the example provided in Section 4.3.3.

The subsequent sections describe the rationale for the values that reflect port-specific habitat conditions along highly modified shorelines, which provide lower habitat value overall. Habitat access values for all conditions are the same as the fully functional inundation calculation described previously. Values for the PBFs were developed for each condition relative to the fully functional condition with simplifying assumptions based on the presence (degraded condition) or proximity (modified condition) of structures as well as different substrate types (fine and large; Anchor QEA 2021; Grette 2021).

4.3.2 Modified

General characteristics associated with a modified habitat condition include an urban waterfront with adjacent structures; vessel traffic; water quality impairments from multiple sources, including stormwater runoff; no functional drift cells; no functional riparian habitat; and impacted natural processes. Without active restoration, fully functional habitat does not develop within the foreseeable future (300 years). The MSP represents the modified habitat condition that is predicted to occur when port structures no longer cause migratory impacts. See Tables 1-2 and 1-3 in Attachment 1 for how the RHVs for the MSP modified habitat condition were calculated, which is described as follows:

- **Migration/Rearing:** The modified habitat condition is still artificially channelized and provides no off-channel or rearing habitat. The upper intertidal, lower intertidal, and shallow subtidal zones provide medium value (2) to Chinook salmon for migration/rearing when compared to fully functional habitat. In the MSP modified habitat condition, the port-owned infrastructure will not be present; however, other anthropogenic conditions associated with an urban waterfront will still be present and will continue to have impacts to migration and rearing. When large overwater structures are present, juvenile Chinook have been found around the edges, indicating juvenile salmon pause their migrations or congregate adjacent to overwater structures (Lambert et al. 2021). Low value (1) is assigned to the mid- and deep subtidal zones due to the limited suitable habitat to support rearing and migration, and no value (0) is assigned to the riparian zone. The riparian zone does not provide migration or rearing opportunities because there is no access.

- **Forage/Prey:** Modified habitat has no functional drift cells and little to no functional riparian habitat, so the riparian, upper intertidal, lower intertidal, and shallow subtidal zones are assigned a lower value (1 or 2) for forage/prey for Chinook salmon when compared to fully functional habitat. Fine substrate is assigned a medium value (2) because it supports more epibenthic prey for these zones compared to large substrate, which is assigned a low value (1) (Anchor QEA 2021; Toft et al. 2023). The mid- and deep subtidal zones still provide some prey resources, but they are overall less valuable to Chinook salmon than the shallower zones when compared to fully functional habitat (1 for fine substrate; 0 for large substrate; Anchor QEA 2021).
- **Cover:** Modified habitat has little to no functional riparian habitat connection and little opportunity for SAV to colonize without active restoration. SAV is limited to sparse, disconnected populations. The majority of vegetation that exists in the riparian zone consists of non-native, invasive weedy species, such as Himalayan blackberry. Therefore, the upper intertidal, lower intertidal, and shallow subtidal zones are low value (1) to Chinook salmon for cover when compared to fully functional habitat due to lack of large wood inputs from the riparian zone. No value (0) is assigned to the riparian zone based on extremely limited input of allochthonous material from the almost nonexistent native vegetation. No value (0) is assigned to the mid-subtidal and deep subtidal zones for lack of natural cover and/or SAV (i.e., kelp).
- **Water Quality:** Modified habitat has little to no functional riparian habitat and little opportunity for SAV to colonize without active restoration. SAV is limited to sparse, disconnected populations. Therefore, low value (1) is assigned to the riparian, upper intertidal, lower intertidal, and shallow subtidal zones for filtration through intertidal sediments and sparse SAV. No evidence is available that the deep subtidal zones contribute to water quality function due to the lack of SAV, so no value (0) is assigned.

4.3.3 Degraded

General characteristics associated with the degraded habitat condition (i.e., current habitat conditions) include an urban industrial working waterfront with structures; shading; vessel traffic; water quality impairments from multiple sources, including stormwater runoff; no functional drift cells; extremely limited riparian vegetation and SAV, with the majority of the related functions (e.g., forage provided by interspersed restoration islands, parks, and some mostly disconnected riparian vegetation making up a very small percentage of the shoreline); and impacted natural processes. See Tables 1-4 and 1-5 in Attachment 1 for the individual values, described as follows:

- **Migration/Rearing:** Degraded habitat includes the presence of overwater structures, armored shoreline stabilization, and vessel traffic impacting migratory corridor function. The upper intertidal, lower intertidal, shallow subtidal, mid-subtidal, and deep subtidal zones provide low value (1) to Chinook salmon for migration/rearing when compared to fully functional habitat. No value (0) is assigned to the riparian zone. The riparian area does not provide migration or rearing opportunities because there is no access.

- **Forage/Prey:** Degraded habitat has impacted sediments, no functional drift cells, and no functional riparian habitat, limiting opportunities for successful foraging (USACE 2022; Anchor QEA 2021). Therefore, no value (0) is assigned to all habitat zones for forage/prey for Chinook salmon, regardless of substrate type, compared to fully functional habitat.
- **Cover:** Degraded habitat has little to no riparian habitat connection and little to no opportunity for SAV to colonize due to shading and sparse, disconnected donor populations. Therefore, no value (0) is assigned to all habitat zones for cover for Chinook salmon, regardless of substrate type, compared to fully functional habitat.
- **Water Quality:** Degraded habitat has no functional riparian habitat and little to no opportunity for SAV to colonize. Therefore, low value (1) is assigned to the upper intertidal, lower intertidal, and shallow subtidal zones for filtration through intertidal sediments (fine substrate only; large substrate is no value). No value (0) is assigned to the riparian zone for Chinook salmon due to lack of riparian habitat to remove contaminants. No evidence is available that the lower (mid- and deep) subtidal zones contribute to water quality function without SAV, so no value (0) is assigned.

See Table 1-6 in Attachment 1 for a summary of the RHVs by habitat zone and habitat condition.

For some projects, the baseline condition (degraded) and the post-project condition (modified) have the same RHV. For example, maintaining a structure in the deep subtidal with large substrate (i.e., >20%) where there is no habitat conversion has the same baseline and post-project RHV. In those instances, the impacts to habitat from the activity do not result in an enduring effect to ESA-listed species.

4.4 Structure Degradation and Habitat Recovery Evaluation

To calculate the enduring effect of maintaining a structure in the environment, typical port structures and their likely decay without the proposed action were evaluated. The maintenance action prevents structure decay, ultimately delaying recovery of habitat function that would otherwise occur but for the maintenance. NMFS relied on the Ports' expertise to conduct an evaluation to determine the likely future habitat condition without maintenance. The Ports assembled a group of SMEs to evaluate the likely decay of structures and development of habitat in the absence of maintenance and repairs on the structures within the foreseeable future (300 years) (see Attachment 2 for SME qualifications). This evaluation used the comprehensive thought experiment described in *World Without Us* (Weisman 2007) as a framework to predict the inverse relationship between structural degradation and potential for habitat recovery. In the Port Calculator, this evaluation is referred to as the World Without Us (WWU).

Three hundred years was chosen to represent a future equilibrium state for two reasons: 1) The Port Calculator uses HEA for its integration of impacts over time. With HEA, debits and benefits do not change much after 300 years because of HEA's use of a discounting factor, and 2) engineering estimates of structural decay can be extrapolated to 300 years with moderate certainty. This evaluation focused on individual structure types, so the overarching assumption is that the surrounding area will still be a highly modified urban waterfront. Considerations included typical maintenance cycles, reviewing examples of existing port infrastructure that have not been maintained for decades, reviewing other abandoned structures, material decay curves, and typical storm cycles.

The evaluation started with a list of typical structures that are covered by the Programs, which includes several similar structures of varying durability. First, the maintenance cycle of each structure was determined by the Port of Seattle's structural engineer based on material durability and experience with schedules for routine maintenance that has been required on similar port structures. For example, a heavy industrial pier (e.g., Terminal 5) is expected to have an average maintenance cycle of 75 years, whereas a recreational marina overwater structure (e.g., Shilshole Bay Marina) is anticipated to have an average maintenance cycle of 50 years based on the known maintenance activities at Port of Seattle structures over the last 60 to 90 years.

Then, the SMEs estimated the structural loss that is likely to occur in 300 years as a percent of the fully operational condition. For example, a vertical bulkhead is expected to fail (i.e., 100% structural loss) within 300 years, regardless of material type, based on observation of bulkheads around Puget Sound. This structural loss was evaluated for each habitat zone because the structural degradation is assumed to be more significant in the habitat zones where tidal forces and wave action impact the structure. See Table 3-1 in Attachment 3 for the full structural assessment table and the supporting rationale. See the photograph log in Attachment 3 for example photographs of port infrastructure degradation over time.

Finally, the SMEs estimated the potential habitat functional recovery that is likely to occur as a result of the degradation of each structure. Each structure was evaluated as a whole, and the habitat functional recovery was assessed as a percent improvement calculated as the total value of four applicable ESA-species habitat function variables (HFVs) divided by the number of applicable HFVs. For Chinook salmon and bull trout, the four HFVs used as indicator metrics to evaluate site/structure-specific habitat gain were migration/rearing, forage/prey, cover, and water quality. For marbled murrelets, the four HFVs used as indicator metrics to evaluate site/structure-specific habitat gain were access,[4]

[4] Access is defined as open access (i.e., no obstructions) to foraging grounds for marbled murrelets.

forage/prey, water quality, and noise (piling and overwater cover only[5]). For all species, the four HFVs were given equal weighting for the percent improvement calculation.

Valuation was a binary function with a 0 assigned if no improvement was assumed and a 1 assigned if the HFV was assumed to improve as a result of structural degradation. For any structures that do not have impacts to a particular HFV when the structure is fully operational, no value was assigned, and that HFV was not included in the denominator for the percent improvement. For example, if a structure is assumed to impact all four HFVs and degradation of that structure is predicted to result in improvements to two of the four HFVs, then the resulting habitat gain would be 50%. However, if a structure is assumed to impact only three of the HFVs and degradation of that structure is predicted to result in improvements to two of the three HFVs, then the resulting habitat gain would be 66%. See Table 3-2 in Attachment 3 for the full habitat assessment table and the supporting rationale.

Structural degradation and habitat gain are related, and their quantitative relationship depends on the type of structure and its mode of degradation. The Port Calculator uses the weighted habitat improvement, which is the percent structural loss multiplied by the percent habitat gain (Table 3-3 in Attachment 3) to serve as the scaling factor for calculating the ASP. The weighted habitat improvement is then applied to determine how close the habitat gain would get to the MSP from the baseline condition. The variables and steps used for this evaluation are as follows:

1. RHV_{MSP}: Determined by expert valuation of PBFs and duration of access (see Tables 1-2 and 1-3 in Attachment 1). Habitat values are relative to the highest value fully functional habitat zone.
2. $RHV_{degraded}$: Determined by expert valuation of PBFs and duration of access (see Tables 1-4 and 1-5 in Attachment 1). Habitat values are relative to the highest value fully functional habitat zone.
3. Determination of RHV_{ASP}:
    a. Percent of structural functional loss (at 300 years as surrogate for in perpetuity; Table 3-1 in Attachment 3) determined by expert valuation.
    b. Related percent of habitat gain from structural functional loss, determined by expert valuation of each habitat function variable as improved or not (0 or 1) for each of the three considered species (Table 3-2 in Attachment 3).
    c. Multiply the percent of structural functional loss by the percent of habitat gain to determine the weighted habitat improvement (WHI).
    d. Apply the following equation: $RHV_{ASP} = (RHV_{MSP} - RHV_{degraded}) \times WHI + RHV_{degraded}$

[5] Noise was only evaluated for those structures where the enduring effect of the structure would support vessel traffic, which could generate noise that affects marbled murrelet foraging.

i. If RHV_{ASP} and $RHV_{degraded}$ are the same; there are no debits associated with an enduring effect because the area is already functioning at the ASP.

For example, the RHV for degraded fine substrate in the lower intertidal zone is 0.45; the MSP for fine substrate in the lower intertidal is 0.68; the delta between these two represents the maximum habitat function that is precluded by performing the maintenance activity (0.68 - 0.45). The percent habitat improvement anticipated for Chinook salmon/bull trout for structural degradation of a heavy-duty overwater pier/ramp/float is 75%; this percentage is multiplied by the delta between the MSP and degraded condition: (e.g., [0.68 - 0.45] × 0.75). This represents the actual habitat functional gain predicted from this specific structure's degradation. Finally, the product is then added to the degraded condition (e.g., [0.68 - 0.45] × 0.75 + 0.45) to calculate the ASP; therefore, the ASP is 0.62.

4.5 Climate Change

The Ports will have to adapt their approach to maintenance and repair activities in response to climate change. Climate change will be taken into consideration in several ways when using the Port Calculator. Maintenance cycles, as well as the types of materials used, could be influenced by climate change. If more robust materials are used in response to climate change, the maintenance cycle may be longer, thus increasing the impact of the enduring effect. Additionally, sea level rise could influence how structures are replaced. In some instances, structures could be built higher or landward, and the Port Calculator will evaluate the impact of these structural alterations. Shoreline armoring that has to be installed higher on the slope in response to sea level rise will also be captured in the Port Calculator because the affected area will be greater as a result.

4.6 Creosote Removal

For simplicity, the Port Calculator's creosote removal approach is identical to the PSNHC Calculator.

4.7 Dredging Projects

Dredging projects have unique impacts compared to other structures that required a few special considerations for the Port Calculator. First, as demonstrated by other dredging projects, the duration of impact for dredging impacts is temporary (up to 1 year) in nature. For example, Guerra-Garcia et al. 2003 found the benthic community similar to an undisturbed area re-established within approximately 6 months, and Loia et al. 2020 found that benthic abundance and species richness were in a recovery and advanced recolonization condition within 9 months of dredging. Therefore, dredging impacts are quantified over 1 year instead of over the maintenance cycle, as with all other structure types.

Second, there needed to be a procedure to determine whether dredging impacts were limited to enduring effects or whether they were considered to be an expansion impact. Maintenance dredging areas that will not result in a habitat conversion (i.e., depth stays within the same habitat zone) are considered an enduring effect. In the absence of empirical data demonstrating a significant change in habitat function across a specific depth change, SMEs determined that a depth change of more than 10 feet coupled with habitat conversion is significant enough to be classified as an expansion. Therefore, if maintenance dredging results in a habitat conversion and the change in depth is greater than 10 feet, the impact is multiplied by a factor of two (consistent with the PSNHC Calculator for expansion activities). If maintenance dredging results in a habitat conversion and the change in depth is less than 10 feet, the impact is multiplied by a factor of one because there is not a significant change in habitat function. New dredging (i.e., not previously dredged) is considered an expansion, and DSAYs are multiplied by a factor of two (consistent with the PSNHC Calculator for expansion activities).

The following are baseline assumptions for Port Calculator dredge inputs:

- Maintenance dredging areas baseline habitat condition is degraded.
- New dredging areas (i.e., expansion) baseline habitat condition is modified.
- If SAV is present, then the SAV footprint (acres) baseline habitat condition is fully functional and the remaining portion of the dredging footprint is modified.
- If there is no SAV present and the project converts lower intertidal to shallow subtidal, no impact is assessed because shallow subtidal has a higher RHV due to being fully inundated at all times.

5 Adaptive Management

The Port Calculator will be updated as new science and approaches become available. For example, the Port Calculator uses the adjustment factors and creosote removal benefit determinations developed by the Services for the Nearshore Calculator. Updates to these aspects of the Nearshore Calculator will also apply to the Port Calculator. If new research demonstrates that the Chinook salmon PBFs are not considered protective of marbled murrelets, the Port Calculator can be updated at the request of USFWS. Other updates will be discussed in annual meetings. This initial Port Calculator is set to address all of the known habitat types, conditions, and structures for the Ports. New values will be added to the RHV table as the need arises in a future version as part of adaptive management. Updates to the Port Calculator will have the approval of the Services prior to being implemented.

6 Summary

The Port Calculator was developed in close collaboration with NMFS and USFWS to optimize application of this alternative calculator for port-specific infrastructure. Every effort was made to be consistent with the PSNHC Calculator while acknowledging and addressing the PSNHC Calculator elements not applicable to port structures. This document represents rationale for the initial Port Calculator, and it is anticipated that small updates will be made every 1 to 2 years as the calculator is applied to projects, additional needs are identified, and new science become available, similar to the PSNHC Calculator. These updates will be made in consultation with NMFS and USFWS.

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Attachment 1

Relative Habitat Value Determination

Relative Habitat Value Determination

The following figures and tables illustrate the detailed methodology to determine the RHVs that are used in the Port Calculator. For habitat access, the NOAA Inundation Analysis Tool page (NOAA 2024) was used to determine the percent annual inundation above a chosen datum. The Port Calculator used Station 9447130 for Seattle as a representative station for both Ports. We selected data for 2023 at the highest offered temporal resolution: 6-minute Height and High Water Analysis.

For inundation in the upper intertidal zone, we took the average of the highest elevation in Elliott Bay for this zone (HAT; +13.3 feet MLLW) and the lowest elevation (+4 feet MLLW), which is +8.65 feet MLLW to represent the elevation where 50% of the zone would be inundated for value determination (Figure 1-1). In Commencement Bay, the HAT is +13.7 feet MLLW; however, when calculating the average percent of inundation, there is no appreciable difference between the two locations. Therefore, the Port Calculator uses elevations from Elliott Bay. For inundation in the lower intertidal zone, we took the average of the highest elevation for this zone (+4 feet MLLW) and the lowest elevation (-4 feet MLLW), which is +0 feet MLLW, to represent the elevation where 50% of the zone would be inundated for value determination (Figure 1-2).

Figure 1-1
Inundation for Upper Intertidal Zone

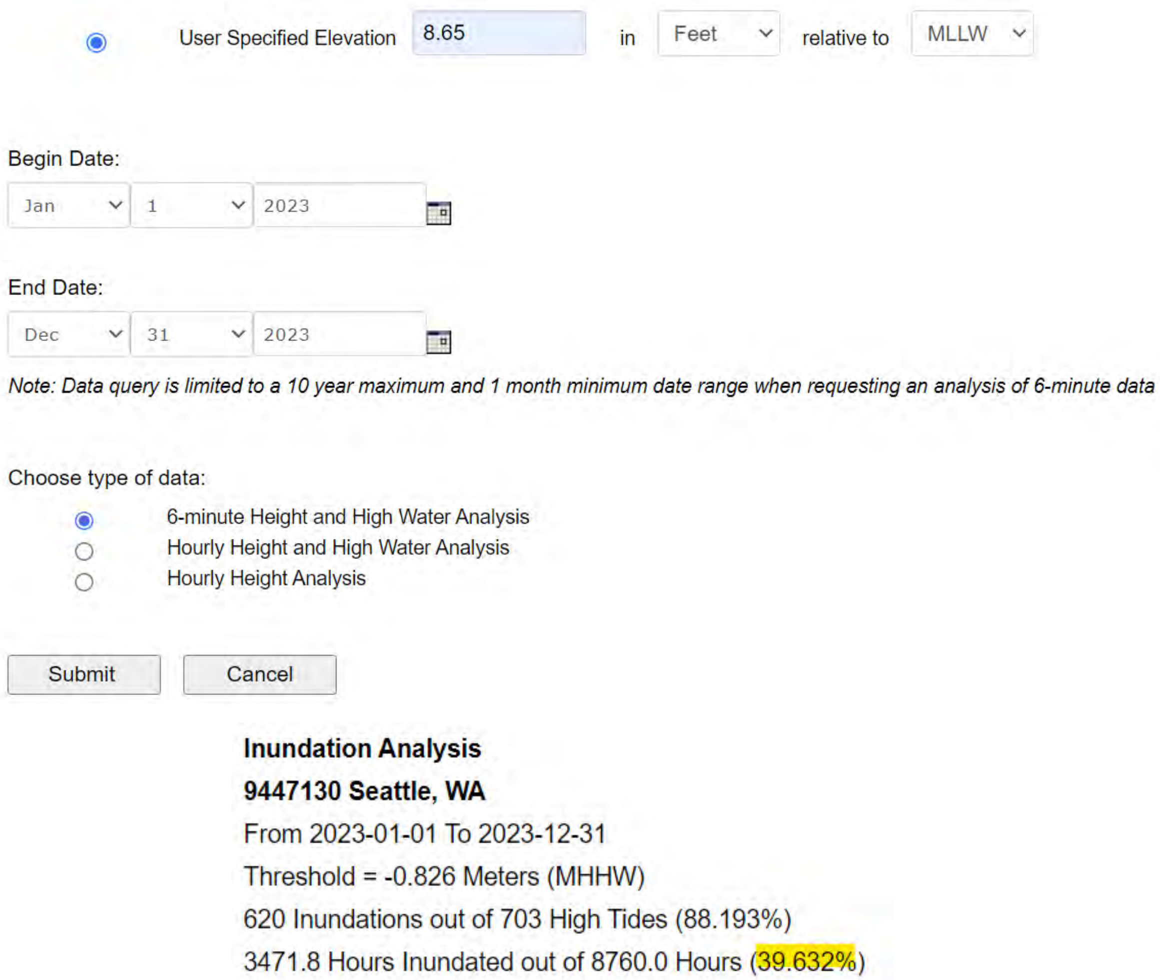
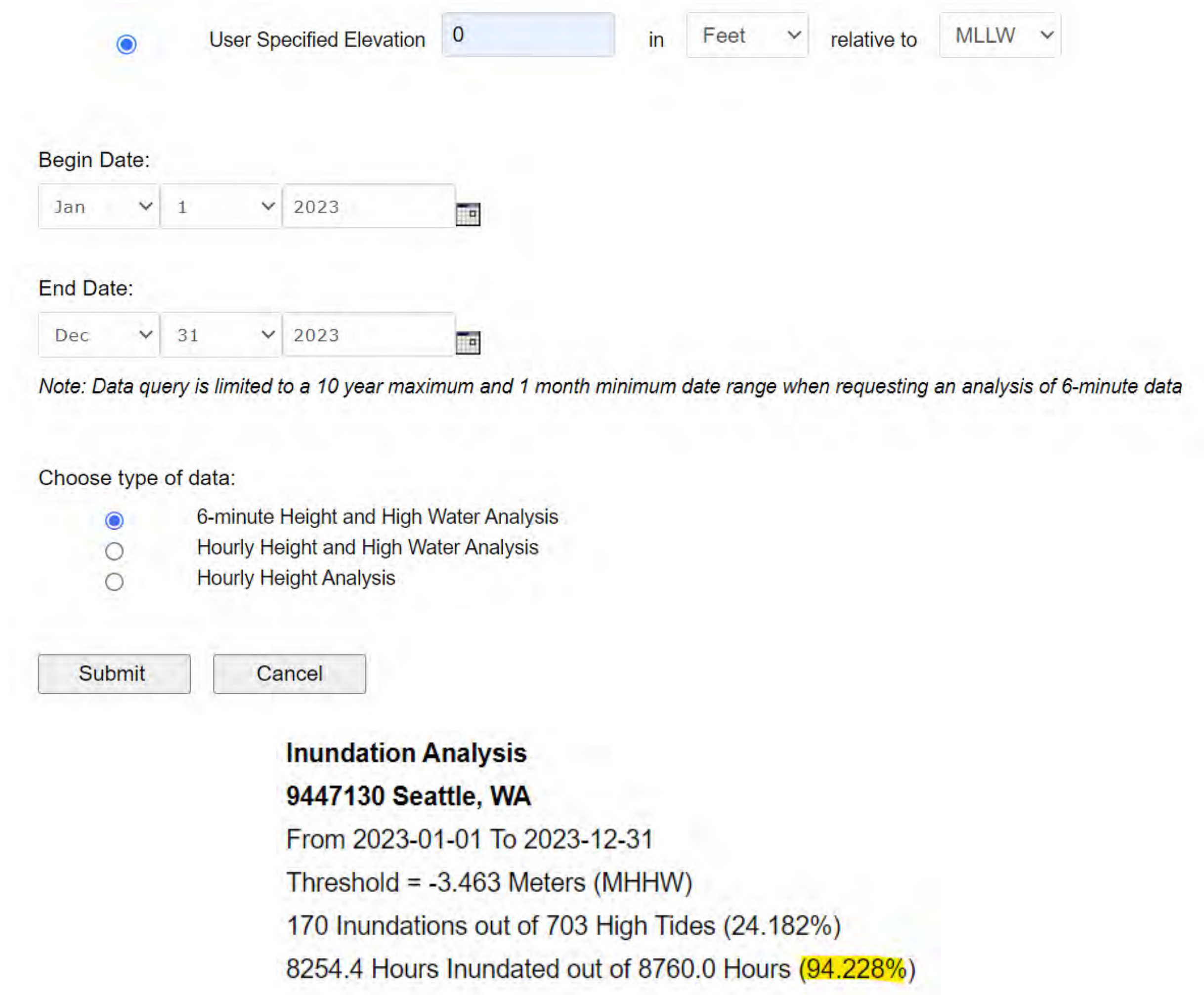


Figure 1-2
Inundation for Lower Intertidal Zone



The following five tables show the numerical values assigned to derive the RHVs for each habitat zone and habitat condition. Starting with the fully functional habitat condition, duration of access (i.e., inundation) and the relevant PBFs for Chinook salmon were evaluated. Duration of access (i.e., inundation) was given the most weight and assigned a point value from 0 to 1 to represent the proportion of time over a tidal cycle that fish can access the elevation zone. For the four remaining PBFs, each feature was assigned a point value from 0 to 3 points based on the expert-informed ranking of no/low/medium/high value. In this way, up to 1 point was based on access, and up to 12 points total were based on zone-specific maximum potential contributions to the four PBFs. To be consistent with the PSNHC Calculator, the sum is weighted so that access is one-third of the total and the PBFs are two-thirds of the total (i.e., the sum total of the PBFs was divided by six). The fully functional shallow subtidal habitat zone (highlighted in Table 1-1) has the highest value of all the habitat zones; therefore, the fully functional shallow subtidal habitat zone has an RHV of 1.00. All the other habitat zone sum values for each habitat condition and substrate type are divided by the fully functional shallow subtidal sum to calculate their respective RHVs. All numerical values are summarized for the three species in Table 1-6.

Table 1-1
Fully Functional Habitat Valuation

Habitat Zone	Access	Chinook PBF Point Values				Sum	RHV
		Migration/ Rearing	Forage/ Prey	Cover	Water Quality		
Riparian	0	0	2	2	3	1.17	0.41
Upper Intertidal	0.4	3	3	3	2	2.23	0.79
Lower Intertidal	0.94	3	3	3	2	2.77	0.98
Shallow Subtidal	1	3	3	3	2	2.83	1.00
Mid-Subtidal	1	2	1	1	1	1.83	0.65
Deep Subtidal	1	2	1	0	0	1.50	0.53

Note:
Using the values assigned, the maximum habitat value was 2.83 for the shallow subtidal fully functional condition. This is considered the 1.0 RHV, and all other values were divided by 2.83 to determine the RHV.

Table 1-2
Modified Fine Substrate Habitat Valuation

Habitat Zone	Access	Chinook PBF Point Values				Sum	RHV
		Migration/ Rearing	Forage/ Prey	Cover	Water Quality		
Riparian	0	0	1	0	1	0.33	0.12
Upper Intertidal	0.4	2	2	1	1	1.40	0.49
Lower Intertidal	0.94	2	2	1	1	1.94	0.68
Shallow Subtidal	1	2	2	1	1	2.00	0.71
Mid-Subtidal	1	1	1	0	0	1.33	0.47
Deep Subtidal	1	1	1	0	0	1.33	0.47

Note:
These RHVs are relative to the shallow subtidal fully functional condition.

Table 1-3
Modified Large Substrate Habitat Valuation

Habitat Zone	Access	Chinook PBF Point Values				Sum	RHV
		Migration/ Rearing	Forage/ Prey	Cover	Water Quality		
Riparian	0	0	1	0	1	0.33	0.12
Upper Intertidal	0.4	2	1	1	1	1.23	0.44
Lower Intertidal	0.94	2	1	1	1	1.77	0.63
Shallow Subtidal	1	2	1	1	1	1.83	0.65
Mid-Subtidal	1	1	0	0	0	1.17	0.41
Deep Subtidal	1	1	0	0	0	1.17	0.41

Note:
These RHVs are relative to the shallow subtidal fully functional condition.

Table 1-4
Degraded Fine Substrate Habitat Valuation

Habitat Zone	Access	Chinook PBF Point Values				Sum	RHV
		Migration/ Rearing	Forage/ Prey	Cover	Water Quality		
Riparian	0	0	0	0	0	0.00	0.00
Upper Intertidal	0.4	1	0	0	1	0.73	0.26
Lower Intertidal	0.94	1	0	0	1	1.27	0.45
Shallow Subtidal	1	1	0	0	1	1.33	0.47
Mid-Subtidal	1	1	0	0	0	1.17	0.41
Deep Subtidal	1	1	0	0	0	1.17	0.41

Note:
These RHVs are relative to the shallow subtidal fully functional condition.

Table 1-5
Degraded Large Substrate Habitat Valuation

Habitat Zone	Access	Chinook PBF Point Values				Sum	RHV
		Migration/ Rearing	Forage/ Prey	Cover	Water Quality		
Riparian	0	0	0	0	0	0.00	0.00
Upper Intertidal	0.4	1	0	0	0	0.57	0.20
Lower Intertidal	0.94	1	0	0	0	1.11	0.39
Shallow Subtidal	1	1	0	0	0	1.17	0.41
Mid-Subtidal	1	1	0	0	0	1.17	0.41
Deep Subtidal	1	1	0	0	0	1.17	0.41

Note:
These RHVs are relative to the shallow subtidal fully functional condition.

Table 1-6
Summary of Relative Habitat Values by Habitat Zone

Habitat Zone	Habitat Condition	Habitat Substrate[1]	Chinook Salmon	Bull Trout[2]	Marbled Murrelet[2]
Riparian Zone/Uplands (50 feet landward of HAT)	Fully Functional	Vegetated buffer (native)	0.41	0.41	0.41
	Modified	Sparse, non-native vegetation	0.12	0.12	0.12
	Modified	Large substrate	0.12	0.12	0.12
	Modified	Pavement[3]	0.12	0.12	0.12
	Degraded	Large substrate	0	0	0
	Degraded	Pavement	0	0	0
Upper Intertidal (HAT to +4 feet MLLW)	Fully Functional	Vegetated (i.e., marsh)	0.79	0.79	0.79
	Modified	Fine substrate	0.49	0.49	0.49
	Modified	Large substrate	0.44	0.44	0.44
	Degraded	Fine substrate	0.26	0.26	0.26
	Degraded	Large substrate	0.20	0.20	0.20
Lower Intertidal (+4 feet to -4 feet MLLW)	Fully Functional	Vegetated (i.e., SAV)	0.98	0.98	0.98
	Modified	Fine substrate	0.68	0.68	0.68
	Modified	Large substrate	0.63	0.63	0.63
	Degraded	Fine substrate	0.45	0.45	0.45
	Degraded	Large substrate	0.39	0.39	0.39

Habitat Zone	Habitat Condition	Habitat Substrate[1]	Chinook Salmon	Bull Trout[2]	Marbled Murrelet[2]
Shallow Subtidal (-4 feet MLLW to -14 feet MLLW)	Fully Functional	Vegetated (i.e., SAV)	1	1	1
	Modified	Fine substrate	0.71	0.71	0.71
	Modified	Large substrate	0.65	0.65	0.65
	Degraded	Fine substrate	0.47	0.47	0.47
	Degraded	Large substrate	0.41	0.41	0.41
Mid-Subtidal (-14 feet MLLW to -33 feet MLLW)	Fully Functional	Vegetated (i.e., SAV)	0.65	0.65	0.65
	Modified	Fine substrate	0.47	0.47	0.47
	Modified	Large substrate	0.41	0.41	0.41
	Degraded	Fine substrate	0.41	0.41	0.41
	Degraded	Large substrate	0.41	0.41	0.41
Deep Subtidal (> -33 feet MLLW)	Fully Functional	Fine substrate	0.53	0.53	0.53
	Modified	Fine substrate	0.47	0.47	0.47
	Modified	Large substrate	0.41	0.41	0.41
	Degraded	Fine substrate	0.41	0.41	0.41
	Degraded	Large substrate	0.41	0.41	0.41

Notes:

1. Fine substrate is defined as sand/silt with less than 20% rock; large substrate is defined as greater than 20% rock.
2. RHVs for bull trout and marbled murrelet are the same as Chinook salmon for the purposes of this Port Calculator. See main text for description.

The pavement category was included to account for a future condition (i.e., affected area slope layback). User would enter baseline and post-project conditions as “pavement” and “modified,” which has the same RHVs as sparse, non-native vegetation.

Attachment 2

Subject Matter Expert Qualifications

Subject Matter Expert Qualifications

The following experts were assembled to conduct the WWU evaluation requested by NMFS to estimate the likely equilibrium habitat condition that would occur if each structure were left to degrade through natural forces with no further maintenance. This evaluation was a novel approach to allow for quantification of the DSAYs attributed specifically to the enduring effect of maintaining the structure. Due to the lack of applicable quantitative information or peer-reviewed literature, the conclusions and outputs from the evaluation rely heavily on expert opinion from decades of experience and available qualitative information/anecdotal evidence.

Jon Sloan leads the environmental permitting, planning and compliance group for the Maritime Division of the Port of Seattle. His work includes securing regulatory approvals and entitlements for the seaport's capital program as well as management of the Port of Seattle's Umbrella Mitigation Bank. Prior to his work with the Port of Seattle, Jon led project teams as a senior scientist with Atkins Engineering, senior ecologist with King County (Washington), and habitat biologist with the Suquamish Indian Tribe. He has a biology degree from University of Central Florida and over 72 credit hours in graduate coursework at University of Washington, Imperial College London, and Portland State University.

Perry Welch, PE, is a registered professional engineer in Washington and California with more than 17 years of experience in structural engineering. He is a senior manager in the Structural/Architectural Design Services group at the Port of Seattle. He has provided consultant design services for new construction, renovations, and incident responses on residential, commercial, education, aviation, and maritime projects. He has worked on projects all over the United States and internationally. His experience includes code compliance with the International Building Code, existing facility evaluations and seismic upgrades per American Society of Civil Engineers 31/41, condition assessments of waterfront facilities, and peer design reviews.

George Blomberg is an ecologist with the Port of Seattle Maritime Environment and Sustainability division with more than 40 years of experience preparing shoreline, marine industrial, and harbor area facility plans and environmental analyses and evaluations as well as in the implementation of shoreline and marine industrial facility improvements, including city, state, and federal approvals. His work also includes extensive experience with design and construction of environmental remediation and restoration actions at port facilities. He has a zoology degree from the University of California, Berkeley and a Master of Science from the School of Marine Affairs at the University of Washington.

Jenn Stebbings is an environmental program manager and biologist with the Port of Seattle Maritime Environment and Sustainability division with more than 20 years of experience in the Pacific Northwest, primarily in habitat restoration ecology, including project design, construction, and monitoring; environmental permitting; and regulatory compliance. Her work includes a broad range of avian, terrestrial, aquatic, and semiaquatic species as well as projects ranging from forest resource management to high-voltage transmission linear construction to dam removal. For the past 12 years, she has focused on habitat, water quality, and large capital projects in the highly urbanized maritime environments of Commencement Bay and Elliott Bay, and she has worked to promote salmon recovery in the Puyallup-White and Green-Duwamish watersheds. She has a Bachelor of Science degree in forest resources with a major in wildlife science from the University of Washington's College of Forest Resources (now named the School of Environmental and Forest Sciences).

John Laplante, PE, PEng, ENV SP, is a registered professional engineer at Anchor QEA with more than 25 years of experience in geotechnical and environmental engineering, providing services as a design and field engineer, construction inspector, and project manager for a variety of sediment cleanup and restoration projects in Puget Sound and nationwide. He has a Master of Engineering in civil engineering with a focus on geotechnical engineering from the Massachusetts Institute of Technology. John has experience developing and implementing geotechnical and environmental field investigations and environmentally critical areas review; preparing feasibility and design studies; developing and reviewing plans and specifications; estimating construction costs; and providing technical oversight throughout construction. His experience includes extensive geotechnical engineering for breakwaters, revetments, coastal groins, dredging, living shorelines, marsh restoration, demolition, structure foundations, pedestrian and vehicle trails, culvert and stream crossings, bridge foundations, earthwork, docks, shoreline slope stability, and seismic design.

Michelle Havey is a fisheries biologist at Anchor QEA with more than 20 years of experience in salmon ecology, ecosystem monitoring, habitat assessment, and behavioral science in the Pacific Northwest and Alaska. She has a Bachelor of Science and Master of Science from the School of Aquatic and Fishery Sciences at the University of Washington. Her work includes leading natural resource investigations and permitting projects, extensive field research on anadromous fish populations, fishery baseline studies in remote areas, habitat restoration, and agency engagement with the Washington State Department of Ecology, the Washington Department of Fish and Wildlife, the U.S. Army Corps of Engineers, NMFS, and USFWS. She has developed numerous functional assessments and HEA models to identify project impacts and develop mitigation options to offset those impacts. Her experience includes technical oversight for numerous SSNP permitting projects, estimating mitigation bank site credits for the Ports of Seattle and Tacoma, habitat restoration planning for the Port of Seattle, and natural resource damage assessments.

Attachment 3
Structural Decay and Habitat Recovery Evaluation for Actual Site Potential Factor

Table 3-1 Step 1: Structural Assessment

Table 3-2 Step 2: Habitat Assessment

Table 3-3 Actual Site Potential Factor Output for Port Calculator

Port Structures Photograph Log

Table 3-1
Step 1: Structural Assessment

Structure	Elevation Habitat Zone	Structural Assessment				
		Structure Type (Light, Medium, Heavy)	Primary Material (Timber, Steel, Concrete, Rock, Asphalt, Concrete)	Maintenance Cycle (i.e., Years Functional Without Maintenance)	% of Structural Functional Loss (at 300 Years as Surrogate for In Perpetuity)	Structural Degradation Rationale
Rubble-Strewn Slope	Riparian	Medium	Unconsolidated materials	15	100%	Mixture of sizes, including some pieces that are so large that they will continue to reinforce the slope even after 300 years. However, the nature of the armor, which can be random, is less durable than engineered armor rock. Structural degradation is assumed to be more significant in the zones where tidal forces and wave action would be impacting the structure (i.e., intertidal zones). See examples of structural degradation in the photograph log.
	Upper IT			50	50%	
	Lower IT					
	Shallow ST				25%	
	Mid-ST				--	
	Deep ST				--	
Conventional Armored Slope	Riparian	Heavy (e.g., avg rock diameter = 36 inches 2,000–4,000-pound rock; cargo terminal)	Rock	15	100%	Engineered structure, so more durable than rubble-strewn slope and would maintains more structural function over the 300-year period. Examples for Port of Seattle include heavy/large granite riprap, which is very durable and not expected to significantly degrade over the long term. Structural degradation is assumed to be more significant in the zones where tidal forces and wave action would be impacting the structure (i.e., intertidal zones). See examples of structural degradation in the photograph log.
	Upper IT			75	40%	
	Lower IT					
	Shallow ST				30%	
	Mid-ST				20%	
	Deep ST				10%	
Conventional Armored Slope	Riparian	Light (e.g., average rock diameter = 12 inches 500–1,000-pound rock; volleyball size)	Rock	15	100%	Engineered structure, but with smaller materials rock than heavy armor that will be less resistant more susceptible to long-term movement mobilization (i.e., functional degradation) compared to the heavy armored slope. Structural degradation is assumed to be more significant in the zones where tidal forces and wave action would be impacting the structure (i.e., intertidal zones). See examples of structural degradation in the photograph log.
	Upper IT			50	100%	
	Lower IT					
	Shallow ST			75		
	Mid-ST				--	
	Deep ST				--	
Bulkhead (at top of slope and at bottom) and Conventional Armored Slope	Riparian	Heavy	Concrete, steel, or timber bulkhead/rock armor	50	100%	Vertical bulkheads are generally created using steel and wood, which degrade over time in the marine environment. The slope in between below top-of-bank would be armored with rock, which is a robust natural material (as opposed to a human-made material) that does not degrade during that same time frame as the bulkhead. See discussion for rubble-strewn slope. See examples of structural degradation in the photograph log.
	Upper IT				50%	
	Lower IT			75		
	Shallow ST			100	25%	
	Mid-ST				100%	
	Deep ST			75		
Bulkhead, Toewall, and Conventional Armored Slope	Riparian	Heavy	Rock, concrete, steel, possibly timber piles	50	100%	Vertical bulkheads are generally created using steel and wood, which degrade over time in the marine environment. The slope in between top-of-bank and toe-of-slope would be armored with rock, which is a robust natural material (as opposed to a human-made material) that does not degrade during that same time frame. See discussion for rubble-strewn slope. See examples of structural degradation in the photograph log.
	Upper IT				50%	
	Lower IT			75		
	Shallow ST			100	25%	
	Mid-ST				100%	
	Deep ST			75		

Structure	Elevation Habitat Zone	Structural Assessment: Structure Type (Light, Medium, Heavy)	Primary Material (Timber, Steel, Concrete, Rock, Asphalt, Concrete)	Maintenance Cycle (i.e., Years Functional Without Maintenance)	% of Structural Functional Loss (at 300 Years as Surrogate for In Perpetuity)	Structural Degradation Rationale
Vertical Bulkhead	Riparian	Heavy	Concrete, steel or timber	50	100%	Vertical bulkheads are generally created using steel and wood, which degrade over time in the marine environment. Expected to have total structural functional loss at 300 years. When maintenance of the bulkhead is preventing contamination from entering the marine environment, the maintenance is being protective of the environment and the Port Calculator will not be used to determine impacts. See examples of structural degradation in the photograph log.
	Upper IT			75		
	Lower IT					
	Shallow ST					
	Mid-ST			100		
	Deep ST					
Dredged Berth: Shallow depth<-14 feet MLLW (recreational marina)		Light	Fine-grain substrate	30	100%	Sediment deposition rates result in a full loss of function as a berth with accumulation at 300 years. Though deposition has not been shown to be uniform, full complete structural functional loss is being applied as a conservative measure in this evaluation. Berthing for different vessels could still be accommodated, but not for the originally intended design vessel. When maintenance of dredged berths removes contamination and debris from the marine environment (e.g., upland disposal instead of open-water disposal), the maintenance is being protective of the environment and the Port Calculator will not be used to determine enduring effects.
	Lower IT					
	Shallow ST					
Dredged Berth: Mid depth -15 feet MLLW to -33 feet MLLW (barge moorage, fish processor, cruise ship)		Medium	Fine-grain substrate	15	100%	Sediment deposition rates result in a full loss of function as a berth with accumulation at 300 years. Though deposition has not been shown to be uniform, full complete structural functional loss is being applied as a conservative measure in this evaluation. Berthing for different vessels could still be accommodated, but not for the originally intended design vessel. When maintenance of dredged berths removes contamination and debris from the marine environment (e.g., upland disposal instead of open-water disposal), the maintenance is being protective of the environment and the Port Calculator will not be used to determine enduring effects.
	Mid-ST					
Dredged Berth: Deep depth >-33 feet MLLW (cargo, grain)		Heavy	Fine-grain substrate	15	100%	Sediment deposition rates result in a full loss of function as a berth with accumulation at 300 years. Though deposition has not been shown to be uniform, full complete structural functional loss is being applied as a conservative measure in this evaluation. Berthing for different vessels could still be accommodated, but not for the originally intended design vessel. When maintenance of dredged berths removes contamination and debris from the marine environment (e.g., upland disposal instead of open-water disposal), the maintenance is being protective of the environment and the Port Calculator will not be used to determine enduring effects.
	Deep ST					
Piles – Timber (wrapped or ACZA-treated preserved; mostly fender piles)	Riparian	Light	Timber	25	--	Timber piles degrade over time in the marine environment. Expected to have total structural functional loss at 300 years. See examples of structural degradation in the photograph log.
	Upper IT				100%	
	Lower IT					
	Shallow ST					
	Mid-ST					
	Deep ST					

Structure	Elevation Habitat Zone	Structural Assessment				
		Structure Type (Light, Medium, Heavy)	Primary Material (Timber, Steel, Concrete, Rock, Asphalt, Concrete)	Maintenance Cycle (i.e., Years Functional Without Maintenance)	% of Structural Functional Loss (at 300 Years as Surrogate for In Perpetuity)	Structural Degradation Rationale
Piles – Steel	Riparian	Medium	Steel	50	--	Steel pilings piles degrade over time in the marine environment. Expected to have total structural functional loss at 300 years. See examples of structural degradation in the photograph log.
	Upper IT				100%	
	Lower IT					
	Shallow ST					
	Mid-ST					
	Deep ST					
Piles – Concrete	Riparian	Heavy	Concrete	100	--	Concrete pilings piles degrade over time in the marine environment. Expected to have total structural functional loss at 300 years. See examples of structural degradation in the photograph log.
	Upper IT				100%	
	Lower IT					
	Shallow ST					
	Mid-ST					
	Deep ST					
Stormwater Outfalls	Riparian	Medium	Steel or concrete	50	50%	Although the materials will likely degrade in their entirety, there are likely still to be voids where the outfall was located that still provides some of the drainage functions that the fully maintained outfall would have provided. When the outfall has end-of-pipe stormwater treatment, maintenance of the outfall is preventing untreated stormwater from entering the marine environment. In these instances, no mitigation would be required because the maintenance is being protective of the environment and the Port Calculator will not be used to determine impacts. See examples of structural degradation in the photograph log.
	Upper IT					
	Lower IT					
	Shallow ST					
	Mid-ST					
	Deep ST					
Overwater Cover: Heavy Industrial Pier (cargo/cruise/commercial/fishing fleet)	Riparian	Heavy	Concrete/asphalt	75	--	Overwater decking is created using concrete and wood, which degrade over time due to weathering, surface, and proximity to the marine aquatic environment. Expected to have total structural functional loss at 300 years; however, materials will remain in the environment. See examples of structural degradation in the photograph log.
	Upper IT				100%	
	Lower IT					
	Shallow ST					
	Mid-ST					
	Deep ST					
Overwater Cover: Medium Public Access (viewpoint pier, T-pier catwalk-type structure)	Riparian	Medium	Concrete, steel, timber	75	--	Overwater decking is created using concrete and wood, which degrade over time due to weathering, surface, and proximity to the marine aquatic environment. Expected to have total structural functional loss at 300 years; however, materials will remain in the environment. See examples of structural degradation in the photograph log.
	Upper IT				100%	
	Lower IT					
	Shallow ST					
	Mid-ST					
	Deep ST				--	

Structure	Elevation Habitat Zone	Structural Assessment				
		Structure Type (Light, Medium, Heavy)	Primary Material (Timber, Steel, Concrete, Rock, Asphalt, Concrete)	Maintenance Cycle (i.e., Years Functional Without Maintenance)	% of Structural Functional Loss (at 300 Years as Surrogate for In Perpetuity)	Structural Degradation Rationale
Overwater Cover: Light Pier/Ramp/Float (recreational marina)	Riparian	Light	Concrete, steel	50	--	Overwater decking is created using concrete and wood, which degrade over time due to weathering, surface, and proximity to the marine environment. Expected to have total functional loss at 300 years; however, materials will remain in the environment. See examples of structural degradation in the photograph log.
	Upper IT				100%	
	Lower IT					
	Shallow ST					
	Mid-ST					
	Deep ST				--	
Upland Impervious Surface: Concrete or Asphalt or Compacted Gravel (container cargo yard)	Riparian	Heavy	Concrete or asphalt	15	100%	Without maintenance, natural weathering of these materials provides voids that precludes the originally designed function of the structure type.
Upland Impervious Surface: Concrete or Asphalt or Compacted Gravel (parking lot at marina)	Riparian	Medium	Concrete or asphalt	15	100%	Without maintenance, natural weathering of these materials provides voids that precludes the originally designed function of the structure type.
Upland Pervious Surface: Unimproved (gravel, turf, or similar)	Riparian	Light	Gravel, turf, industrial fill, or similar	15	100%	Without maintenance, natural weathering of these materials provides voids that precludes the originally designed function of the structure type.
Upland Impervious Surface: Building	Riparian	Heavy	Concrete, steel, timber	75	100%	Without maintenance, natural weathering of these materials provides voids that precludes the originally designed function of the structure type.

Notes:
Calculated percent improvement assumed at 300 years without maintenance of the structure. Value used in the calculator to calculate the ASP (i.e., X% of the delta between the baseline condition and MSP).
--: not a relevant habitat zone for the structure
ACZA: ammoniacal copper zinc arsenate
ASP: actual site potential
IT: intertidal
MLLW: mean lower low water
MSP: maximum site potential
ST: subtidal

Table 3-2
World Without Us Step 2: Habitat Assessment

Structure	Habitat Assessment										
	Chinook Salmon/Bull Trout Habitat Function Variables[2]				Chinook Salmon/Bull Trout % Habitat Gain[2]	MAMU Function Variables[1]				MAMU % Habitat Gain[2]	Habitat Function Rationale
	Migration/ Rearing	Forage/ Prey	Cover	Water Quality		Access	Forage/ Prey	Water Quality	Noise		
Rubble-Strewn Slope	--	0	--	0.5	25%	--	0	0.5	--	25%	• Slumping of rubble opens up migratory corridor function and access by flattening the slope and opens up interstitial spaces and allows fine sediment to deposit, which can be colonized by epibenthic prey and improves access to forage/prey. • No improvements to cover or water quality are provided specifically by the degradation of the structure. • No impacts to migratory corridor function or access with this structure type, so no value assigned for this HFV. • For MAMU, no noise-related impacts associated with this structure type (i.e., no vessel traffic supported), so no value assigned for this HFV.
	1	1	0	0	50%	1	1	0	--	67%	
Conventional Armored Slope – Heavy	--	0	--	0.25	13%	--	0	0.25	--	13%	• Slumping of armored sloped opens up migratory corridor function and access by flattening the slope and opens up interstitial spaces and allows fine sediment to deposit, which can be colonized by epibenthic prey and improves access to forage/prey. • No improvements to cover or water quality are provided specifically by the degradation of the structure. • No impacts to migratory corridor function or access with this structure type, so no value assigned for this HFV. • For MAMU, no noise-related impacts associated with this structure type (i.e., no vessel traffic supported), so no value assigned for this HFV.
	1	1	0	0	50%	1	1	0	--	67%	
Conventional Armored Slope – Light	--	1	--	1	100%	--	1	1	--	100%	• Slumping of armored sloped opens up migratory corridor function and access by flattening the slope and opens up interstitial spaces and allows fine sediment to deposit, which can be colonized by epibenthic prey and improves access to forage/prey. • No improvements to cover or water quality are provided specifically by the degradation of the structure. • No impacts to migratory corridor function or access with this structure type, so no value assigned for this HFV. • For MAMU, no noise-related impacts associated with this structure type (i.e., no vessel traffic supported), so no value assigned for this HFV.
	1	1	0	0	50%	1	1	0	--	67%	
Bulkhead (at top of slope and at bottom) and Conventional Armored Slope	1	1	0	0	50%	1	1	0	--	67%	• No habitat function until structure has a catastrophic failure. Failure of bulkhead opens up more migratory habitat behind the bulkhead and soil material from behind the bulkhead becomes substrate for colonization by epibenthic prey. • No beneficial improvements to cover or water quality are provided specifically by the degradation of the structure.

Structure	Habitat Assessment										
	Chinook Salmon/Bull Trout Habitat Function Variables[2]				Chinook Salmon/Bull Trout % Habitat Gain[2]	MAMU Function Variables[1]				MAMU % Habitat Gain[2]	Habitat Function Rationale
	Migration/ Rearing	Forage/ Prey	Cover	Water Quality		Access	Forage/ Prey	Water Quality	Noise		
Bulkhead, Toewall, and Conventional Armored Slope	1	1	0	0	50%	1	1	0	--	67%	• No habitat function until structure has a catastrophic failure. Failure of bulkhead opens up more migratory habitat behind the bulkhead and soil material from behind the bulkhead becomes substrate for colonization by epibenthic prey. • No beneficial improvements to cover or water quality are provided specifically by the degradation of the structure.
Vertical Bulkhead	1	1	0	0	50%	1	1	0	--	67%	• No habitat function until structure has a catastrophic failure. Failure of bulkhead opens up more migratory habitat behind the bulkhead and soil material from behind the bulkhead becomes substrate for colonization by epibenthic prey. • No beneficial improvements to cover or water quality are provided specifically by the degradation of the structure.
Dredged Berth: Shallow depth <-14 MLLW (recreational marina)	--	1	1	1	100%	--	1	1	--	100%	• Forage/prey colonization, potential for SAV establishment and recruitment of any wood from adjacent vegetated riparian areas, and any water quality benefits improvements from intertidal sediments re-establish within a short time period and therefore do not constitute an enduring effect. • No impacts to migratory corridor function or access with this structure type, so no value assigned for this HFV. • For MAMU, no noise-related impacts associated with this structure type (i.e., no vessel traffic supported), so no value assigned for this HFV.
Dredged Berth: Medium depth - 15' MLLW to -33' MLLW (barge moorage, fish processor, cruise ship)	--	1	1	1	100%	--	1	1	--	100%	• Forage/prey colonization, potential for SAV establishment and recruitment of any wood from adjacent vegetated riparian areas, and any water quality benefits improvements from intertidal sediments re-establish within a short time period and therefore do not constitute an enduring effect. • No impacts to migratory corridor function or access with this structure type, so no value assigned for this HFV. • For MAMU, no noise-related impacts associated with this structure type (i.e., no vessel traffic supported), so no value assigned for this HFV.
Dredged Berth: Deep depth >-33' MLLW (cargo, grain)	--	1	1	--	100%	--	1	--	--	100%	• Forage/prey colonization, potential for SAV establishment and recruitment of any wood from adjacent vegetated riparian areas, and any water quality benefits improvements from intertidal sediments re-establish within a short time period and therefore do not constitute an enduring effect. • No impacts to migratory corridor function or access with this structure type, so no value assigned for this HFV. • For MAMU, no noise-related impacts associated with this structure type (i.e., no vessel traffic supported), so no value assigned for this HFV.

Structure	Habitat Assessment										
	Chinook Salmon/Bull Trout Habitat Function Variables[2]				Chinook Salmon/Bull Trout % Habitat Gain[2]	MAMU Function Variables[1]				MAMU % Habitat Gain[2]	Habitat Function Rationale
	Migration/ Rearing	Forage/ Prey	Cover	Water Quality		Access	Forage/ Prey	Water Quality	Noise		
Piles – Timber (wrapped or ACZA-treated preserved; mostly fender piles)	1	1	1	--	100%	1	1	--	1	100%	• Failure of piles opens up migratory corridor function, pile footprint becomes available for prey colonization, and cover improved by eliminating predator hiding places. • No impacts to water quality with this structure type, so no value assigned for this HFV.
Piles – Steel	1	1	1	--	100%	1	1	--	1	100%	• Failure of piles opens up migratory corridor function, pile footprint becomes available for prey colonization, and cover improved by eliminating predator hiding places. • No impacts to water quality with this structure type, so no value assigned for this HFV.
Piles – Concrete	1	1	1	--	100%	1	1	--	1	100%	• Failure of piles opens up migratory corridor function, pile footprint becomes available for prey colonization, and cover improved by eliminating predator hiding places. • No impacts to water quality with this structure type, so no value assigned for this HFV.
Stormwater Outfalls	--	1	0	0	33%	--	1	0	--	50%	• Failure of outfall would open up interstitial spaces and allows fine sediment to deposit, which can be colonized by epibenthic prey and improves access to forage/prey. • No improvements to cover or water quality are provided specifically by the degradation of the structure. • No impacts to migratory corridor function or access with this structure type, so no value assigned for this HFV. • For MAMU, no noise-related impacts associated with this structure type (i.e., no vessel traffic supported), so no value assigned for this HFV.
Overwater Cover: Heavy Industrial Pier (cargo/cruise/commercial/fishing fleet)	1	0	0	0	25%	1	0	0	1	50%	• Residual structure elements (e.g., concrete rubble, piles) persist and continue to impact habitat and prevent fine-grained substrate deposition, however migratory corridor function is improved. • No improvements to foraging habitat, natural cover re-establishment, or water quality.

Structure	Habitat Assessment										
	Chinook Salmon/Bull Trout Habitat Function Variables[2]				Chinook Salmon/Bull Trout % Habitat Gain[2]	MAMU Function Variables[1]				MAMU % Habitat Gain[2]	Habitat Function Rationale
	Migration/ Rearing	Forage/ Prey	Cover	Water Quality		Access	Forage/ Prey	Water Quality	Noise		
Overwater Cover: Medium (public access viewpoint pier, T-pier, catwalk-type structure)	1	0	1	0	50%	1	0	0	1	50%	• Some residual structure elements (e.g., concrete rubble, piles) persist and continue to impact habitat and limit fine-grained substrate deposition. Migratory corridor function is improved, and some natural cover deposition re-established. • No improvements to foraging habitat or water quality due to lack of fine-grained substrate deposition and no assumed SAV establishment.
Overwater Cover: Light Pier/Ramp/Float (recreational marina)	1	1	1	0	75%	1	1	0	--	67%	• Some residual structure elements (e.g., concrete rubble, piles) persist and continue to impact habitat and limit fine-grained substrate deposition. Migratory corridor function is improved, limited improvements to foraging habitat, and some natural cover deposition re-established. • No improvements to water quality due to lack of fine-grained substrate deposition and no assumed SAV establishment. • For MAMU, no noise-related impacts associated with this structure type (i.e., no large vessel traffic supported), so no value assigned for this HFV.
Upland Impervious Surface: Concrete or Asphalt or Compacted gravel (container cargo yard)	--	0	--	0.25	13%	--	0	0.25	--	13%	• Limited water quality benefits from riparian soils re-established with a small amount of filtration through cracks in the concrete. • Migration/access, cover, and noise-related impacts are not relevant for the riparian zone, so no value assigned for these HFVs.
Upland Impervious Surface: Concrete or Asphalt or Compacted gravel (parking lot at marina)	--	0	--	0.5	25%	--	0	0.5	--	25%	• Moderate water quality benefits from riparian soils re-established with some amount of filtration through isolated areas where integrity of the surface compromised. • Migration/access, cover, and noise-related impacts are not relevant for the riparian zone, so no value assigned for these HFVs.
Upland Pervious Surface: Unimproved (gravel, turf, or similar)	--	1	--	1	100%	--	1	1	--	100%	• Water quality benefits from riparian soils re-established and prey inputs improved with invasive (mostly shrub) colonization. • Migration/access, cover, and noise-related impacts are not relevant for the riparian zone, so no value assigned for these HFVs.
Upland Impervious Surface: Building	--	0	--	0.25	13%	--	0	0.25	--	13%	• Limited water quality benefits from riparian soils re-established with a small amount of filtration through cracks in the concrete. • Migration/access, cover, and noise-related impacts are not relevant for the riparian zone, so no value assigned for these HFVs.

Notes:

1. Each HFV is valued with either a 0 (no improvement assumed/predicted) or a 1 (improvement predicted/assumed) based on the degradation of the structure as described in Table 3-1.
2. Each ESA-species HFV has equal weighting, and only those applicable variables are included in the percent habitat gain calculation.

--: not included in HFV determination because the structure does not have an impact on the habitat function relevant habitat zones for the structure
ACZA: ammoniacal copper zinc arsenate
ESA: Endangered Species Act
HFV: habitat function variable
MAMU: marbled murrelet
MLLW: mean lower low water
SAV: submerged aquatic vegetation

Table 3-3
World Without Us Output for Port Calculator

Structure	Elevation Habitat Zone	Output for Calculator		
			Chinook Salmon and Bull Trout	Marbled Murrelet
		Maintenance Cycle (i.e., Years Functional Without Maintenance)	Weighted Habitat Improvement (%)[1]	Weighted Habitat Improvement (%)[1]
Rubble-Strewn Slope	Riparian	15	25%	25%
	Upper IT	50	25%	33%
	Lower IT		25%	33%
	Shallow ST		13%	17%
	Mid-ST		--	--
	Deep ST		--	--
Conventional Armored Slope – Heavy	Riparian	15	13%	13%
	Upper IT	75	20%	27%
	Lower IT		20%	27%
	Shallow ST		15%	20%
	Mid-ST		10%	13%
	Deep ST		5%	7%
Conventional Armored Slope – Light	Riparian	15	100%	100%
	Upper IT	50	50%	67%
	Lower IT		50%	67%
	Shallow ST	75	50%	67%
	Mid-ST		--	--
	Deep ST		--	--

Structure	Elevation Habitat Zone	Output for Calculator		
			Chinook Salmon and Bull Trout	Marbled Murrelet
		Maintenance Cycle (i.e., Years Functional Without Maintenance)	Weighted Habitat Improvement (%)[1]	Weighted Habitat Improvement (%)[1]
Bulkhead (at top of slope and at bottom) and Conventional Armored Slope	Riparian	50	50%	67%
	Upper IT		25%	33%
	Lower IT	75	25%	33%
	Shallow ST	100	13%	17%
	Mid-ST		50%	67%
	Deep ST	75	50%	67%
Bulkhead, Toewall, and Conventional Armored Slope	Riparian	50	50%	67%
	Upper IT		25%	33%
	Lower IT	75	25%	33%
	Shallow ST	100	13%	17%
	Mid-ST		50%	67%
	Deep ST	75	50%	67%
Vertical Bulkhead	Riparian	50	50%	67%
	Upper IT	75	50%	67%
	Lower IT		50%	67%
	Shallow ST		50%	67%
	Mid-ST	100	50%	67%
	Deep ST		50%	67%
Dredged Berth: Shallow depth <-14 feet MLLW (recreational marina)	Lower IT	30 [2]	100%	100%
	Shallow ST		100%	100%
Dredged Berth: Medium depth -15 feet MLLW to -33 feet MLLW (barge moorage, fish processor, cruise ship)	Mid-ST	15 [2]	100%	100%

Structure	Elevation Habitat Zone	Output for Calculator		
			Chinook Salmon and Bull Trout	Marbled Murrelet
		Maintenance Cycle (i.e., Years Functional Without Maintenance)	Weighted Habitat Improvement (%)[1]	Weighted Habitat Improvement (%)[1]
Dredged Berth: Deep depth >-33 feet MLLW (cargo, grain)	Deep ST	15 [2]	100%	100%
Piles – Timber (wrapped or ACZA-treated preserved; mostly fender piles)	Riparian	25	--	--
	Upper IT		100%	100%
	Lower IT		100%	100%
	Shallow ST		100%	100%
	Mid-ST		100%	100%
	Deep ST		100%	100%
Piles – Steel	Riparian	50	--	--
	Upper IT		100%	100%
	Lower IT		100%	100%
	Shallow ST		100%	100%
	Mid-ST		100%	100%
	Deep ST		100%	100%
Piles – Concrete	Riparian	100	--	--
	Upper IT		100%	100%
	Lower IT		100%	100%
	Shallow ST		100%	100%
	Mid-ST		100%	100%
	Deep ST		100%	100%

Structure	Elevation Habitat Zone	Output for Calculator		
			Chinook Salmon and Bull Trout	Marbled Murrelet
		Maintenance Cycle (i.e., Years Functional Without Maintenance)	Weighted Habitat Improvement (%)[1]	Weighted Habitat Improvement (%)[1]
Stormwater Outfalls	Riparian	50	--	--
	Upper IT		17%	25%
	Lower IT		17%	25%
	Shallow ST		--	--
	Mid-ST		--	--
	Deep ST		--	--
Overwater Cover: Heavy Industrial Pier (cargo/cruise/commercial/fishing fleet)	Riparian	75	--	--
	Upper IT		25%	50%
	Lower IT		25%	50%
	Shallow ST		25%	50%
	Mid-ST		25%	50%
	Deep ST		25%	50%
Overwater Cover: Medium Public Access (Viewpoint pier, T-pier catwalk-type structure) (medium)	Riparian	75	--	--
	Upper IT		50%	50%
	Lower IT		50%	50%
	Shallow ST		50%	50%
	Mid-ST		50%	50%
	Deep ST		--	--

Structure	Elevation Habitat Zone	Output for Calculator		
			Chinook Salmon and Bull Trout	Marbled Murrelet
		Maintenance Cycle (i.e., Years Functional Without Maintenance)	Weighted Habitat Improvement (%)[1]	Weighted Habitat Improvement (%)[1]
Overwater Cover: Light Pier/Ramp/Float (recreational marina)	Riparian	50	--	--
	Upper IT		75%	67%
	Lower IT		75%	67%
	Shallow ST		75%	67%
	Mid-ST		75%	67%
	Deep ST		--	--
Upland Impervious Surface: Concrete or Asphalt or Compacted Gravel (container cargo yard)	Riparian	15	13%	13%
Upland Impervious Surface: Concrete or Asphalt or Compacted Gravel (parking lot at marina)	Riparian	15	25%	25%
Upland Pervious Surface: Unimproved (gravel, turf, or similar)	Riparian	15	100%	100%
Upland Impervious Surface: Building	Riparian	75	13%	13%

Notes:

1. Calculated percent improvement (percent of structural functional loss times percent habitat gain) assumed at 300 years without maintenance of the structure. This value used in the calculator to calculate the ASP (i.e., X% of the delta between the baseline condition and MSP).
2. For dredging, impacts are assessed for a one year duration rather than over the maintenance cycle due to the demonstrated rapid recovery of the benthic habitats.

--: not a relevant habitat zone for the structure
ACZA: ammoniacal copper zinc arsenate
ASP: actual site potential
IT: intertidal
MLLW: mean lower low water
MSP: maximum site potential
ST: subtidal

Exhibit 1
Rubble-Strewn Slope

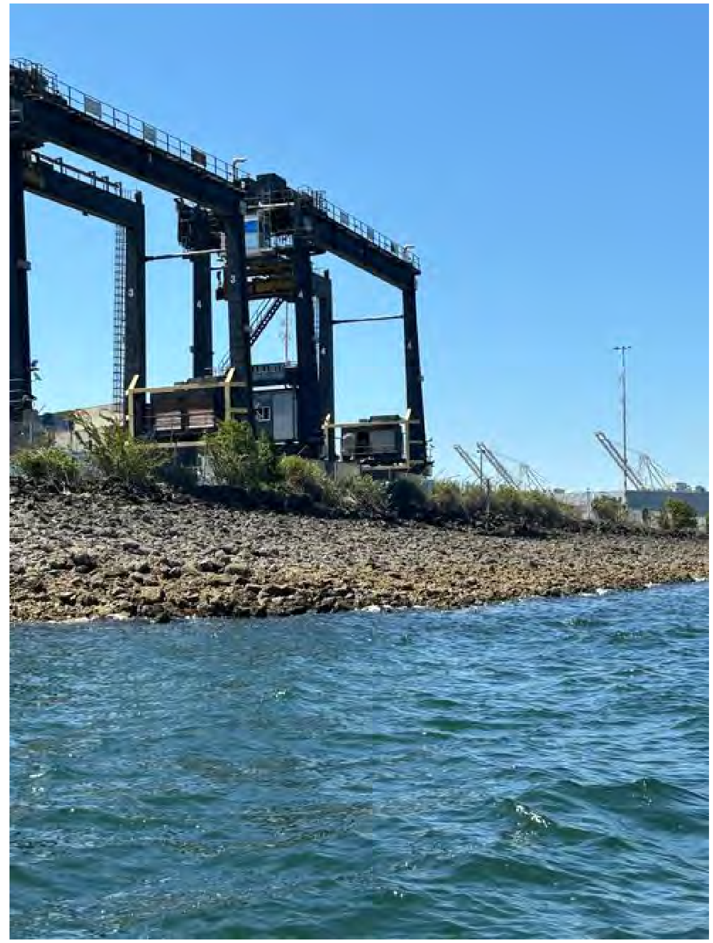
Duwamish Waterway shorelines with no measurable maintenance in the last 85 years.

Exhibit 2
Conventional Armored Slope – Heavy


Northeast Elliott Bay, featuring heavy granite armor unimproved for more than 100 years. Armor is slumped with smaller material/sediments mobilized from subgrade behind the armored slope, littering intertidal area in the foreground.

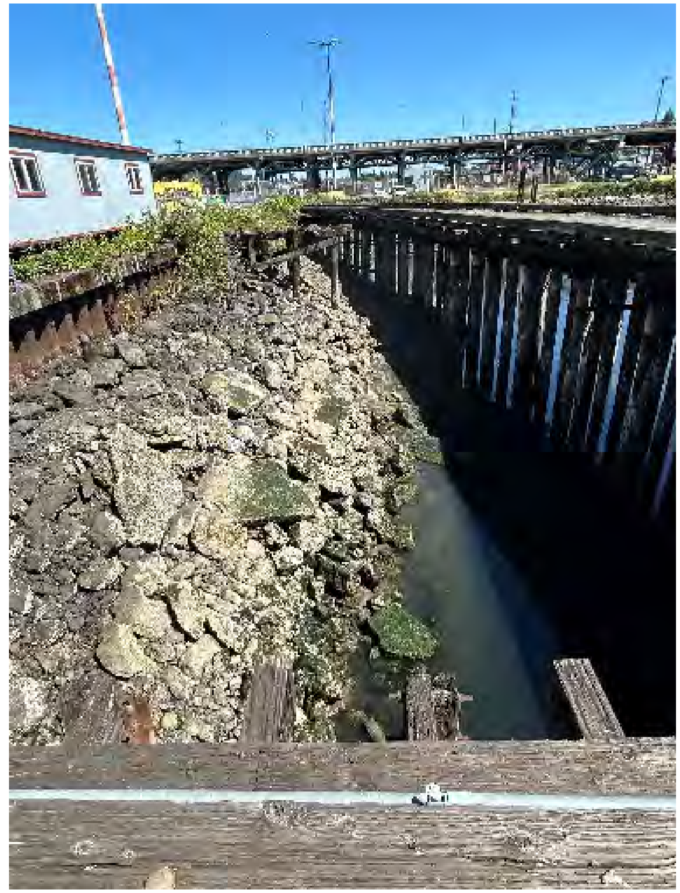
Exhibit 3
Conventional Armored Slope – Light

Port of Seattle's Jack Block Park light armor installed over heavy armor and rubble in 1997. Minor material migration at the toe of the slope. No maintenance in past 27 years.



Port of Seattle's northeast Terminal 18 light armor installed over heavy armor in 1969. Some migration of smaller material downslope. No maintenance in past 55 years.

Exhibit 4
Bulkhead (at top-of-slope) and Conventional Armored Slope



Top-of-slope bulkhead, with riprap extending from approximately +10 feet mean lower low water to shallow subtidal area. Port of Seattle's Pier 90 armored slope has slumped, with no measurable maintenance in past 80 years.

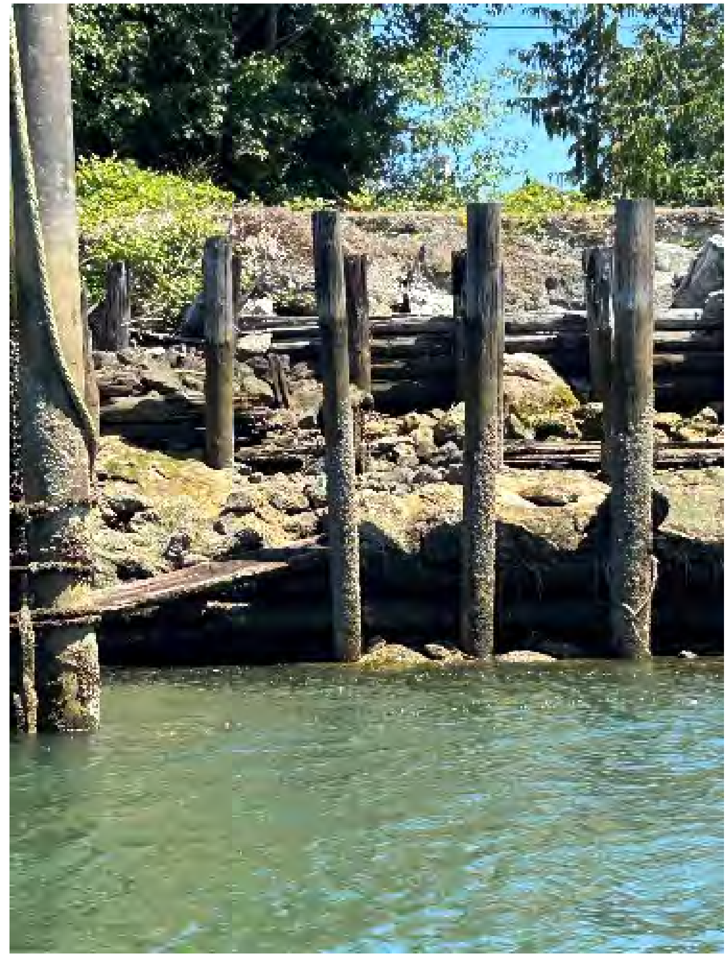
Exhibit 5
Bulkhead, Toewall, and Conventional Armored Slope

Port of Tacoma's North Intermodal Yard, step bulkhead with conventional armor and rubble-strewn slope. Aerial images indicate it was constructed between 1950 and 1973. Some of the creosote piling have been cut, but there has been no other measurable maintenance for at least 50 years.

Port of Seattle's South Terminal 25, top-of-bank bulkhead (red arrow), with stepped series of toewall bulkheads. No maintenance in past 90 years.

Exhibit 6
Bulkhead, Toewall, and Conventional Armored Slope

Port of Seattle's North Terminal 30, toewall is at the base of vertical sheet pile bulkhead and riprap is downslope of toewall. No measurable maintenance in past 80 years.



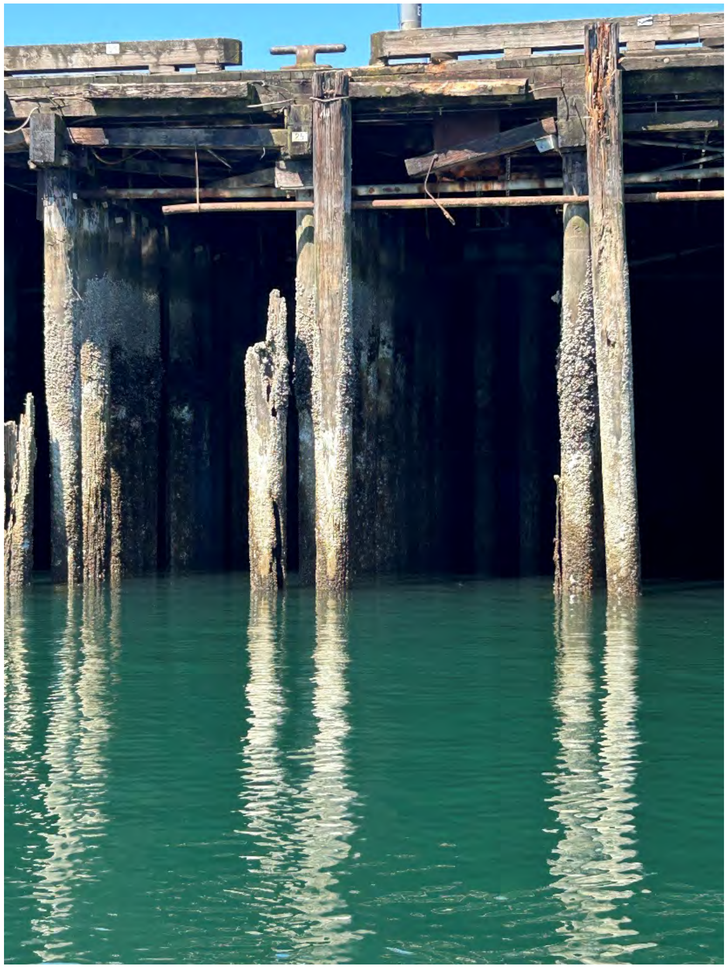
Upper and lower bulkhead, with latter functioning as a toewall. Note rock armor between bulkhead and toewall. No measurable maintenance in past 85 years.

Exhibit 7
Vertical Bulkhead

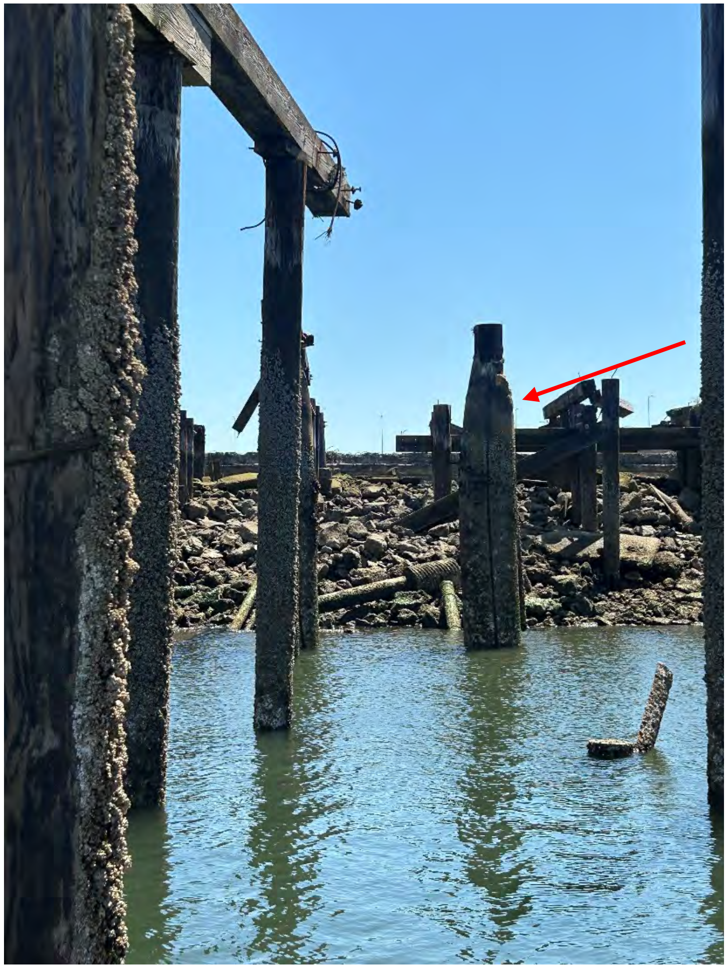
Port of Tacoma's Parcel 86 vertical bulkhead, installed 2020. This bulkhead protects an environmental cap from slope erosion. Future maintenance of this bulkhead will ensure the environmental cap is stable; thus, its maintenance is protective of the environment.

Port of Seattle's North Terminal 30, vertical sheet pile bulkhead located in deeper water. Note bulging, outward failure of bulkhead (red oval). No structural maintenance in more than 80 years.

Exhibit 8
Piling – Timber (wrapped or ACZA-treated)



Port of Seattle's Terminal 91, illustrating creosote fender piling, last replaced 40 to 50 years ago.



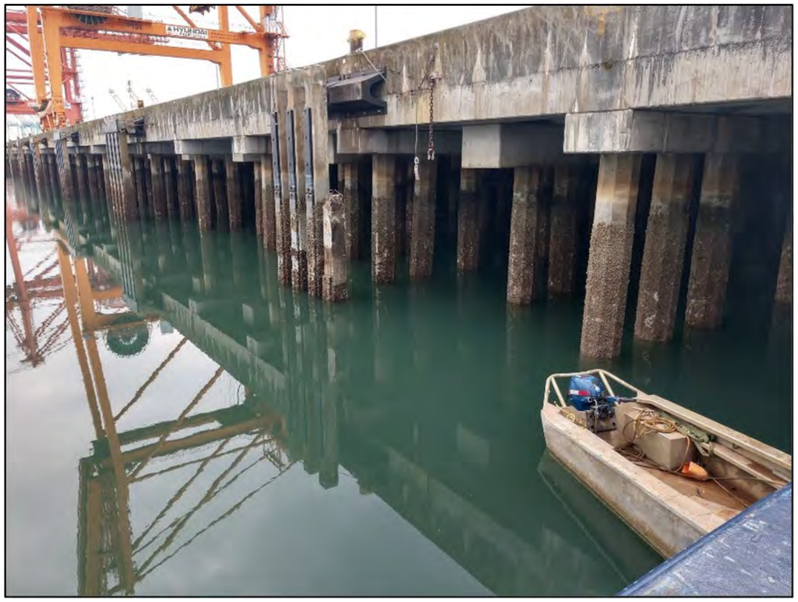
Port of Seattle's Southwest Terminal 25, illustrating common pile repair (red arrow). Pile was wrapped and pumped with grout. In this instance, the repair is approximately 45 to 50 years old. Meanwhile, portions of the surrounding 80-year-old timber pier have failed/collapsed.

Exhibit 9
Piling – Steel and New

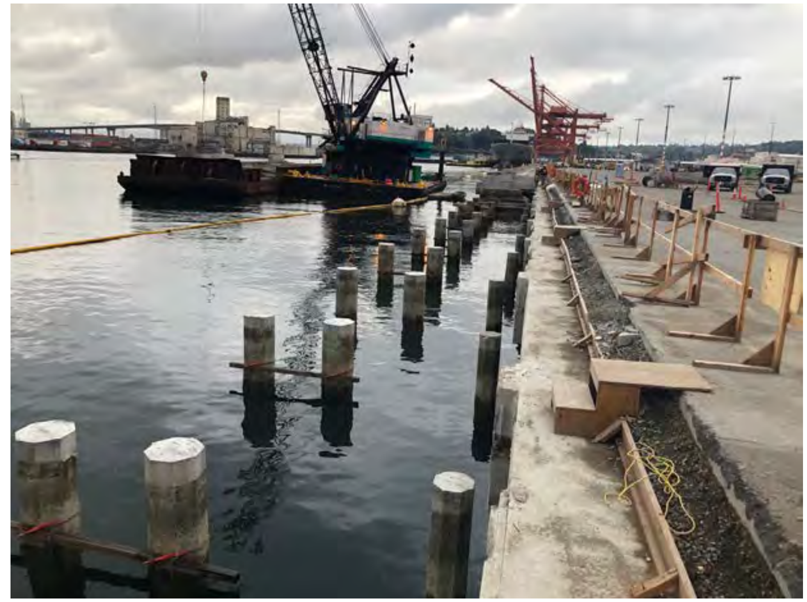
Port of Seattle's Duwamish River People's Park public access pier with steel piling. The pier was installed in 2021.

Port of Seattle's Pier 66 cruise terminal, with steel piling and timber- and rubber-bladder fender system. Steel piling was installed 2000 with no meaningful maintenance since installation.

Exhibit 10
Piling – Concrete



Port of Tacoma's Washington United Terminal, illustrating octagonal concrete structural piling with a square concrete fender pile system. The structural piling was installed in 1998, with no meaningful maintenance since installation.



Port of Seattle's Terminal 5 during construction in 2019, illustrating octagonal concrete structural piling before pile cap and stringer installation.

Exhibit 11
Stormwater Outfalls

Sitcum Waterway 36-inch outfall and spillway installed 46 years ago. Maintenance consists solely of marine debris removal. No improvements to the concrete spillway since installation. Surrounding slope was re-stabilized in 2014.

West Waterway, Harbor Island outfall, illustrating a double rank, creosote bulkhead and rock armor protection. Outfall structure has not been improved in past 90 years, except for the installation of "duck-bill" tide-gate, to replace a failed hinged, flap-gate.

Exhibit 12
Overwater Cover: Heavy Industrial Pier

Port of Tacoma's Terminal 7 A-B. Pier was constructed in 1940s with creosote timber piling, pile caps, stringers, and decking. Asphalt has been poured over the top of the timber decking. The pier has caught fire twice (most recently in the 1970s); however, no major structural improvements have occurred since construction. It is load-restricted but still in operation; however, the rail trestle was taken out of service more than 13 years ago.

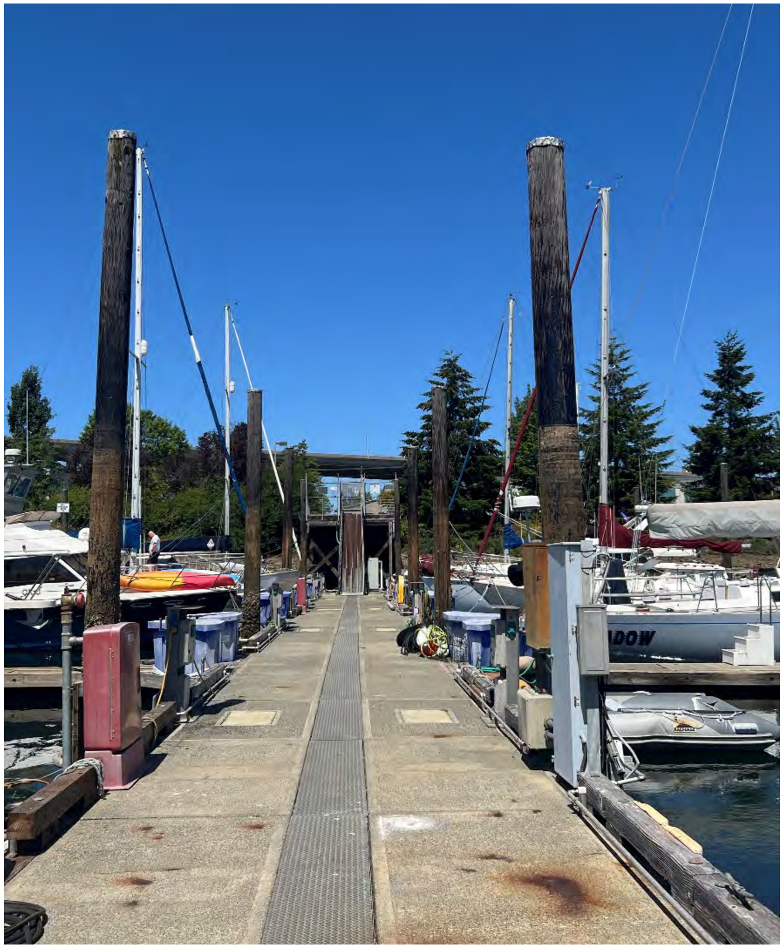
Legacy in-water structures from steam plant on Hylebos Waterway. The steam plant was constructed prior to 1931 according to aerial images. The coal-fired main boiler house and related infrastructure were removed in 2008, along with several creosote wood piling, timber walls, and the lid of the intake/outlet structure and piping. The remaining sheet pile and timber bulkheads show signs of deterioration; however, the concrete intake/outlet is still intact with only minor evidence of spalling/deterioration.

Exhibit 13
Overwater Cover: Medium T-Pier/Public Access

Port of Seattle's Terminal 91, illustrating over-water coverage at former rail spur, connecting to Pier 90. The structure will be demolished in 2024, having received no significant maintenance in past 90 years. Note the structure is still adequate for light use despite extreme age.

Port of Tacoma's Parcel 2 T-pier. Based on aerial imagery, the T-pier was constructed between 1931 and 1944. No meaningful maintenance has been performed since construction at least 80 years ago. Note the failing railing and some of the creosote timber deck panels are missing. This pier is no longer in service; however, the creosote timber piling and stringers are still intact.

Exhibit 14
Overwater Cover: Light Pier/Ramp/Float



Harbor Island Marina pedestrian access pier, ramp (gangway), and concrete float with treated timber piling. Pedestrian access pier and floats were constructed in mid-1980s with no measurable maintenance in last 40 years.

Attachment 4
Basis of Shoreline Armoring Affected Area

Basis of Shoreline Armoring Affected Area

This technical discussion describes a model for estimating long-term slope angles of repose for a future condition where slope or structure maintenance is no longer performed. This discussion also describes the basis for selecting the elevation range of interest over which these assumptions can be applied for habitat modeling under the WWU program.

Long-Term Side Slope Angles – Upland and Submerged

Slope stability is typically evaluated by assessing factors of safety. The slope stability factor of safety compares the "driving" forces (forces responsible for slope movement) to the "resisting" forces. Resisting forces are different for different types of materials and the relative compaction or density of those materials. Resisting forces are commonly represented as a friction angle for the soil, which can be used to calculate the strength of soil for a given soil type and density/compaction condition. When the slope stability factor of safety equals 1.0, this is another way of saying the driving and resisting forces are equal, which implies the slope is on the verge of movement. Often this condition is called a slope's "natural angle of repose."

Natural Soil Slopes – Upland

Unreinforced and unmaintained slopes can reasonably be assumed to achieve their natural angle of repose over the long term. Assuming no external forces (like building loads), the natural angle of repose for soil slopes can be estimated using industry-standard correlations of friction angles for a range of soils.

Table 4-1 summarizes reported literature values (Department of Defense 2022) of friction angle for a variety of soils, for both loose and dense conditions. This table also summarizes the calculated natural angle of repose for both conditions. As demonstrated in this table, natural slopes can conservatively be assumed to be 2H:1V or steeper for loose to dense soils.

Table 4-1
Natural Angle of Repose for Soil Slopes

Soil Type	Loose Conditions		Dense Conditions	
	Friction Angle	Angle of Repose	Friction Angle	Angle of Repose
Uniform Sand	27	2.0 H:1V	34	1.5 H:1V
Well-Graded Sand	33	1.5 H:1V	45	1.0 H:1V
Sandy Gravel	35	1.4 H:1V	50	0.8 H:1V
Silty Sand (Low End)	27	2.0 H:1V	30	1.7 H:1V
Inorganic Silt (Low End)	27	2.0 H:1V	30	1.7 H:1V
Silty Sand (High End)	33	1.5 H:1V	34	1.5 H:1V
Inorganic Silt (High End)	30	1.7 H:1V	35	1.4 H:1V

Natural Soil Slopes – Submerged

Submerged soil slopes represent a special case compared to the upland soil slopes mentioned previously. Because of soil saturation and dynamic underwater forces, unreinforced, unmaintained submerged soil may achieve a flatter long-term angle of repose compared to upland slopes. Accounting for these factors using traditional slope stability theory is complex and unnecessary considering the technical team's extensive experience evaluating underwater slopes for dredging and material placement construction projects over the last 20 years in Puget Sound. Experience on these projects suggests, based on engineering judgement and direct observation, that long-term submerged slopes achieve an angle of repose of 3H:1V if they are not maintained.

Elevation Ranges of Interest

The application of a long-term 3H:1V "natural angle of repose" slope assumption is appropriately conservative for a range of elevations that could be affected by tidal action and wave forces. Tidal inundation will occur over the elevation range from HAT to LAT. Beyond these elevation ranges, wave runup and wave-generated erosion forces could also affect the long-term slope.

As a conservative assumption at the top of slope, it can be assumed that wave runup above HAT could also flatten the slope from an upland natural angle of repose (2H:1V) to a submerged natural angle of repose (3H:1V). Although wave runup may not necessarily reach the top-of-bank, it is a simplifying conservative assumption to use the 3H:1V slope over the range that includes elevations to the top-of-bank.

Below the LAT elevation, breaking waves at low tide can induce erosive forces below the water line. The potential depth of erosion is equal to the significant wave height as discussed in U.S. Army Corps of Engineers (USACE; 1984). Finlayson (2006) developed a model of Puget Sound that includes estimates of storm-generated significant wave heights. For facilities at the Ports, modeled significant wave heights are typically on the order of 0.2 to 0.5 meters high and in all locations are less than 1 meter high due to the sheltered nature of these facilities. Thus, natural erosive forces from storm-generated waves can reasonably be estimated to occur at elevations no deeper than 1 meter below LAT. This corresponds to a lower elevation of approximately -7 feet MLLW, which is within the shallow subtidal habitat band (-4 to -14 feet MLLW).

As a point of reference, Finlayson (2006) describes Puget Sound beach geomorphology and identifies the presence of a "nearshore platform" where a slope break occurs from steeper submarine slopes to flatter shallow subtidal and intertidal slopes. In two example locations, this break occurs at elevations approximately -2 to -4 meters MLLW, which is consistent with the shallow subtidal habitat elevation range and is another indicator that deeper natural submarine slopes tend to be steeper in their natural condition.

Human-induced influences on shoreline slopes deeper than the shallow subtidal include erosion from propeller wash, ship wakes, and construction activities such as dredging. In the context of the WWU, it can be assumed that if a facility is no longer maintained, these human-induced influences will no longer be present because the function of the facility is no longer needed. Thus, future changes to slopes below the shallow subtidal zone can be excluded from further consideration in a WWU habitat modeling exercise.

Attachment 5

Port Calculator User Guide

Port Calculator User Guide

The following sections provide step-by-step guidance and examples for how to enter common structure types into the Port Calculator. It is anticipated that this User Guide will be updated, as needed, to capture any adaptive management updates made to the Port Calculator as part of the annual review with the Services.

General Calculator Considerations

One key concept that will inform project entries and information requests from the Port engineer team is that the entire baseline and post-project footprint must be delineated to be inclusive of any maintenance, repair, expansion, and/or removal activities as well as any affected areas (e.g., uplands for shoreline stabilization or buffers for overwater cover). For the model to work properly (i.e., assessing the change in function for a defined area), the acreage must be the same on both sides of the equation (pre- and post-project). If the pre- and post-project structural areas are different, then the difference in acreage most likely needs to be added into the Credit tab (if the footprint is being reduced) or into the Expansion tab (if the footprint is getting larger). Once the comprehensive project footprint has been defined, it must then be split into habitat polygons that represent the unique combination of the structure type, baseline habitat zone, and post-project habitat zone. This is often called a habitat conversion table and is typically generated using GIS tools to compare a baseline layer and post-project layer. Each layer should define structure type and habitat zone so that the habitat conversion table defines those unique combinations to account for all acreage within the project footprint. For the Port Calculator, each unique habitat polygon is entered on a separate line. Project quantities are entered into the Calculator as plan view acres. More details on project-type specifics for area quantifications are provided below.

Any maintenance that would impact substrate where existing SAV is present would be considered an expansion for that portion of the project (i.e., habitat polygon) because SAV is considered fully functional habitat. SAV presence will be initially assessed using the Washington State Coastal Atlas and then confirmed using an on-site survey. For non-shaded areas (i.e., no overwater cover), confirmation surveys include visual observations at low tide for intertidal areas and/or visual, video, diver, or acoustic surveys for subtidal areas).

Simple maintenance projects (e.g., overwater decking repair or maintenance dredging with no change in habitat zone) can be entered into the Enduring Effect tab in the Port Calculator. However, more complex projects (e.g., habitat conversion or structure removal/expansion in addition to maintenance) may require the user to divide project elements across different tabs. This User Guide is intended to provide guidance and examples of different project scenarios to inform consistent entries into the Port Calculator.

Calculator Entries

Project Information

The Port Calculator is designed to evaluate the following three types of potential outcomes from a project action, each with its own input tab in the Port Calculator:

- Enduring effect (i.e., repair and maintenance project with no change to structural footprint area)
- Expansion (i.e., habitat conversion or increased area of impact and/or degradation of habitat condition)
- Credit (i.e., reduction in structural footprint area or improved habitat condition)

The user can utilize the **ProjectInfo** tab to organize project information, including photographs and images, to support quantities entered into the Port Calculator. Enter the project information, user, and date info at the top of the tab. These entries will autopopulate all other tabs in the calculator for reference. Additionally, several structure-specific summary tables have been developed to provide guidance on how to assemble the applicable quantities and which dropdown option to select in the three project type tabs (**EnduringEffect_Input**, **Expansion_Input**, and **Credit_Input)**.

For the project type tabs (**EnduringEffect_Input**, **Expansion_Input**, and **Credit_Input)**, the user will select the structure, the habitat condition (fully functional, modified, or degraded), the dominant substrate type (fine or large), and the applicable habitat elevation zone for the baseline condition. The default assumption when calculating enduring effects for a maintenance activity is that baseline (i.e., current conditions) is the degraded habitat condition and post-project is the modified habitat condition; therefore, the post-project habitat condition and RHV are autopopulated for the applicable habitat zone(s) and dominant substrate type from a lookup table. This quantifies the delta (i.e., the enduring effect) between the ASP and the baseline (i.e., current conditions). More detailed instructions on how these are entered are provided below in the Tab Entries section.

Adjustment Factors

Similar to the PSNHC Calculator (and relying on the same data sources), final credits or debits are multiplied by a factor for habitat conditions that are especially important for Puget Sound Chinook salmon. The Port Calculator only applies these site-specific adjustment factors to aspects of the project that would affect the important habitat condition. Before entering project-specific quantities in the project type tabs, the user should enter in the project location-specific information in the table in the **AdjFactors** tab. These selections will autopopulate site-specific adjustment factors on the three project type tabs. The project location-specific information includes the following:

- Major Estuary Zones: A map of Puget Sound Natal & Pocket Estuaries developed for the PSNHC is used as the basis for this adjustment factor. NMFS used the historical extent of

Puget Sound Chinook salmon natal river deltas plus a 5-mile buffer (as the fish swims), as per the *Puget Sound Salmon Recovery Plan* nearshore chapter (Redman et al. 2005). Both Ports are located in a Major Estuary Zone for Puget Sound Chinook salmon.

- Pocket Estuary or Embayment: See the Puget Sound Natal & Pocket Estuaries map.
- Forage Fish Spawning: NMFS relies on Washington Department of Fish and Wildlife's (WDFW's) Forage Fish Spawning map and surveys to determine presence and extent of Pacific herring, Pacific sand lance, and surf smelt. If questions arise for a specific location, USACE, USFWS, or NMFS staff will clarify presence in consultation with WDFW. This adjustment factor only applies to the upper intertidal habitat zone for all structures.
- Shoreline armoring that is located within the same drift cell and updrift of forage fish spawning habitat. Use the Washington State Department of Ecology Coastal Atlas map to determine drift direction. This adjustment factor only applies to the upper intertidal habitat zone for all structures. In almost all instances, both Ports are located in areas with no appreciable drift.

Structure Type

The following are a few of the most common structure types that will be maintained or repaired under these Programs. Tables have been developed and included on the **ProjectInfo** tab to assist the user in working with the project engineer and with developing the habitat conversion table. Additionally, some project examples have been provided to illustrate how project information should be entered in the project type tabs.

Shoreline Stabilization

Project quantities are entered into the Port Calculator as plan view acreage. Armored slope maintenance or repair work will be quantified using the plan view for segment length and the slope face (cross-section) for each habitat zone to quantify height and slope surface. Vertical bulkhead maintenance or repair work will be quantified as the plan view acreage.

Shoreline stabilization structures will have an additional impact quantified for structures shallower than -14 ft MLLW to account for an affected area. Therefore, the user will need to identify the highest and lowest elevations for the extent of the work and the total linear feet in order to calculate the affected area impact. This affected area is calculated differently for armored slopes and vertical bulkheads. For armored slopes, the affected area is the same distance as the total height of the repair area and entered in the same habitat zone as the topmost elevation of repairs (Figure 5-1). Figure 5-2 illustrates a project example where armor will be placed as maintenance with no habitat conversion, so these entries are entered into the **EnduringEffect** tab. For vertical bulkheads, the affected area is three times the total height of the repair area and within the same habitat zone as the topmost elevation of repairs. Figure 5-3 illustrates a project example where a 12-foot-tall bulkhead will be repaired with no habitat conversion, so these entries are entered into the **EnduringEffect** tab.

Figure 5-1
Armored Slope Affect Area Illustration

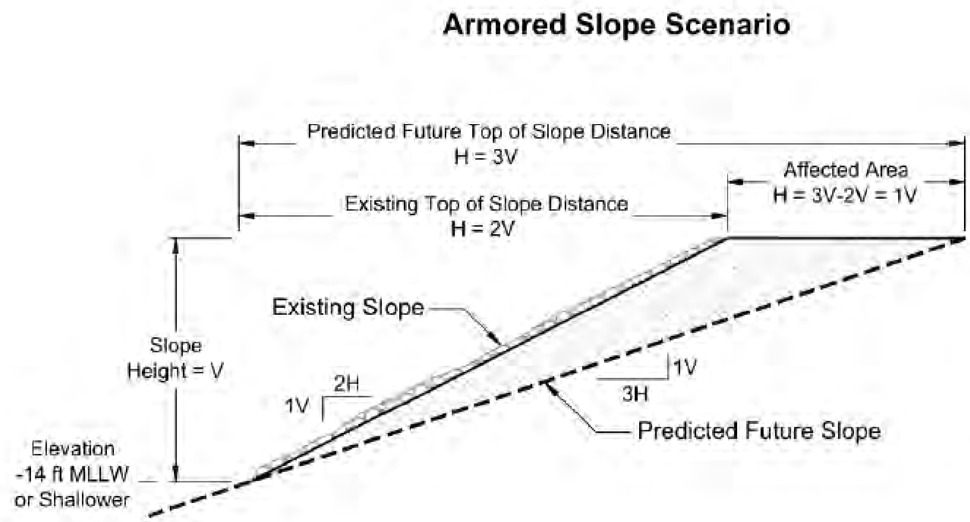
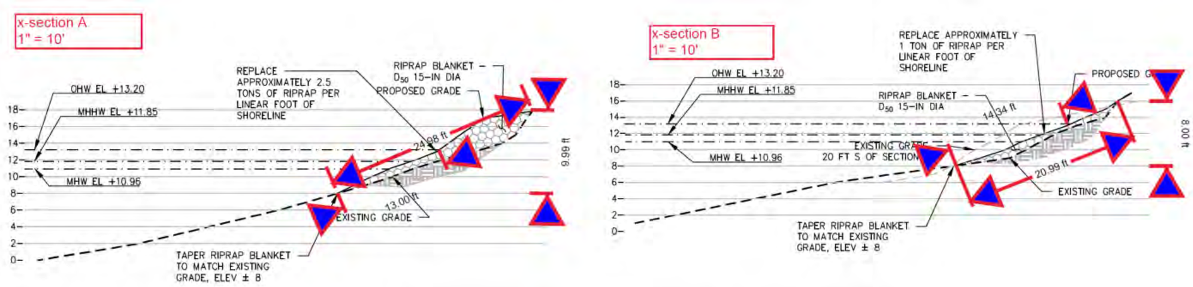


Figure 5-2
Armored Slope Entry Table and Project Example



User Entry Assist Table - Shallow (i.e., w/affected area) Sloped Shoreline Projects

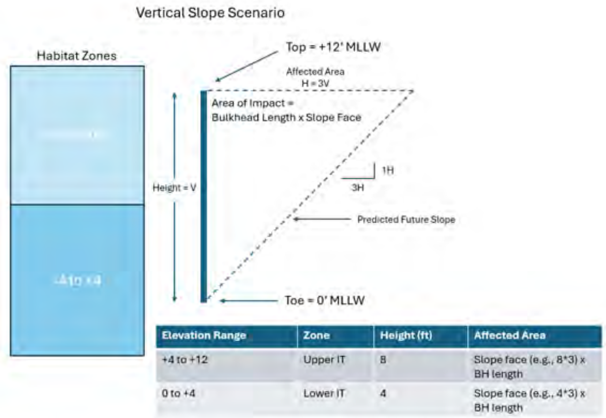
Project Section/Area	Habitat Zone	Segment Length (ft)	Height (ft)	Slope Surface (ft)	Affected Area Dist (ft)	Slope Area (acres)	Upland Affected Area (acres)	Notes/Comments
North portion (x-section A)	riparian	104	4.8	12	10	0.0287	0.0239	
	Upper IT	104	5.2	13		0.0310		
South portion (x-section B)	riparian	43	2.8	6.66	8	0.0066	0.0079	
	Upper IT	43	5.2	14.34		0.0142		
				Riparian slope area		0.0352		
				Upper IT slope area		0.0452		

riparian is defined as above OHW

XX	user entry field
XX	calculated field

red text are values to be pulled into the input tab

Figure 5-3
Vertical Bulkhead Entry Table and Affected Area Illustration



User Entry Assist Table - Shallow (i.e., w/affected area) Vertical Shoreline Projects

Bulkhead Height	12
Top of Bulkhead (MLLW)	12
Toe of Bulkhead (MLLW)	0

if these two elevations are in different habitat zones, then enter the heights for however many zones the bulkhead crosses

Elevation Range	Habitat Zone	Height (ft)	Bulkhead Length (ft)	Affected Area (acres)
+4 to +12 MLLW	Upper IT	8	20	0.0110
0 to +4 MLLW	Lower IT	4	20	0.0055
				0.0000
				0.0000

XX	user entry field
XX	calculated field

red text are values to be pulled into the input tab

The following are examples of different project types and how they would be entered into the Port Calculator:

- **Enduring Effect:** Repair of slumping armor or patching/re-supporting a failing bulkhead[6] with no change to overall plan view area or the substrate under the structure would be considered an enduring effect. Each habitat zone (i.e., polygon) that the repair overlaps with will be entered into the **EnduringEffect_Input** tab as a separate line.
- **Expansion:** Installation of additional armor at the toe of a slope or top of slope that increases the overall plan view area for a structure would be considered an expansion. The portion of the project that will be in the existing footprint will be entered on the **EnduringEffect_Input** tab and the additional armor areas (including any additional affected area) will be entered on the **Expansion_Input** tab. Increasing the height of a bulkhead results in an extended affected area, so the affected area based on the height of the existing bulkhead will be entered on the **EnduringEffect_Input** tab and the additional affected area from the bulkhead height extension will be entered into the **Expansion_Input** tab.

[6] When maintenance of the bulkhead is preventing contamination from entering the marine environment, the maintenance is being protective of the environment and the Port Calculator will not be used to determine impacts (debits).

- **Credit:** A repair that results in a reduction in the overall footprint would be considered a credit. The portion of the structure that remains within the existing footprint will be entered on the **EnduringEffect_Input** tab. The portion of the structure that is removed will be entered on the **Credit_Input** tab. The post-project structure will be one of the five "habitats" (i.e., top of slope riparian buffer, on-slope riparian buffer, emergent marsh bed, intertidal habitat, and subtidal habitat), and the post-project condition will be modified (most common) unless the Port is conducting restoration activities (uncommon), which will require monitoring and site protections.

7.1.1.1 Dredging

Dredging activities have a few additional considerations to accurately calculate the associated project debits. If dredging is does not result in a habitat conversion (i.e., depth stays within the same habitat zone), those areas will be entered on the **EnduringEffect** tab. If dredging does result in a habitat conversion (e.g., mid-subtidal to deep subtidal), then those areas within the project footprint will be entered into the **Expansion_Input** tab. It is likely that a dredging project will include both scenarios, so the habitat conversion table will be used to separate the polygons that are entered on each tab. For those polygons entered on the **Expansion_Input** tab, the following items must be considered and included in development of the habitat conversion table for dredging projects:

- New dredging areas (i.e., not previously dredged) are multiplied by a factor of two (consistent with the PSNHC for expansion activities). This is uncommon.
- If maintenance dredging results in a habitat conversion and the change in depth is greater than 10 feet, the impact is multiplied by a factor of two (consistent with PSNHC for expansion activities).
- If maintenance dredging results in a habitat conversion and the change in depth is less than 10 feet, the impact is multiplied by a factor of one since there is not a significant change in habitat function; however, it is still considered an expansion. This is likely the most common expansion scenario.
- If there is no SAV present, the baseline habitat condition default assumption for maintenance dredging is degraded, and for new dredging areas (i.e., true expansion) the baseline habitat condition default assumption is modified.
- If there is no SAV present and the project will convert lower intertidal habitat to shallow subtidal, no impact is assessed because the shallow subtidal zone has a higher RHV due to being fully inundated at all times.

Figure 5-4 is the dredging user entry assistance table included on the **ProjectInfo** tab, which reflects the bullets described above and has been provided to support organizing quantities for entry into the project type tabs. One item to note, when entering quantities on the **Expansion_Input** tab, selections should only be made on the dredge columns for dredge entries. The buffer columns should be left blank. Each of these only apply to certain structure types and may incorrectly calculate the multiplier if selections are made for both.

Figure 5-4
Dredging Entry Table

Entry tab	Habitat conversion from 1 zone to another?	SAV present	Maintenance Dredge or New?	Dredging: Change >10 feet?	Existing Habitat Zone	Post-Project Habitat Zone	Baseline Habitat Condition	Area (sf)	Dredge Area (acres)	Notes
EnduringEfffect tab	No	No	--	--		same	Degraded		0.000	
EnduringEfffect AND Expansion tabs	No	Yes	user enters	user enters			Fully Functional		0.000	Fully Functional for SAV portion only
Expansion tab	Yes	No	New	Yes			Modified		0.000	
Expansion tab	Yes	No	Maint	Yes			Degraded		0.000	
Expansion tab	Yes	Yes	New	Yes			Fully Functional		0.000	
Expansion tab	Yes	Yes	Maint	Yes			Fully Functional		0.000	
Expansion tab	Yes	No	New	No			Modified		0.000	
Expansion tab	Yes	No	Maint	No			Degraded		0.000	
Expansion tab	Yes	Yes	New	No			Fully Functional		0.000	
Expansion tab	Yes	Yes	Maint	No			Fully Functional		0.000	

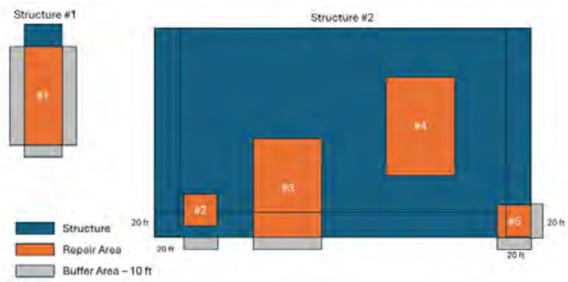
XX user entry field
red text are values to be pulled into the input tab

Overwater Cover

Project quantities are entered into the Port Calculator as plan view acres. Therefore, any decking maintenance or repair work will be quantified for each habitat zone and dominant substrate type that it overlaps with from a plan view perspective. Additionally, any decking repairs that overlap with structural pile repair or maintenance will be considered inclusive of the impact area. Structural piles (e.g., mooring dolphins) will be entered using the plan view acreage.

The one additional consideration for overwater cover structures is that a buffer area of reduced impact (0.5 multiplier) may be included. If the structure type is overwater cover and the maintenance or repair action is within 20 feet of the waterward edge of the structure, the user will need to quantify the appropriate buffer area (linear feet of activity footprint × 10 feet; Figure 5-5). One item to note: When entering quantities on the **Expansion_Input** tab, a selection should only be made on the buffer column for overwater cover entries. The dredge columns should be left blank. Each of these only apply to certain structure types and may incorrectly calculate the multiplier if selections are made for both.

Figure 5-5
Overwater Cover Entry Table and Buffer Illustration



User Entry Assist Table - Overwater Cover Projects

Repair Area	Habitat Zone	Repair Length (ft)	Repair Width (ft)	Within 20 ft of Edge?	Length (ft) w/i Edge	Width (ft) w/i Edge	Repair Area (acres)	Buffer Area (acres)	Notes
#1		100	25	Yes	200	25	0.057	0.052	
#2		25	25	Yes	25	0	0.014	0.006	
#3		100	50	Yes	0	50	0.115	0.011	
#4		100	50	No	0	0	0.115		
#5		25	25	Yes	25	25	0.014	0.011	

**If there is a buffer area, enter it on it's own line in the Input tab

XX user entry field
red text are values to be pulled into the input tab

The following are examples of different project types for overwater cover and how they will be entered into the Port Calculator:

- **Enduring Effect:** Repair of a portion of decking with no change to overall plan view area or disturbance to the substrate under the structure would be considered an enduring effect. Each habitat zone (i.e., polygon) that the repair overlaps with will be entered into the **EnduringEffect_Input** tab as a separate line.
- Expansion: An activity which increases the overall plan view area for a structure (e.g., installation of a line-handling platform) would be considered an expansion. The area of the expansion would result in converting modified habitat adjacent to an existing overwater structure to degraded habitat due to shading impacts. That portion of the project (i.e., habitat polygon[s]) will be entered on the **Expansion_Input** tab.
- **Credit:** An activity that results in a reduction in the overall structure footprint would be considered a credit. The portion of the structure that remains within the existing footprint will be entered on the **EnduringEffect_Input** tab. The portion of the structure that is removed will be entered on the **Credit_Input** tab. The post-project structure will be one of the five "habitats" (i.e., top of slope riparian buffer, on-slope riparian buffer, emergent marsh bed, intertidal habitat, and subtidal habitat), and the post-project condition will be modified (most common) unless the Port is conducting restoration activities (uncommon), which will require monitoring and site protections.

Creosote Removal

Regardless of the project type, enter creosote-treated timber removal on the bottom of the **Credit_Input** tab. When removing creosote-treated piles associated with overwater structures, enter the total weight of the creosote-treated wood in tons. The Creosote Tonnage Estimator at the bottom of the tab can aid in estimating the weight.

Similar to the PSNHC Calculator, credits for creosote removal apply only if sufficient documentation is provided. Provide the following information with the Project Information Form when proposing to remove creosote for credit:

1. Pictures of the creosote structure(s) prior to removal
2. Design drawings clearly indicating dimensions and location of creosote
3. Number of piles proposed for removal
4. Documentation of the average diameters for piles and/or dimensions of non-pile creosote-treated timber proposed for removal
5. A rationale for the estimate of the length of piles. Estimates may be based on as-built drawings, substrate data, or experience/data of average break off rate and length. Piles are typically driven an additional half of the length that is above the mud line. For example, a pile with 20 feet above the mudline could have 10 feet below the mudline for a total length of 30 feet.
6. Documentation of the weight of the creosote-treated wood proposed for removal. Enter weight in tons in the **Credit_Input** tab.

To confirm estimates of credits gained from creosote removal, the Services require documentation of the actual weight of removed creosote. NMFS's preferred method for verification is the submission of dump disposal receipts and a picture of the dump truck on the scale. Disposal receipts must contain actual weight of the total removed creosote. Creosote weight verification may also be accomplished with other methods, if necessary (for example, using a crate or similar equipment with an arm scale and submitting time stamped photos of both the scale on the crane and the material being lifted). Port Calculator outputs will be adjusted to reflect the actual disposed quantity.

Tab Inputs

Once all the information described above has been assembled on the **ProjectInfo** tab and the appropriate tab(s) has been selected, the user should enter information into the blue cells and follow the steps as follows:

1. Select the first species from the dropdown list.
2. Enter baseline information for each project polygon (likely already summarized on the **ProjectInfo** tab) by habitat zone. These columns reference options from the **Lookup_values** tab.
    a. Select structure type from the dropdown list. There are 22 different "structure" types and five different "habitat" types.
        i. For **EnduringEffect_Input** tab, this will generally be one of the 22 "structure" types.

ii. For the **Expansion_Input** tab, this will generally be one of the 5 "habitat" types.
iii. For the **Credit_Input** tab, this will generally be one of the 22 "structure" types.

b. Select all the relevant habitat zones within the project footprint. Use a new line for each habitat polygon. There are up to six different habitat zones.

c. Select baseline (i.e., current) habitat condition (fully functional, modified, or degraded).
   i. For the **EnduringEffect_Input** tab, the baseline condition default assumption will be degraded.
   ii. For the **Expansion_Input** tab, the baseline condition default assumption will be modified. The two exceptions are as follows: 1) if SAV is present then, the delineated SAV area will be fully functional; and 2) if maintenance dredging results in a habitat conversion, then the baseline condition will be degraded. See the Dredging section for more information on dredge-specific entries.
   iii. For the **Credit_Input** tab, the baseline condition default assumption will be degraded because the crediting action for most projects in these Programs will be to remove or reduce the footprint of an existing structure (i.e., degraded). The exception is if the Port conducts a restoration project, which could be degraded or modified as the baseline condition. Restoration projects will require monitoring and site protections, so those are not anticipated to be common projects in these Programs.

d. Select the dominant substrate, which drives RHVs in combination with the selected species and habitat zone. There are seven different dominant substrates.

e. Enter individual acreages for each habitat polygon on applicable lines. See description in the General Calculator Considerations section for how to generate the habitat polygons. The post-project acreage is autopopulated based on the baseline acreage for all three tabs.

f. RHV is autopopulated from the **Habitat Zones and Values** tab based on all the above selections.

3. Enter post-project conditions information, which should be the same as baseline except for any habitat conversions (e.g., placement of additional material at the base of armored slopes; removal of substrate with dredging).
   a. Select structure type from the dropdown list.
      i. For the **EnduringEffect** tab, this will be the same as the baseline condition.
      ii. For the **Expansion_Input** tab, this will generally be one of the 22 "structure" types.
      iii. For the **Credit_Input** tab, this will generally be one of the five "habitat" types.
   b. Select all relevant habitat zones within the project footprint. Use a new line for each habitat polygon.
      i. For **EnduringEffect** tab, this will be the same as the baseline condition.

ii. For the **Expansion_Input** tab, this could be the same as or different from baseline, depending on the habitat conversion table.
iii. For the **Credit_Input** tab, this could be the same as or different from the baseline, depending on the habitat conversion table. The general assumption is that the post-project condition will have the same habitat zones as the baseline but the habitat condition will be modified because the crediting action for most projects in these Programs will be to remove or reduce the footprint of the structure but with no other restoration actions (i.e., modified). The exception is if the Port conducts a restoration project, which will be fully functional as the post-project condition. Restoration projects will require monitoring and site protections, so those are not anticipated to be common projects in these Programs.

c. Select the post-project habitat condition
   i. For the **EnduringEffect_Input** tab, the default assumption for the post-project habitat condition (i.e., urban environment with no restoration action) will be modified. This is autopopulated.
   ii. For the **Expansion_Input** tab, the general assumption is that the post-project condition will be degraded.
   iii. For the **Credit_Input** tab, this could be the same as or different from baseline, depending on the habitat conversion table.
d. Select the dominant substrate, which drives RHVs in combination with the selected species and habitat zone.
   i. For the **EnduringEffect** tab, this will be the same as the baseline condition.
   ii. For the **Expansion_Input** tab, this could be the same as or different from baseline, depending on the habitat conversion table.
   iii. For the **Credit_Input** tab, this could be the same as or different from baseline, depending on the habitat conversion table.
e. Maintenance cycle is autopopulated from the **WWU** tab.
f. Each dynamic model uses the MSP (determined by the zone, habitat condition, and substrate; which is autopopulated from **Habitat Zones and Values** tab) and the WHI (percent; from **WWU** tab) to determine the future RHV which is delayed by the maintenance action (i.e., ASP).
   i. For instances when ASP and MSP are the same, the WHI percent does not apply, and there are no debits associated with enduring effect because the area is already functioning at the maximum expected level.
   ii. For instances when a habitat conversion results in an ASP that is greater than an MSP (e.g., Mid-Subtidal Degraded to Deep Subtidal Modified), the WHI is assumed to be 100% to account for the spatial and temporal impacts.
g. Structure-Specific Entries

i. For overwater cover structure types, select Yes or No if the acreage represents the buffer area for the project (see figure and entry table example in the Overwater Cover section).

ii. For dredging activities entered on the **Expansion_Input** tab, select if the activity is maintenance or new (Maint or New) dredging and if the dredging will result in more than 10 feet of change in elevation (Yes or No).

iii. On the **Expansion_Input** tab, make a selection on the buffer column *or* the dredge columns, not both. Each of these only apply to certain structure types and may incorrectly calculate the multiplier if selections are made for both.

4. If there is any creosote removal, enter quantities at the bottom of the **Credit_Input** tab (below the main table and notes sections). Note that the quantities must be entered separately for upper intertidal from the lower intertidal, shallow subtidal, mid-subtidal, and deep subtidal areas.
5. Copy and paste value from "Species-Specific Output (DSAYs)" into the applicable blue species cell. Select another species and paste special output into applicable blue species cell. Repeat for all applicable species on each tab with project inputs.
6. The Project Total on each tab selects the value with the highest impact (i.e., the largest number of debits) from the three project type tabs and then sums the three project type tabs to show whether the project is debit-generating or credit-generating.

Attachment 6
Port Calculator

Provided as an Excel file.

PORT OF TACOMA AND PORT OF SEATTLE COMPREHENSIVE MITIGATED MAINTENANCE AND REPAIR PERMITS COMPENSATORY MITIGATION CREDIT INSTRUMENT

This Compensatory Mitigation Credit Instrument sets forth the details and understandings of the Port of Tacoma and the Port of Seattle (collectively, "the Ports") and the U.S. Army Corps of Engineers (USACE), as the federal action agency, regarding the establishment and use of a Mitigation Credit Scheme designed for, and for use solely in connection with, the Ports' Comprehensive Mitigated Maintenance and Repair Permits ("CMMP").

I. **Background and Purpose**

A. The USACE is consulting with NOAA's National Marine Fisheries Service ("NMFS") and the U.S. Fish and Wildlife Service ("FWS") (jointly referred to as "Services" pursuant to section 7 of the Endangered Species Act on the Ports' proposed CMMP. The NMFS consultation number is WCRO-2024-02448. The USFWS consultation number is 2025-0000930.

B. Under the CMMP, the Ports propose to conduct routine maintenance, repair, relocation, replacement and/or demolition of their structures (e.g., piling, decking systems, outfalls, bulkheads, fender systems, slope protection, etc.), utilities, as well as do maintenance dredging, and scientific sediment and geotechnical sampling. These routine activities will be conducted at the Ports' facilities as needed over the 10-year duration of the CMMP. The CMMP also allows for beneficial activities such as pile and overwater structure removal (including creosote removal), alternative shoreline stabilization, and debris removal, which may occur as stand-alone activity or part of a repair and maintenance action.

C. Under the CMMP, any unavoidable adverse long-term effects on nearshore habitat from the proposed activities will be calculated as conservation debits and offset with a proportional amount of conservation credits.

D. The purpose of the Compensatory Mitigation Credit Scheme described in this Instrument is to provide a reliable, accountable and transparent system so that NFMS has a basis for evaluating the benefits of CMMP Conservation Credits as offsets to CMMP debits in the CMMP's Biological Opinion.

II. Separate Scheme for Each Port

There is a separate Mitigation Credit Scheme for each Port. The following provisions should be read as applying separately to the Port of Seattle and the Port of Tacoma.

III. CMMP Conservation Credits

A. To offset conservation debits incurred by CMMP activities a Port may:

(i) Generate credits by implementing <u>stand-alone beneficial activities located within the Port's project area</u> (as defined in Section 2.3 of the Opinion) as part of the CMMP, such as removal of structures, fill, rip-rap, bulkheads, and creosote-treated piling, provided there is compliance with the Habitat Improvement Plan ("HIP") conditions in III.B.; or

(ii) Generate credits by integrating beneficial activities into a CMMP repair and maintenance action, provided there is compliance with the HIP conditions in III.B. Examples of this option include reducing the overall footprint of a structure by removing portions of it; replacing solid surface decking with materials that allow light penetration; removing anthropogenic debris from the shoreline and/or seabed; or installing alternative shoreline stabilization features such as logs, root-wads, native plants, and topsoil lifts to improve habitat functions; or

(iii) Purchase credits from a Services- or NMFS-approved conservation bank or in-lieu fee program (e.g. for Port of Tacoma, from its Upper Clear Creek Mitigation Bank) that has a service area that includes the respective Port's project area (as defined in Section 2.3 of the Opinion);

(iv) Generate credits by undertaking an "applicant-responsible" restoration project within the South-Central service area[1], separate from the CMMP, provided the project will be completed within three years of completion of the activity incurring debits[2], and provided there is compliance with the HIP conditions in III.B; or

(v) Provide funding for a local habitat restoration project within the South-Central service area, provided the project will be completed within three years of completion of the activity incurring debits, and provided there is compliance with the HIP conditions in III.B; or

(vi) Apply credits from the Place of Circling Waters advance mitigation restoration project (in the case of Port of Tacoma), provided the credits are being applied in accordance with the service values described in Appendix F.

(vii) Apply credits from a future advance mitigation site within the South-Central service area provided there is compliance with the conditions in III.C.

B. For the activities described in (i), (ii), (iv), (v) there must be a HIP that includes performance standards, a description of before and after conditions, a monitoring plan, a site protection instrument, and a long-term management and maintenance proposal as appropriate for the activity. For example, for creosote pile and structure removal, a HIP can be limited to the description of the before and after condition and needs to include pictures, site plans, and creosote dump receipts to confirm creosote weigh; for planting, a HIP needs to include

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[1] A service area is the geographic area in which conservation offsets can be traded to balance the loss of salmonid resource functions. A description of the South-Central Service Area can be found in Ehinger et al. 2025 Puget Sound Nearshore Habitat Calculator User Guide which is available on NOAA's Nearshore web page; and in Ehinger et al. 2023. The Puget Sound Nearshore Habitat Conservation Calculator. NOAA Draft Report.

[2] This timeframe minimizes temporal losses and follows the established practice for in lieu fee programs.

vegetation performance standards, a monitoring plan, and a site protection description or instrument. The HIP for activities (i) and (ii) will be submitted to the Services with post-project calculators; pre-project coordination is on a case-by-case optional basis. Activities (iv) and (v) require a pre-project HIP approval through coordination with the Services.

C. For future advance mitigation sites described in (vii) above, the following conditions must be met:

(i) the site was developed in accordance with technical assistance provided by the Services;

(ii) The Port has prepared an advance mitigation plan for the site; [3]

(iii) Informed by the advance mitigation plan, NMFS has determined that the advance mitigation site is generally appropriate for offsetting impacts from Port projects; and,

(iv) NMFS has approved an advance mitigation use plan finding that those credits are appropriate for use with CMMP.

D. Accordingly, subject to the Exclusions listed in V. below, "CMMP Conservation Credit" is defined as:

(i) Credits that are generated by the Port through CMMP activities– as described in A.(i)-(ii) above;

(ii) Credits that have been generated, purchased, or funded by the Port through one of the means described in A.(iii)-(v) above to offset CMMP debits, and are included on the CMMP ledger (as described below); and,

(iii) In the case of Port of Tacoma, credits from the Place of Circling Waters Advance Compensatory Mitigation site that are being applied to offset CMMP debit and are included on both the CMMP ledger and the Place of Circling Waters joint Clean Water Act and Conservation Credit ledger.

IV. Advance Conservation Credits.

A. In any given fiscal year, the Port's generation, purchase, or funding of CMMP Conservation Credits could result in more credits than are necessary to offset CMMP debits occurring in the same fiscal year. It is USACE's and the Ports' understanding that

[3] An advance mitigation plan must contain: executive summary, goals and objectives, geographic service area, site selection criteria, description of baseline conditions, mitigation work plan, proposed credit generation, performance standards, monitoring plan including adaptive monitoring, site protection, long-term management and maintenance, and financial assurances.

any such surplus credits can be "saved" on the CMMP ledger and applied to offset debits from CMMP activities in subsequent fiscal years.

B. Accordingly, subject to the Exclusions listed in V. below, "Advance Conservation Credits" are defined as CMMP Conservation Credits that:

(i) Have not already been applied to offset CMMP debits generated within the same fiscal year; and,

(ii) Are "saved" within the CMMP's administrative regime, i.e., on the CMMP ledger, and can be applied to offset debits generated by the CMMP in future fiscal years.

C. The main purpose of Advance Conservation Credits is to provide the Port with a basis for undertaking or funding beneficial projects in advance of permitted impacts and as consolidated projects (rather than multiple, small projects), thus facilitating immediate and meaningful habitat improvements. The reason and motivation for the Port to undertake or fund such early and consolidated projects would be to efficiently generate credits on the understanding they could be used to offset debits from CMMP activities occurring in the future.

D. In the future, should the Port develop a joint Services- or NMFS-USACE approved conservation bank, Advance Conservation Credits may be transferred from the CMMP ledger to the conservation bank, if mutually agreed upon by the Port, USACE and Services.

V. Exclusions

A. The following activities do not generate CMMP Conservation Credits or Advance Conservation Credits:

(i) Habitat restoration activities mandated by Federal, state, or local law;

(ii) Habitat restoration activities required to resolve unavoidable impacts to tribal treaty rights; and,

(iii) Activities funded and/or undertaken with the sole purpose of supporting habitat restoration rather than for mitigation purposes.

B. Credits from Port-owned restoration projects that are separate from CMMP activities do not qualify as Advance Conservation Credits, i.e., cannot be "saved" on the CMMP ledger. Port-owned conservation banks and any future Port mitigation sites will retain independent credit-debit ledgers.

VI. Measurement of Debits and Credits

A. All conservation debits incurred and credits generated by CMMP activities will be measured and ascribed values using the port-specific conservation offset calculator ("Port Calculator") which has been reviewed and approved by the Services or, where that is not possible, by an individual credit assessment conducted or approved by the Services.

B. Credits generated, purchased or applied from activities not part of the CMMP will be measured and ascribed values using the instrument or method deemed most applicable by the Services, which could be the Port Calculator, the Puget Sound Nearshore Calculator, or an individual credit assessment conducted or approved by the Services.

VII. Requirement and Timeframe for Offsetting CMMP Debits

A. Debits accrued during any one fiscal year of the CMMP must be offset by conservation credits during that fiscal year or within the subsequent two fiscal years.

VIII. Debits and Credit Verification on a Project Basis

A. For CMMP projects that require NMFS review and a Calculator, the Port will send post-project Calculators within 30 days of project completion to communicate to NMFS the number of conservation credits or debits computed. Within 30 days, NMFS will review the Port Calculator outputs and indicate confirmation or disagreement.

B. For CMMP compensatory mitigation projects that require a pre-project HIP approval, the Port will send pre-project HIPs to the Services prior to construction and coordinate as needed. Credit release will be based on the achievement of performance standards developed in the HIP, as verified by the Services.

C. The USACE and the Port may resubmit debit and credit computations with additional explanation if they disagree; however, the Services will make the final determination as to the conservation credits and/or debits generated or incurred by a CMMP activity.

D. Calculators shall be sent to projectreports.wcr@noaa.gov, with a cc to CMMP.wcr@noaa.gov and to USACE. Reports shall include "WCRO-2024-02448 PORTS" in the regarding line.

IX. Dynamic Ledger and Annual Reconciliation of CMMP Debits and Credits

A. The Port will maintain a ledger of all conservation debits incurred under the CMMP, and all CMMP Conservation Credits applied to offset those debits including any type of credit that qualifies under section III.B. above. In this way, the ledger will provide a dynamic documentation of the number of CMMP Conservation Credits available.

B. The ledger will be included in an Annual Report to the Services by the Port, in coordination with the USACE. Where there is an annual debit balance, the Port will communicate in the Annual Report the intended source of offsetting CMMP Conservation Credits

C. At an Annual Meeting between the Services, the Port and the USACE, the following will be evaluated and confirmed by the attendees (in addition to other elements described in the CMMP):

a. Conservation debits incurred by the CMMP during the reporting year;
b. Conservation credits accumulated during the reporting year;
c. Conservation credits applied to offset conservation debits during the reporting year.
d. Advance Conservation Credits proposed for carry-over to the subsequent reporting year.

D. Advance Conservation Credits will remain on the ledger and be carried forward to the following fiscal year. When Advance Conservation Credits are applied to offset debits, the ledger must clearly show the Advance Conservation Credits that have been applied and are no longer available.

XI. No Double Counting

Once a CMMP Conservation Credit has been applied to offset a debit generated under the CMMP, it cannot be applied to offset any debit in any context in the future.

X. Use of CMMP Conservation Credits During and After CMMP

A. During the CMMP 10-year period, CMMP Conservation Credits can only be applied by the Port to offset conservation debits generated under the CMMP.

B. At the end of the CMMP 10-year period, remaining CMMP Conservation Credits may be transferred to the ledger for any CMMP renewal, or transferred to another Port conservation credit ledger approved by the Services.

C. Subject to the provision in IV.D. above, at no time can CMMP Conservation Credits be transferred or sold to any other entity.

XII. Commencement Date

The Mitigation Credit Scheme will commence operation when the Services issue their Biological Opinions on the CMMP.

Port of Seattle

Comprehensive Routine Maintenance, Repair, and Scientific Sampling Program

JARPA Application

Appendix B

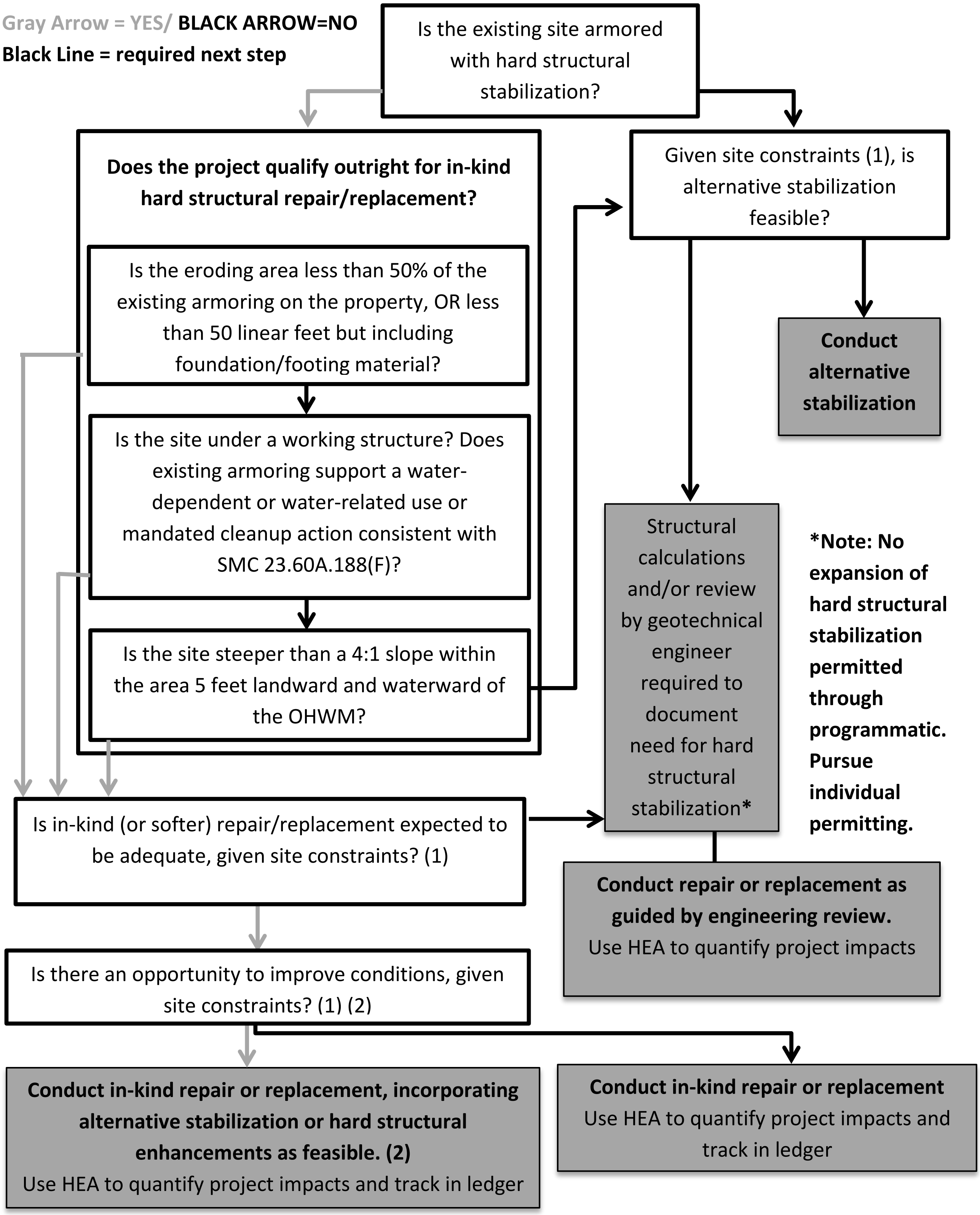
Bankline Stabilization Decision Flow Chart

Adopted from the Port of Seattle Bankline Repair and Enhancement Multi-Site Program (NWS-2018-780-WRD)

Bankline Decision Flowchart

December 2018, Revised October 2019.

Where bankline repair need is identified, use the following decision tree to determine feasible options.



(1) Site constraints may include adjacent uses, public access requirements, existing topography and bathymetry, degree of wind and wave exposure, and existing and anticipated erosional forces.

(2) Stabilization treatments in order of declining preference:

Alternatives to stabilization / passive options:

- Set back upland use
- Beach nourishment
- Upland drainage control

Alternative stabilization (see Alternative Stabilization Typicals "B", Sheets 46-52)

Hard structural stabilization (see Hard Structural Stabilization Typicals)

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Modeling Underwater Noise Associated with Pile Driving Activities - 2021

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Introduction

The Port of Seattle routinely engages in pile driving activities to support the continued operations of its facilities. This document presents the Port's approach to modeling underwater noise related to pile driving and identifies where gaps in hydro-acoustic data and common method pitfalls. The approach and the scenarios presented in this document will be used to support the Port's permitting efforts for routine pile driving projects.

The Port's approach draws heavily on the work of the Washington State Department of Transportation ("WSDOT") and the California Department of Transportation ("Caltrans"), which have spent considerable effort addressing issues related to underwater construction noise. These organizations have compiled guidance documents, funded academic investigations, and continue to collect hydro-acoustic monitoring data. The 2020 Caltrans guidance document prepared by ICF International and Illingworth and Rodkin, Inc. provides a strong background on the issue of underwater noise related to pile driving. WSDOT has also prepared a guidance document for its biological assessment staff that covers underwater construction noise related to pile driving in Washington waters. For in-depth introductions to underwater noise assessment and pile driving installation methods, the WSDOT and Caltrans manuals provide excellent references.

This manual is divided into three sections. The first section provides a very brief introduction to underwater acoustics related to pile driving. The second section describes how the Port's analysis was performed. The final section presents the results of the Port's modeling effort. Maps attached as an appendix to this document depict where various underwater noise thresholds are predicted to occur in relation to worst-case potential project location at representative Port facilities.

Environmental Setting

The Port's facilities are set within highly-modified maritime industrial areas and urban waterways. These facilities are primarily committed to maritime industrial, cargo, cruise, recreational and commercial moorage, and other water-dependent or water-related commercial uses. Properties adjacent to the Port's facilities generally share a similar setting and support similar uses. These uses include transportation facilities, maritime industrial facilities, and moorage.

Existing environmental conditions reflect modifications associated with current and historic commercial uses. The shoreline area is typically dominated by over-water piers, riprap slopes, constructed seawalls, and bulkheads. Subtidal areas are typically dredged to between 15 feet (4.6 m) and 50 feet (15 m) to provide sufficient depth for commercial vessel operations. Sand, silt, and mud are the dominant substrate types. Ambient noise near the Port's facilities is estimated to be approximately 120dB_{RMS} (Laughlin 2020).

Typical Pile System Repair and Maintenance

Pile system repair and maintenance activities typically include the replacement of structural, fender, dolphin, float, and/or other types of piles typically ranging in size between 12" and 30" in diameter. Pile materials include wood, steel, concrete, HDPE plastic, and others. Pile systems also include fender components, cathodic protection, rub strips, and pile caps.

Typically, vibratory and/or mechanical impact methods stationed on a barge, derrick, or landside crane will be used to remove or install piling. Impact pile drivers force a pile into the substrate using a heavy weight that repeatedly strikes the pile, much like using a hammer to strike a nail. This method can produce high peak sound pressure levels that can injure fish and other organisms. For this reason, noise mitigation strategies have been developed including bubble curtain devices and other barriers that slow or reduce the propagation of underwater noise related pile driving (ICF International and Illingworth and Rodkin, Inc. 2020; WSDOT 2020).

Another installation method is vibratory pile driving. The vibratory hammer uses continuously oscillating weights that shake a pile, liquefying adjacent substrate, and pressing the pile to depth. Vibratory pile drivers typically produce lower sound pressure levels than impact hammers and have become the Port's preferred installation method. The National Oceanic and Atmospheric Administration (NOAA) has classified vibratory pile drivers as continuous noise and therefore an important consideration when evaluating the impact of any project on marine mammal species. Both installation methods and noise reduction strategies will be described in more detail later in this manual.

The Port performs all in-water construction within work windows established by the Corps of Engineers through consultation with NOAA and the U.S. Fish and Wildlife Service (USFWS). In-water construction windows are intended to concentrate work during periods when listed fish species, including Chinook salmon and bull trout, are generally not present in the project area due to their seasonal life history patterns. Other listed fish and wildlife, including marine mammals and avifauna, are less predictable with respect to seasonal presence/absence. To ensure these taxa are not impacted, trained personnel are engaged to monitor a predetermined action area and stop work if necessary. The Port follows all permit conditions and has a robust compliance tracking system to ensure and document permit compliance.

Fundamentals of Underwater Noise Assessment

Underwater acoustics is a highly complex science and this section is intended only to provide a very basic introduction. For a more in-depth introduction to underwater acoustics please review the 2009 Caltrans guidance manual prepared by ICF International and Illingworth and Rodkin, Inc.

Sound is emitted by the vibration of materials in a medium such as air or water. This vibration produces a sound wave that travels away from the source, known as acoustic radiation. In the case of pile driving activities, the piling vibrates as it's struck with an impact hammer or installed using a vibratory hammer. This noise radiates away from the piling and may cause harm if received by a species at sound levels within the auditory range specific to that species, called an audiogram.

Much of the research related to pile driving has focused on peak sound pressure levels received at close ranges (ICF International and Illingworth and Rodkin, Inc. 2020; WSDOT 2020). This is the result of more than a decade of research investigating the effects of impact pile driving on protected fish species, especially salmonids (Feist *et al.* 1996). With increased and recent attention focusing on potential anthropogenic noise impacts to marine mammals, more research has been conducted looking at the transmission of anthropogenic noises at long ranges with much of the recent research focused on the continuous noises produced by the construction and operation of offshore wind and tidal energy facilities as well as vessel noise (Nedwell *et al.* 2003b; Madson *et al.* 2006; Southall *et al*. 2007).

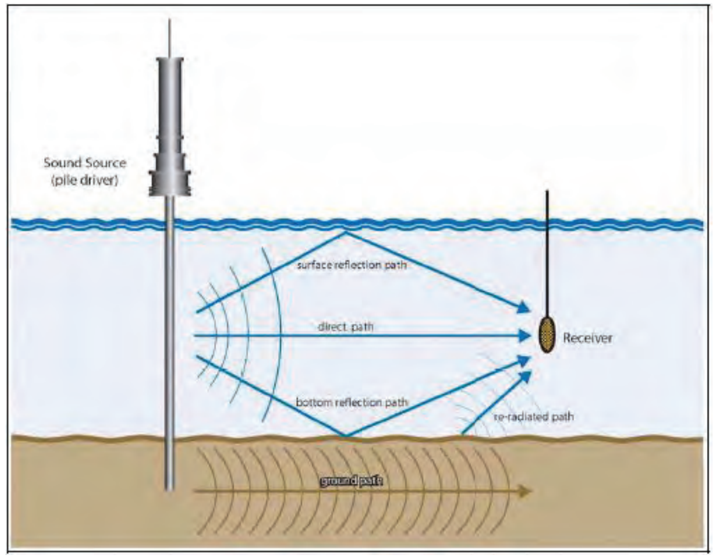

Figure 1: Sound Propagation Paths (ICF International and Illingworth and Rodkin, Inc. 2020)

Underwater Noise Prorogation

Underwater noise propagation is highly complex and difficult to predict with certainty. Complex interactions between other sources of natural and anthropogenic sound, substrate, water surface, temperature, and other factors all influence how sound propagates through the water.

Sound can propagate from the source to the receiver either directly, after reflecting off the surface of the water or substrate, or through and reradiated from the substrate. It is likely that underwater sound is actually received from a combination of all of these paths (ICF International and Illingworth and Rodkin, Inc. 2020; WSDOT 2020). A simplified propagation path diagram is illustrated in Figure 1.

Noise levels are usually expressed as a Sound Pressure Level (SPL) using decibels (dB) as the unit of measure and are tied to a specific reference pressure. A decibel is a logarithmic unit that measures the power or intensity (i.e., amplitude) of a sound pressure wave. For water, the standard reference pressure is one micro Pascal (1 µPa). The standard reference pressure for airborne SPL measurements is 20 µPa. *Within this document, all SPL levels are expressed in decibels (dB) and referenced to 1 µPa unless otherwise noted.*

Hydroacoustic Measurement Metrics

The waveform of underwater noise is typically expressed with three different metrics for the purpose of evaluating underwater noise impacts: Peak, Root Mean Square (RMS), and Sound Exposure Level (SEL). These metrics are illustrated in Figure 2 and described below:

- *Peak sound pressure (dB_{Peak})* — This metric measures the waveform from the node to the crest of the wave. Peak pressure is the maximum absolute value of the instantaneous pressure that occurs during a specified time interval and is usually used for impulsive sounds such as impact pile driving or underwater explosive detonations (WSDOT 2020). Non-auditory tissue damage, injuries such as swim bladder or capillary rupture, is correlated to the received peak pressure (ICF International, Illingworth and Rodkin, Inc 2020). At sufficiently high received levels, single events can injure an organism.

- *Root Mean Square (dB_{RMS})* — RMS measures the average sound level over a reference time period. It is calculated by squaring the amplitudes of the waveform over the reference period, determining the mean, and finally calculating the square root of the mean squared values (ICF International and Illingworth and Rodkin, Inc. 2020). This metric is typically used when measuring or comparing continuous noises such as ambient noise levels or noise produced by vibratory pile driving equipment.

Sound Exposure Level (db_{SEL}) — SEL is the constant sound pressure level in one second of exposure and is calculated by summing the cumulative pressure squared over the time of the event (WSDOT 2020). A single strike is measured to calculate SEL during impact pile driving while a one second duration is measured during vibratory pile driving.

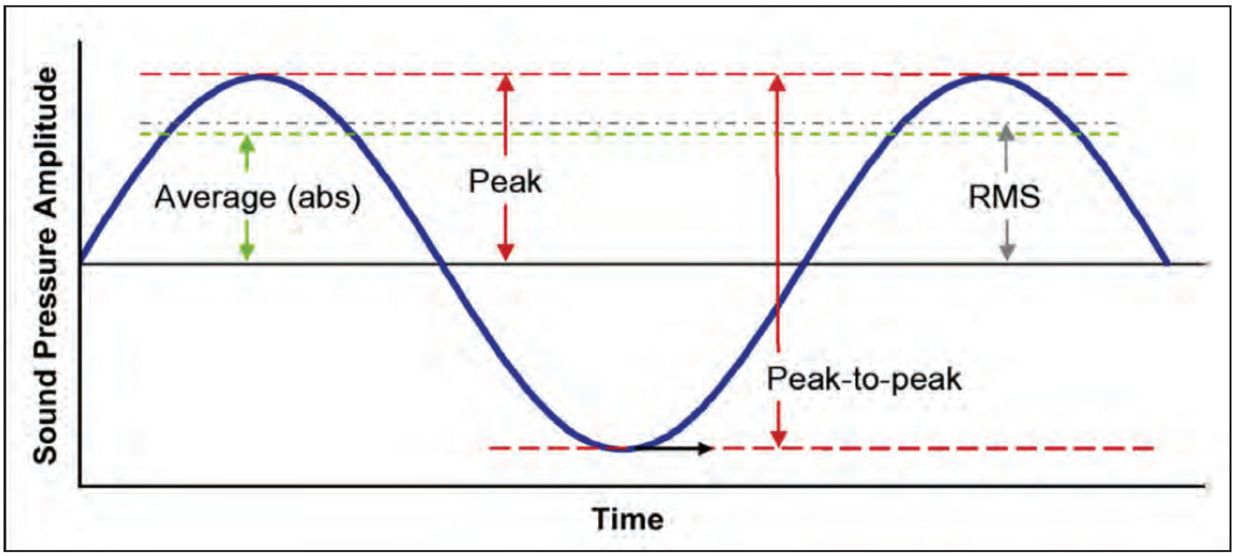

Figure 2: Sound Level Metrics (ICF International and Illingworth and Rodkin, Inc. 2020)

Cumulative SEL is a measure used to evaluate the cumulative effects of exposure to impact pile driving. ICF International and Illingworth and Rodkin, Inc (2020) calculate $SEL_{cumulative}$ using the following equation:

Equation 1: Calculation of $SEL_{cumulative}$
$SEL_{cumulative} = dB_{SEL} + 10 \log (\# \text{ of strikes})$

Another metric that can help describe the configuration of an underwater noise signal is rise time. Rise time describes the time period, typically measured in milliseconds, in which the underwater noise signal rises from 10 percent to 90 percent of its highest peak value (ICF International and Illingworth and Rodkin, Inc. 2020). Figure 3 illustrates rise time.

Rise time may be important in describing the shape of the underwater noise waveform. WSDOT (2010) suggest that a slower rise time, and therefore a more spread-out shape, may help explain why the use of vibratory pile drivers has not been linked to fish injury. Popper *et al.* (2006) notes that mammalian auditory damage is more likely with "sharp" pulsed sounds as opposed to "dull" sounds, meaning that more damage is likely when the sound has a short rise time. Rise time has not been used as a primary metric for noise assessment and is typically not discussed in detail as part of monitoring reports (ICF International and Illingworth and Rodkin, Inc. 2020; WSDOT 2020). The use of different impact and vibratory pile driving equipment, noise attenuation strategies, and other factors would change the signal rise time. We present this metric to illustrate and explain rise time but do not consider it in our analysis as the current noise impact analysis methods suggested by federal resource agencies do not consider it.

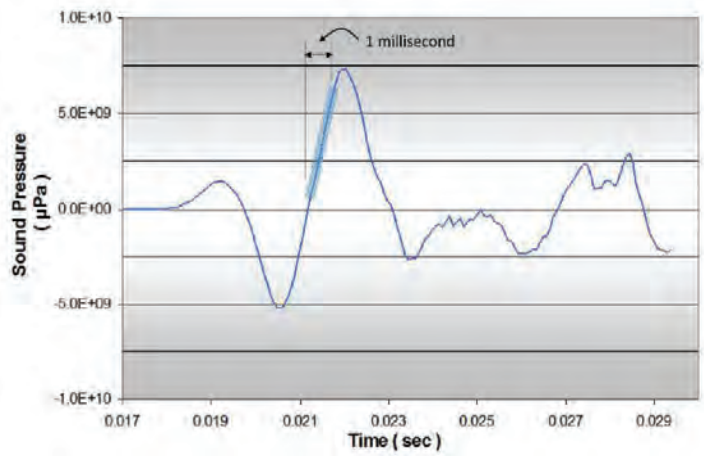

Figure 1. Illustration of Rise Time (ICF Jones & Stokes and Illingworth and Rodkin Inc. 2020)

<u>Audiograms and Frequency-dependent Analysis Bandwidths</u>

Different species "hear" and respond to noise differently (Southall *et al.* 2007; ICF International and Illingworth and Rodkin, Inc. 2020; WSDOT 2020). The hearing ability of an organism is frequency dependent, meaning that an organism may have difficulty hearing a certain frequency (e.g., low frequency) while being extremely sensitive at a different frequency (e.g., high frequency). Audiograms visually portray the relationship between frequency (x axis) and hearing ability (y axis).

It is important to note that while thresholds and acoustic measurements for pile driving typically referenced in decibels, two decibel values may not be directly comparable if the analysis bandwidth—the specific range of signal wavelengths selected for analysis—used to calculate the decibel values differ. If part of the signal frequency lies outside of the analysis bandwidth, it is ignored (Burgess *et al.* 2005). For this reason, injury / disturbance thresholds and monitoring data characterizing different types of noise emitted during pile driving activities have relied on broadband analysis bandwidths that cover a wide range of wavelengths (Burgess *et al.* 2005). While this approach simplifies the sound analysis for projects by reducing the number of data points for a given pile type, the measured sound level for the pile driving may be influenced by other sources, not part of the analysis, masking the true influence of the project under consideration (Burgess *et al.* 2005).

Recent monitoring reports published by WSDOT have calculated and reported decibel measurements of ambient noise using three analysis bandwidths that are appropriate for cetaceans, pinnipeds, as well as a broadband measurement (Laughlin 2011). While this may be valuable data for the future, it is not appropriate to compare sound measurements for piling installation collected using a broadband analysis window with ambient noise data collected and analyzed using a narrower analysis bandwidth specific to a particular species. While it is true that two signals of different wavelengths could be compared using decibels (because the decibel measures amplitude), it is not the case with complex noises such as pile driving that span a wide range of wavelengths. By employing an analysis bandwidth, the sound is compressed. The energy that makes up a decibel value using one analysis bandwidth is different and distinct from another analysis bandwidth and not comparable. A sound measured using a broadband analysis bandwidth includes a wide range of frequencies while narrower analysis bandwidths do not. Most monitoring data are collected and reported using a broadband analysis window. While it is acknowledged that recent guidance on marine mammals recognizes low, mid, and high frequency hearing groups (NOAA 2018), most of the publicly-available pile noise data has been collected as broadband data. Until more data is gathered describing the acoustic properties of pile driving within analysis bandwidths that are appropriate to specific species or hearing groups, sound impact analysis should be performed using a broadband analysis window.

Injury and Disturbance Thresholds

NOAA and others have established thresholds to guide the determination of whether pile driving noise may adversely affect species of concern. The effects depend on the auditory range of a given species (i.e., the range of wavelengths that the species can "hear"), the transmission characteristics of sound within that auditory range, and the harm caused by the received level (Nedwell *et al.* 2007; ICF International and Illingworth and Rodkin, Inc. 2020; WSDOT 2020). Injury may be dependent on the mass of an organism, exposure time, species, functional hearing group, and many other factors (Nedwell *et al.* 2007; Carlson *et al.* 2007; WSDOT 2020).

Generally, the data that has been collected as part of monitoring efforts does not account for species-specific auditory ranges and instead is collected over a broadband range (ICF International and Illingworth and Rodkin, Inc. 2020; WSDOT 2020). Broadband estimates of produced noise allow for the easy application of assessment tools and cover the broad range of frequencies likely to impact species; however, it may not provide an assessment mechanism that accurately predicts harm or disturbance to a species of concern. This is because the thresholds and measured sound levels are not tied to the species-specific auditory range being considered. Additionally, the thresholds established by the agencies are precautionary and may overestimate the distance that sound propagates under water. Care should be taken when compiling data from monitoring reports and other sources to ensure that estimates are comparable.

Impact pile driving produces impulsive noise with higher peak amplitude than the continuous noise produced by vibratory pile driving. While environmental effects of the impulsive noise produced by impact pile driving have been well-documented, the effects of continuous lower-amplitude noise produced by vibratory hammers have not (ICF International and Illingworth and Rodkin, Inc. 2020; WSDOT 2020; Hastings 2010). Although vibratory hammers generate lower peak sound levels than impact hammers, installing a pile by vibratory methods can still generate substantial acoustic energy as this method requires more time than impact driving and operates continuously (ICF International and Illingworth and Rodkin, Inc. 2020). However, to achieve full structural embedment, often impact "proofing" following full vibratory installation is required. At present, however, vibratory hammers are a preferred pile driving method on the basis that they produce lower peak sound pressures, have shorter rise time, and are consequently assumed to have less impact on fish (ICF International and Illingworth and Rodkin, Inc. 2020; WSDOT 2020). This assumption is supported by the fact that there are no indications, anecdotal or otherwise, that vibratory hammers have caused injury or mortality in fish. Despite this, vibratory hammers have increasingly come into question because of their potential cumulative effects on marine mammals, which have a different auditory range and are thus susceptible to underwater noise in a different bandwidth. The specific thresholds for both fish and marine mammals are presented in the tables below. It should be noted that formal thresholds for the vibratory installation of piling have not been established for fish or avian species and no injury or mortality has been observed, as noted above. Hastings (2010) provides the first study to specifically look at the issue of vibratory pile driving and fish injury but the study is focused on preliminary laboratory experiments using warm-water freshwater species, not salmonid species in cold estuarine environments. For this reason, the Port did not use the Hastings thresholds in its analysis.

Table 1: Fish Injury Thresholds: <u>Impact Pile Driving</u>

Effect	**Metric**	**Fish mass (grams)**	**Threshold**
Onset of physical injury	Peak Pressure	All, N/A	206 dB_{Peak}
	Accumulated Sound Exposure Level (SEL)	≥ 2 g	187 $dB_{Cum.\ SEL}$
		< 2 g	183 $dB_{Cum.\ SEL}$
Adverse behavioral effects	Root Mean Square Pressure (RMS)	All, N/A	150 dB_{RMS}

<u>Source:</u> Fisheries Hydroacoustic Working Group (FHWG), 2006. "Agreement in Principle for Interim Criteria for Injury to Fish from Pile Driving Activities"

Table 2: Marine Mammal Thresholds

	Underwater Noise Thresholds				
	Impulsive Sound Impact Pile Driving			Non-Impulsive Sound Vibratory Pile Driving	
	Auditory Injury Threshold (PTS)		Behavioral Disturbance Threshold	Auditory Injury Threshold (PTS)	Behavioral Disturbance Threshold
Species	Peak SPL	dB SEL_{cum}	dB RMS	dB SEL_{cum}	dB RMS
Low-Frequency Cetaceans	219	183 LF, 24h	160	199	120
Mid-Frequency Cetaceans	230	185 MF, 24h	160	198	120
High-Frequency Cetaceans	202	155 HF, 24h	160	173	120

<u>Source</u>: Washington State Department of Transportation, 2020. "Marine Mammal Injury and Disturbance Thresholds." <
https://wsdot.wa.gov/environment/technical/fish-wildlife/esa-efh/BA-preparation-manual> (Retrieved Mar 03, 2020)

NMFS has recently updated injury thresholds for marine mammals to include three different hearing groups—low, mid, and high. The 120 dB_{RMS} continuous noise threshold used by NOAA is a precautionary threshold that is based on a single study. Research done by Southall *et al.* (2007) seems to refute the precautionary threshold, suggesting that industrial noise exposures in the range of 90 dB and 140 dB do not induce strong behavioral responses in pinnipeds. Recognizing this uncertainty, NOAA has undertaken a science-based initiative to establish new thresholds. For the time being, the Port has used the precautionary 120 dB threshold for its analysis. NMFS has recently introduced cumulative auditory injury thresholds from non-impulsive (vibratory) sound, varying with hearing group (NOAA 2018).

Table 3: Marbled Murrelet Thresholds

	Auditory injury threshold (permanent threshold shift)	Non-auditory injury threshold (barotrauma)	Behavioral
Marbled murrelet	202	208	150

<u>Source: USFWS 2011.</u>

Underwater Noise Spreading Models

Underwater sound propagation is dependent on many factors including bathymetry, substrate, and salinity (ICF International and Illingworth and Rodkin, Inc. 2020; WSDOT 2020). Due to the complex nature of the interaction between these factors and others the development of site-specific models that accurately predict sound propagation is impractical. Estimates of sound propagation rely on empirical data gathered as part of past projects and simplified exponential decay spreading models in an attempt to estimate the effects of projects.

The simplified spreading model is defined in Equation 2 below:

Equation 2: Spreading Loss Model
$TL = F \bullet Log(R_1/R_2)$ Where: • TL is the transmission loss in dB • F is a site-specific attenuation factor or generalized attenuation estimate. A value of 15 should be used if more specific data is not available. • R_1 is the range of the SPL • R_2 is the range at which the SPL measurement was taken, typically 10 meters.

Equation 2 has three commonly used variants. These include:

- **Spherical Spreading Model (F = 20),**
- **Practical Spreading Loss Model (F = 15)**
- **Cylindrical Spreading Model (F = 10)**

The F parameter controls how rapidly sound attenuates in water with higher values representing a more rapid attenuation towards zero. The Microsoft Excel based tool developed by John Stadler and David Woodburry at NOAA in 2009 recommends using an F value of 15 if site-specific data is not available. WSDOT and others refer to an F value of 15 as the Practical Spreading Loss Model (PSLM) and the Port has adopted this terminology and value for its analysis.

Equation 3 rearranges Equation 2 to solve for the distance (R_1) at which a known source sound level is expected to attenuate to a target level, such as one of the thresholds presented in Table 1-2 or an ambient noise value.

Equation 3: Application of the spreading model by solving for R_1
$R_1 = (10^\wedge((dB_{Source} - dB_{Target})/F))*R_2$ Where: • R_1 is the range at which the source sound attenuates to dB_{Target} • dB_{Source} represents the source SPL at range R_2 • dB_{Target} represents the SPL you are interested in. For example, this value may represent a threshold or ambient noise value. • F is a site-specific attenuation factor or generalized attenuation estimate. A value of 15 should be used if more specific data is not available. • R_2 is the range at which the SPL measurement was taken, typically 10 meters.

Monitoring reports published by WSDOT for piling projects at the Vashon Island Ferry Terminal indicate that the Spherical Spreading Model (F=20) may approximate the attenuation characteristics better than the PSLM (Laughlin 2010b). Bathymetric conditions at the Vashon Island Ferry Terminal are similar to many Port facilities, including Terminal 91 and Pier 66. As more data specific to central Puget Sound is collected by WSDOT, it may be appropriate to select a different F value. However, until more data is gathered or a better model is developed, the Port will rely on the PSLM for its analysis, consistent with the recommendations of NOAA staff and the training manuals developed by Caltrans and WSDOT.

The PSLM and other variants of the simplified model may not be effective in estimating the area affected by a project at distances greater than one kilometer. This is due to additional sources of anthropogenic and natural underwater noise and scattering (WSDOT 2020). While the Caltrans manual suggests limiting the action area to one kilometer if the expected action area exceeds this distance, the Port has chosen to report the values provided by the equation and accepted by the services. The Port feels that while the PSLM likely significantly overestimates the range at which noise associated with pile-driving projects are detectible, specific data is lacking and therefore choosing one kilometer as the cutoff is arbitrary. Instead, appropriate mitigation and/or monitoring efforts may be discussed with the permitting agencies with jurisdiction.

It should be noted that the outputs of the simple propagation models commonly used for noise impact analysis are rough estimates. Care should be taken to avoid the pitfalls of false precision when developing appropriate monitoring and mitigation strategies.

Pile Driving Data Selection and Model Application

This section provides details on how the Port analyzed underwater noise impacts using the thresholds and the PSLM. To ease future analysis for Port projects, and provide an easy tool for others, we adapted and improved the Stadler and Woodburry (2009) spreadsheet. The tool is described within this section and an electronic copy provided with the submittal of this report.

Acoustic Data Selection

Monitoring data from the Caltrans and WSDOT noise assessment manuals, WSDOT monitoring reports, past Port pile driving projects, and other resources were gathered. In situations where multiple data points for a given type, material, and diameter pile were available, the report that best represented the Port's facilities and bathymetric setting was selected. For example, multiple data points for 16-inch steel piling were available. One data point was from California in Illingworth and Rodkin (2009) and the other was from a Washington State Department of Transportation monitoring report. The WSDOT report was selected because it was gathered locally in Puget Sound in substrate conditions known to be similar. If multiple data points were available and a clear selection could not be made without additional data, both were presented in the table and modeled.

Every effort was made to use the most recent and most applicable data available. In most cases, data specific to Puget Sound was limited. ICF International and Illingworth and Rodkin, Inc. (2020), ICF Jones & Stokes and Illingworth and Rodkin, Inc. (2012) and WSDOT-funded studies, collected in WSDOT 2020 were the primary acoustic data references. The Port's objective was to compile the most complete and representative list of pile driving scenarios possible given an extensive literature review and available data for each type of piling and both impact and vibratory installation methods. Unfortunately, it was impossible to construct a complete vibratory pile driving dataset. To work around this issue, where vibratory data on a specific pile size was not available, comparable impact sound level data was gathered and a 17 dB reduction was applied, consistent with the difference observed between impact and vibratory pile drivers reported in the 2010 WSDOT manual (WSDOT 2010) and Nedwell and Edwards (2002).

Tables depicting the sound pressure levels for each type of modeled piling using an impact and vibratory hammer are presented below. In the results section of this document, the modeled distances to each threshold are presented.

Table 3: Impact Pile Driver Acoustic Data

Pile type	dB_{Peak}	dB_{RMS}	dB_{SEL}	Citation
24" Steel AZ Steel Sheet	205	190	180	ICF Int'l / Illingworth and Rodkin, Inc. 2020
24" Concrete Pile	194	181	167	Laughlin 2007
36" Concrete	192	176	174	WSDOT 2010
10" Steel H-Pile	190	175	155	ICF Int'l / Illingworth and Rodkin, Inc. 2020
12" Steel H-Pile - Thin	190	175	160	ICF Int'l / Illingworth and Rodkin, Inc. 2020
12" Steel H-Pile - Thick	200	183	170	ICF Int'l / Illingworth and Rodkin, Inc. 2020
15" Steel H-Pile	195	180	170	ICF Int'l / Illingworth and Rodkin, Inc. 2020
12" Steel Pile	198	181	166	Laughlin 2006
14" Steel Pile	200	184	174	ICF Int'l / Illingworth and Rodkin, Inc. 2020
16" Steel Piling	200	187	174	Laughlin 2004
18" Steel Pipe	195	169	166	Laughlin 2010d
20" Steel	208	187	176	ICF Int'l / Illingworth and Rodkin, Inc. 2020
24" Steel	207	194	178	ICF J&S / Illingworth and Rodkin, Inc. 2012
30" Steel	212	195	186	Laughlin 2005b
36" Steel	214	201	186	Laughlin 2007
12-14" Wood / Timber	180	170	160	Illingworth &Rodkin, Inc. 2007

Table 4: Vibratory Pile Driver Acoustic Data

Title	dB_{Peak}	dB_{RMS}	dB_{SEL}	Citation
24” Steel Sheet Pile - Typical	175	160	160	ICF J&S / Illingworth & Rodkin, Inc. 2015
24” Steel Sheet Pile - Loudest	182	165	165	ICF J&S / Illingworth and Rodkin, Inc. 2015
24” Concrete [1]	177	164	150	Laughlin 2007[1]
36” Concrete [1]	175	159	157	ICF Int’l / Illingworth and Rodkin, Inc. 2020
10” Steel H-Pile	161	147	-	ICF J&S / Illingworth and Rodkin, Inc. 2007 2012
12” Steel H-Pile	165	150	150	ICF Int’l / Illingworth and Rodkin, Inc. 2020
12” Steel	171	155	155	ICF J&S / Illingworth and Rodkin, Inc. 2012
14” Steel [1]	183	167	157	Laughlin 2004[1]
16” Steel [1]	183	170	157	ICF Int’l / Illingworth and Rodkin, Inc. 2020
18” Steel [1]	196	158	158	ICF J&S / Illingworth and Rodkin, Inc. 2012[2]
20” Steel [1]	191	170	159	ICF Int’l / Illingworth and Rodkin, Inc. 2020
24” Steel	181	153	153	Laughlin 2010b (Keystone)
30” Steel - Keystone	196	171	-	Laughlin 2010c (Vashon)
30” Steel - Vashon	187	164	-	ICF J&S / Illingworth & Rodkin, Inc. 2015
36” Steel Pipe (Loudest)	185	175	175	ICF J&S / Illingworth & Rodkin, Inc. 2012
36” Steel Pipe (Typical)	180	170	170	ICF J&S / Illingworth & Rodkin, Inc. 2012
12” Wood / Timber [1]	163	153	143	ICF J&S / Illingworth and Rodkin, Inc. 2012
18” Wood/ Timber	--	155	--	Grette Associates 2010

[1] Vibratory hydroacoustic data was not available therefore a 17 dB reduction from impact levels was applied (WSDOT 2020; Nedwell and Edwards 2002).
[2] Due to lack of data, the same values for vibratory installation were assumed for vibratory removal.

Noise Attenuation Strategies

WSDOT 2020 reviewed several past projects and found that “unconfined” bubble curtains reduced sound pressure levels by an average of 8.7 dB and “confined” bubble curtains achieved an average reduction of 13.8 dB (WSDOT 2020). However, the WSDOT study revealed, among other things, that the effectiveness of bubble curtains is highly variable – with attenuation ranging from 0 dB to 38 dB. This variability can most likely be attributed to the type of device used and whether it was properly installed.

To address the uncertainly associated with the effectiveness of bubble curtains, the Port is continuing to use a reduction of 9 dB to use for its noise modeling; this has been a standard conservative estimate for general attenuation using a bubble curtain, and no recent data compellingly supports changing this estimate. This is quite conservative and the Port anticipates that bubble curtains deployed during its projects will provide greater attenuation, consistent with the reported results of WSDOT and Caltrans. It should be noted that bubble curtains have not been shown to be effective in reducing underwater noise produced by vibratory pile drivers and there are no known noise reduction strategies for vibratory hammers available at this time. Therefore, no noise attenuation / mitigation device is assumed when analyzing the effects of a vibratory pile driver.

Model Data Requirements

To run an analysis using the methods recommended by the services, the Caltrans manual, and the WSDOT manual, four key pieces of information were needed. These included:

- The dB_{Peak}, dB_{RMS}, and dB_{SEL} underwater sound metric values for a given type of piling gathered from available monitoring reports and other sources.

- The maximum number of piles per day, which was estimated through discussions with Port project managers and engineers. For both impact and vibratory pile drivers, the maximum number of piles we would expect to install is eight per day at a given facility.
- The estimated number of pile strikes needed to install the pile when using an impact hammer. Based on past work conducted by the Port, a conservative estimate of 400 strikes per pile was used.
- The estimated ambient noise level. Recent ambient sound data collected by WSDOT in Elliott Bay indicates a day-time, broadband ambient noise value of 120 dB_{RMS} (Laughlin 2020).
- The threshold to which analysis was being performed. Each threshold presented in Table 1 and Table 2 above was analyzed.

<u>Port of Seattle Sound Evaluation (POSSE) Excel-based tool</u>

The Port developed the Port of Seattle Sound Evaluation (POSSE) tool to build on and improve the Stadler and Woodbury (2009) model. Benefits of the POSSE tool include:

- Reduces the repetition needed to calculate the distances to multiple thresholds;
- Eases data input requirements;
- Allows source sound levels to be input and the ranges at which the measurements were taken;
- Automatically calculates the distance to each threshold using the Spherical, Practical, and Cylindrical spreading models and presents output on the same page; and,
- Allows the user to change various parameters of the model such as thresholds if new science becomes available, the "F" attenuation value, nominal standard measurement range, and ambient noise level.
- Presents output specific to both impact and vibratory thresholds.

The POSSE impact worksheet presents thresholds based on the stationary fish model adapted from Stadler and Woodbury (2009) as well as marine mammal thresholds based on NOAA guidance. The vibratory output worksheet is limited to the marine mammal threshold since continuous noise thresholds have not been established for fish. While researching the assessment of underwater noise, a few common potential analysis pitfalls were identified including: erroneous range calculations when the source level was below the ambient noise or a threshold value; calculation of cumulative SEL at 10 meters when the range of the piling measurement was not 10 meters; and confusion over how to apply ambient noise and noise attenuation devices to the analysis.

The first issue identified was that the Stadler and Woodbury (2009) worksheet would calculate a erroneous range when the received sound pressure level at ten meters was less than a given threshold or ambient noise level. To illustrate this problem, consider the following scenario. A piling emits a SPL of 140 dB at ten meters. The threshold of interest is 130 dB. In this situation transmission loss (TL) defined in Equation 2 would be equal to 140 dB minus 130 dB, or 10 dB. Ten decibels makes sense because we have a positive sound level emitted from the piling during pile driving operations. Now consider the following alternative scenario that illustrates the problem. A piling emits a SPL of 124 dB at ten meters and the threshold we are interested in is 190 dB. The threshold has a greater decibel value than our source and therefore is not exceeded. TL would be -66 dB in this scenario and the Stadler and Woodbury (2009) tool would calculate a range. The POSSE tool that the Port developed catches these situations and marks the cell value as "Src ≤ Thres" to indicate that the threshold is greater than or equal to the sound source level. Similarly, if a threshold is less than the ambient noise value, the field is marked as "Ambient" to indicate that the appropriate project impact area is the distance required to attenuate to the ambient noise level.

The second issue the POSSE tool addresses is the calculation of cumulative SEL at ten meters. A near-field measurement distance of ten meters appears to be the standard used for both acoustic thresholds and acoustic data measurements. The Stadler and Woodburry spreadsheet accommodates any measurement distance as input but only calculates the cumulative SEL at that range. The POSSE tool uses each spreading model to calculate acoustic metrics, including cumulative SEL, at ten meters. This ensures that the acoustic metrics are comparable regardless of the measurement range. While this approach adds some complexity to the calculations that POSSE performs in the background, the values are identical to the Stadler and Woodburry spreadsheet at ten meters assuming a ten-meter acoustic data measurement distance.

The last major issue that POSSE addresses is the application of ambient noise levels and noise mitigation devices to the spreading model. The Stadler and Woodburry (2009) tool requires the user to manually subtract the expected noise attenuation and/or ambient noise level from the source acoustic metrics. The POSSE tool simplifies this process and makes it less prone to error by providing additional input fields that control the ambient noise level and expected noise attenuation from an acoustic mitigation device. The addition of these fields should greatly simplify the use of the PSLM for project evaluation for Port staff and others who wish to use it.

If errors are identified in the POSSE tool please report them to Jon Sloan, Port of Seattle - Seaport Environmental. This tool was developed as in in-house aid for Port of Seattle staff performing noise analysis and the default values provided in the spreadsheet may not be appropriate for all environmental settings or otherwise accurate. Please independently verify your data and the model prior to relying on it for your analysis. The Port of Seattle assumes no responsibility for interpretation of the results of these models by non-Port users.

<u>Mapping the Results</u>

The POSSE tool was used to generate the distance to each threshold for each type of piling. The Port mapped these distances using an advanced GIS system and process.

Within the GIS, the worst-case pile driving location for each facility was selected, meaning that there is no other location at the facility that is more exposed to the free spreading of underwater noises. From this pile-driving point, a GIS process constructed the area potentially exposed to underwater sounds, considering the shape of the shoreline and based on a process similar to traditional "line-of-sight" analysis. Each threshold was constructed by buffering the pile driving point location by the calculated distance and limiting the area displayed by the area "visible" from the pile driving location. The result is an analytical representation of both the distance and extent of underwater noise related to pile driving at the most exposed location at each Port facility. The model does not account for underwater obstructions, bathymetry, or complex refraction or reflection characteristics. It is consistent with, and potentially more accurate than, recommendations to manually interpret the area, treating the shoreline as an obstruction.

Noise Modeling Results

The results of the Port's modeling efforts are presented in the tables at the end of the report. The ambient noise value used for analysis was 120 dB_{RMS} collected using a broadband analysis bandwidth. For impact pile driving the distances to the stationary fish thresholds (Peak injury, cumulative SEL, and behavior) were calculated as well as the distances to marbled murrelet injury and disturbance, cetacean injury and disturbance, and pinniped injury and disturbance. For vibratory pile driving, the results include the distance to ambient noise, cetacean injury and disturbance, and pinniped injury and disturbance. No thresholds have been established for fish or marbled murrelets when using a vibratory hammer.

Conclusion

Both impact and vibratory pile driving create underwater noise that may be harmful to threatened and endangered species above certain threshold levels. The Port of Seattle routinely undertakes pile driving activities in support of its maritime industrial facilities, cruise terminals, marinas and commercial development. As a consequence of regulatory compliance, and to further its environmental stewardship, the Port has completed a rigorous analysis of underwater noise produced by its pile driving activities in order to gain a better understanding of the potential effects it may have.

This report includes discussion of basic hydroacoustic principles as well as model output for different types of piles, pile sizes and hammer types. Also included are facility maps that illustrate the distance to injury and disturbance thresholds for cetaceans, fish, and marbled murrelets. The Port will use the modeled data and associated maps to inform project design as well as to develop effective mitigation and monitoring programs.

Table 1. Distance to injury and behavioral thresholds (meters)

						Salmonids			Murrelets		Marine Mammals					
											Cetacean			Pinnipeds		
Pile Size/Type[1,2]	dB_{PEAK}	dB_{RMS}	dB_{SEL}	Ambient 120 dB_{RMS}[2]	Salmonid and murrelet bhvrl	Single-strike injury	Cum SEL injury - mass <2g	Cum SEL injury - mass >2g	Auditory injury	Baro-trauma	Cum PTS (low-freq hearing group)	Cum PTS (mid-freq hearing group)	Cum PTS (hi-freq hearing group)	Cum PTS (phocid)	Cum PTS (otariid)	Bhvrl
10" Steel H-Pile[4]	190	175	155	11,659	117	-	4	5	0	0	34	1	41	18	1	25
12" Steel H-Pile – Thin[4]	190	175	160	11,659	117	-	9	12	1	0	34	1	41	18	1	25
12" Steel H-Pile – Thick[4]	200	183	170	39,811	398	-	40	54	4	2	117	4	140	63	5	86
15" Steel H-Pile[4]	195	180	170	25,119	251	-	40	54	4	2	74	3	88	40	3	54
12" Steel Pipe[5]	198	181	166	29,286	293	-	22	29	2	1	86	3	1038	46	3	63
14" Steel Pipe[4]	200	184	174	46,416	464	-	74	100	7	3	137	5	163	73	5	100
16" Steel Pipe[6]	200	187	174	73,564	736	-	74	100	7	3	217	8	258	116	8	158
18" Steel Pipe[7]	195	169	166	4,642	46	-	22	29	2	1	40	1	48	21	2	10
20" Steel Pipe[4]	208	187	176	73,564	736	-	101	136	10	4	217	8	258	116	8	158
24" Steel Pipe[8]	207	194	178	215,443	2,154	-	137	185	14	5	253	9	301	135	10	464
24" Steel AZ Sheet Pile[4]	*205*	*190*	*180*	*464,158*	*4,642*	-	*741*	*1000*	*74*	*30*	*1,363*	*49*	*1,630*	*732*	*53*	*1,000*
30" Steel Pipe[9]	212	195	186	251,189	2,512	-	468	631	47	19	863	31	1,028	462	34	541

[1] No attenuation from bubble curtain is assumed as a bubble curtain cannot be used with sheet pile. However, it is assumed that sheet pile would be driven with a vibratory hammer rather than an impact hammer as they would not be weight-bearing. Thus, these SPL levels would not be generated.
[2] Attenuation from bubble curtain is assumed to be 9dB; this has not been applied to the SPL levels but has been applied to the distance to threshold estimates. No attenuation is assumed for impact driving of sheet piles.
[3] Laughlin 2020
[4] ICF Int'l/ Illingworth and Rodkin, Inc. 2020
[5] Laughlin 2006b (Cape Disappointment)
[6] Laughlin 2004 (SR 240 Yakima River)
[7] Laughlin 2010a (Wahkiakum)
[8] Laughlin 2007 (Mukilteo)
[9] WSDOT 2010

Table 2. Distance to injury and behavioral thresholds for vibratory pile driving (meters)

Pile[1]	dB_{RMS}	Cumulative PTS low freq hearing group (199 $dB_{SEL\ CUM}$)	Cumulative PTS med freq hearing group (198 $dB_{SEL\ CUM}$)	Cumulative PTS high freq hearing group (173 $dB_{SEL\ CUM}$)	Cumulative PTS phocid (201 $dB_{SEL\ CUM}$)	Cumulative PTS otariid (219 $dB_{SEL\ CUM}$)	Behavioral threshold (120 dB_{RMS})
10” Steel H-Pile[2]	147	3.2	0.3	4.7	1.9	0.1	631
12” Steel H-Pile[3]	150	5.0	0.4	7.5	3.1	0.2	1,000
12” Wood / Timber[1,3]	153	8.0	0.7	11.8	4.9	0.3	1.585
12” Steel[2]	155	10.9	1.0	16.1	6.6	0.5	2,154
14” Steel[1,3]	167	68.6	6.1	101.5	41.7	2.9	13,593
16” Steel[1,4]	170	108.8	9.6	160.8	66.1	4.6	21,544
18” Wood / Timber [5]	155	10.9	1.0	16.1	6.6	0.5	2,154
18” Steel[2]	158	17.2	1.5	25.5	10.5	0.7	3,414
20” Steel[1,3]	170	108.8	9.6	160.8	66.1	4.6	21,544
24” Steel[2]	153	8.0	0.7	11.8	4.9	0.3	1,585
24” Steel Sheet Pile – Typ.[6]	160	23.4	2.1	34.6	14.2	1.0	4,641
24” Steel Sheet Pile – Loudest[6]	165	50.5	4.5	74.6	30.7	2.2	10,000
24” Concrete[1,7]	164	43.3	3.8	64.0	26.3	1.8	8,577
30” Steel – Vashon[8]	164	43.3	3.8	64.0	26.3	1.8	8,577
30” Steel – Keystone[9]	171	126.8	11.2	882.0	396.3	28.9	25,119

[1] Where vibratory hydroacoustic data was not available, a 17 dB reduction from impact levels was applied (WSDOT 2010; Nedwell and Edwards 2002).
[2] ICF International / Illingworth and Rodkin, Inc. 2020.
[3] ICF Jones & Stokes / Illingworth and Rodkin, Inc. 2012
[4] Laughlin 2004
[5] Grette Associates 2010
[6] ICF Jones & Stokes / Illingworth & Rodkin, Inc. 2015
[7] Laughlin 2004
[8] Laughlin 2010c (Vashon)
[9] Laughlin 2010d (Keystone)

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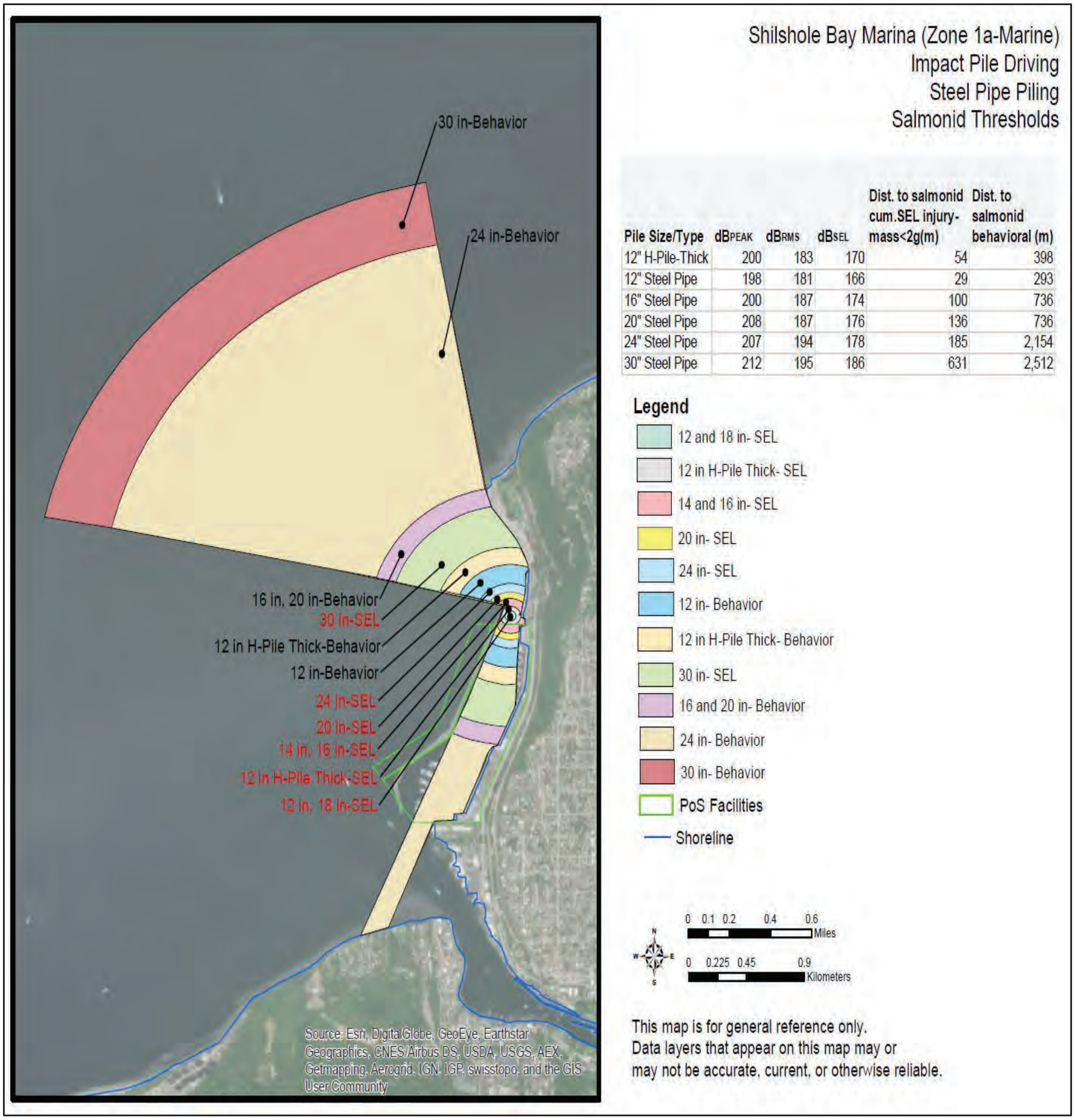
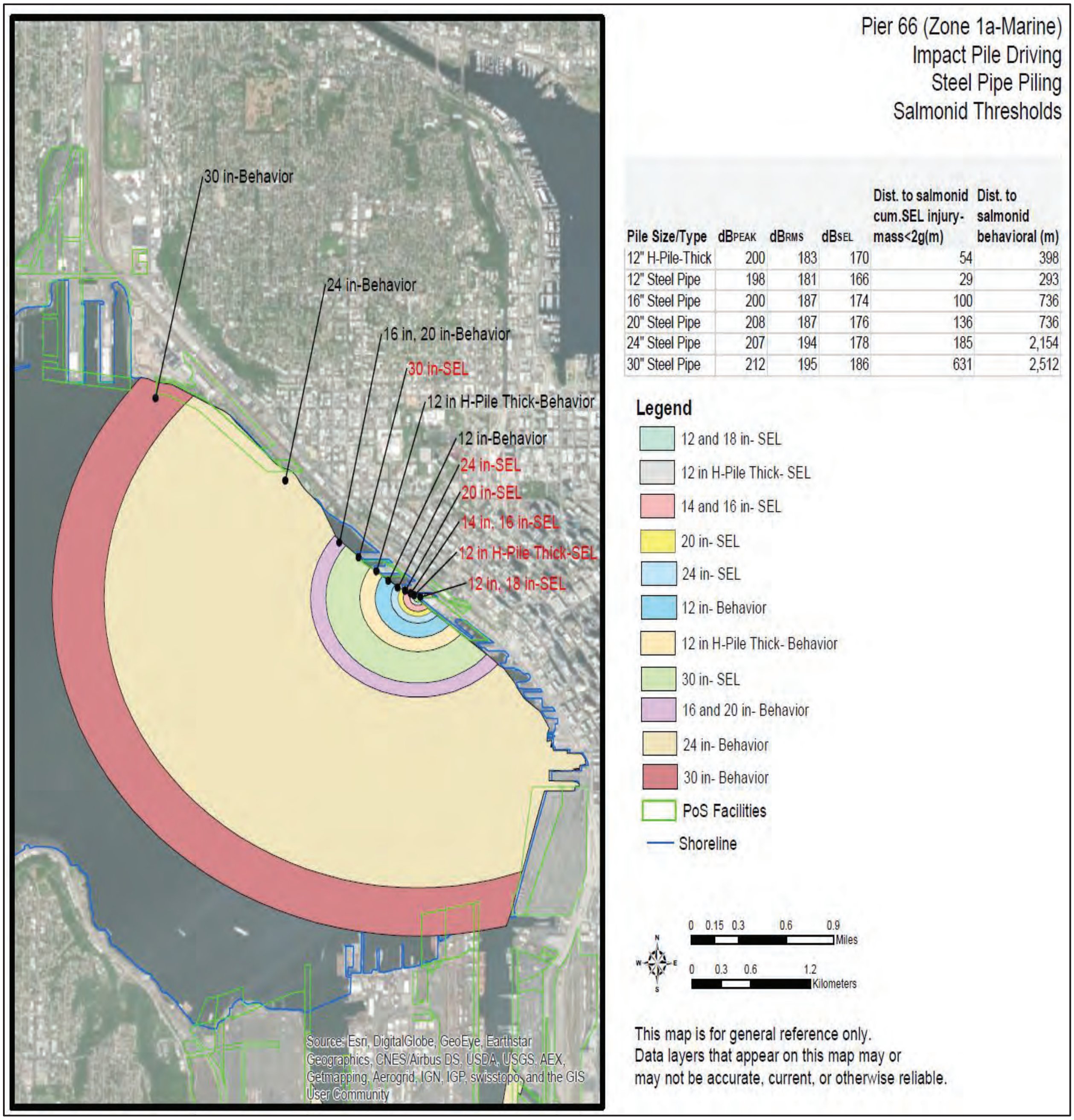
Appendix: Pile Driving Sound Maps



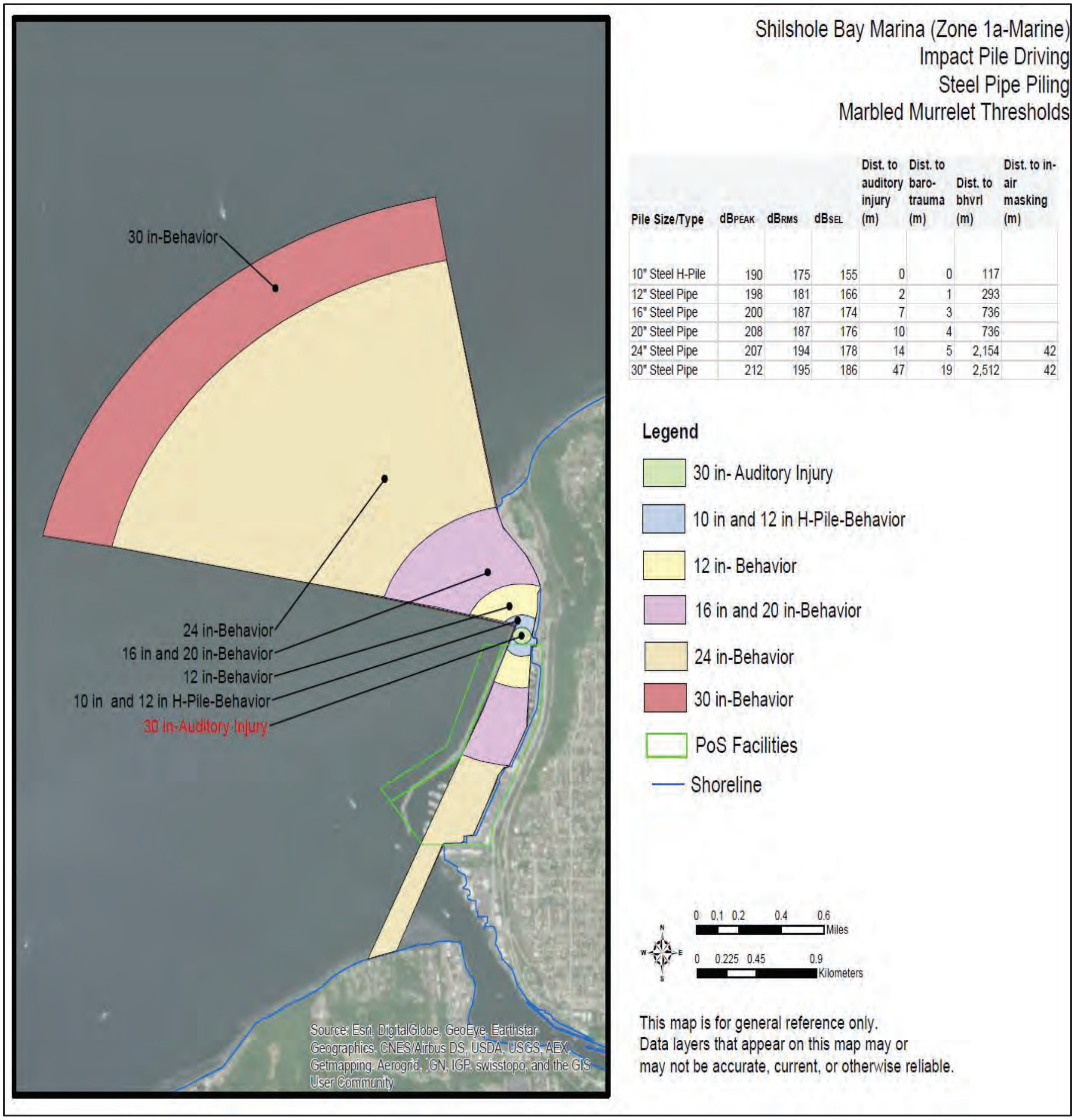
Pile Size/Type	dBPEAK	dBRMS	dBSEL	Dist. to salmonid cum.SEL injury-mass<2g(m)	Dist. to salmonid behavioral (m)
12" H-Pile-Thick	200	183	170	54	398
12" Steel Pipe	198	181	166	29	293
16" Steel Pipe	200	187	174	100	736
20" Steel Pipe	208	187	176	136	736
24" Steel Pipe	207	194	178	185	2,154
30" Steel Pipe	212	195	186	631	2,512

Figure 1. Typical impact pile driving noise extents within Zone 1A, salmonids (Shilshole Bay Marina)



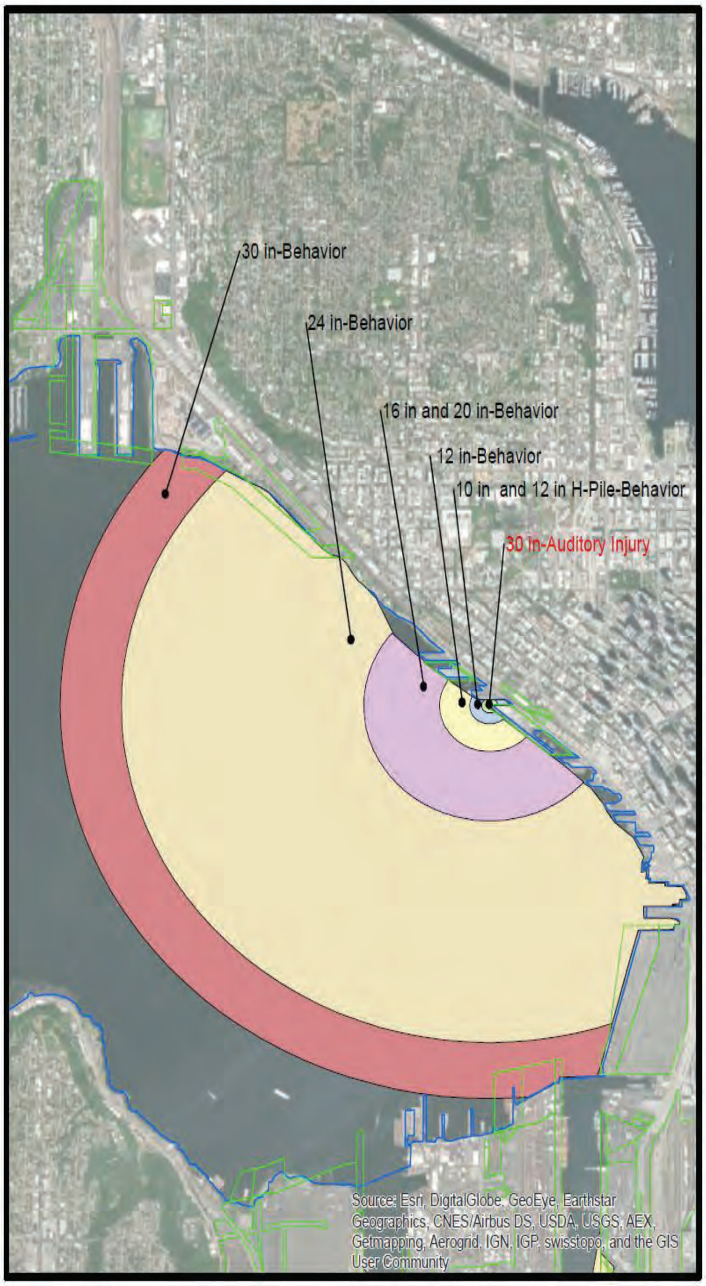
Pile Size/Type	dB_{PEAK}	dB_{RMS}	dB_{SEL}	Dist. to salmonid cum.SEL injury-mass<2g(m)	Dist. to salmonid behavioral (m)
12" H-Pile-Thick	200	183	170	54	398
12" Steel Pipe	198	181	166	29	293
16" Steel Pipe	200	187	174	100	736
20" Steel Pipe	208	187	176	136	736
24" Steel Pipe	207	194	178	185	2,154
30" Steel Pipe	212	195	186	631	2,512

Figure 2. Typical impact pile driving noise extents within Zone 1A, salmonids (Pier 66).



Pile Size/Type	dBPEAK	dBRMS	dBSEL	Dist. to auditory injury (m)	Dist. to baro-trauma (m)	Dist. to bhvrl (m)	Dist. to in-air masking (m)
10" Steel H-Pile	190	175	155	0	0	117	
12" Steel Pipe	198	181	166	2	1	293	
16" Steel Pipe	200	187	174	7	3	736	
20" Steel Pipe	208	187	176	10	4	736	
24" Steel Pipe	207	194	178	14	5	2,154	42
30" Steel Pipe	212	195	186	47	19	2,512	42

Figure 3. Typical impact pile driving noise extents within Zone 1A, marbled murrelets (Shilshole Bay Marina).

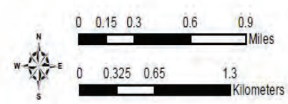


Pier 66 (Zone 1a-Marine)
Impact Pile Driving
Steel Pipe Piling
Marbled Murrelet Thresholds

Pile Size/Type	dB_{PEAK}	dB_{RMS}	dB_{SEL}	Dist. to auditory injury (m)	Dist. to baro-trauma (m)	Dist. to bhvrl (m)	Dist. to in-air masking (m)
10" Steel H-Pile	190	175	155	0	0	117	
12" Steel Pipe	198	181	166	2	1	293	
16" Steel Pipe	200	187	174	7	3	736	
20" Steel Pipe	208	187	176	10	4	736	
24" Steel Pipe	207	194	178	14	5	2,154	42
30" Steel Pipe	212	195	186	47	19	2,512	42

Legend

- 30 in- Auditory Injury
- 10 in and 12 in H-Pile-Behavior
- 12 in- Behavior
- 16 in and 20 in-Behavior
- 24 in-Behavior
- 30 in-Behavior
- PoS Facilities
- Shoreline



This map is for general reference only.
Data layers that appear on this map may or may not be accurate, current, or otherwise reliable.

Figure 4. Typical impact pile driving noise extents within Zone 1A, marbled murrelets (Pier 66).

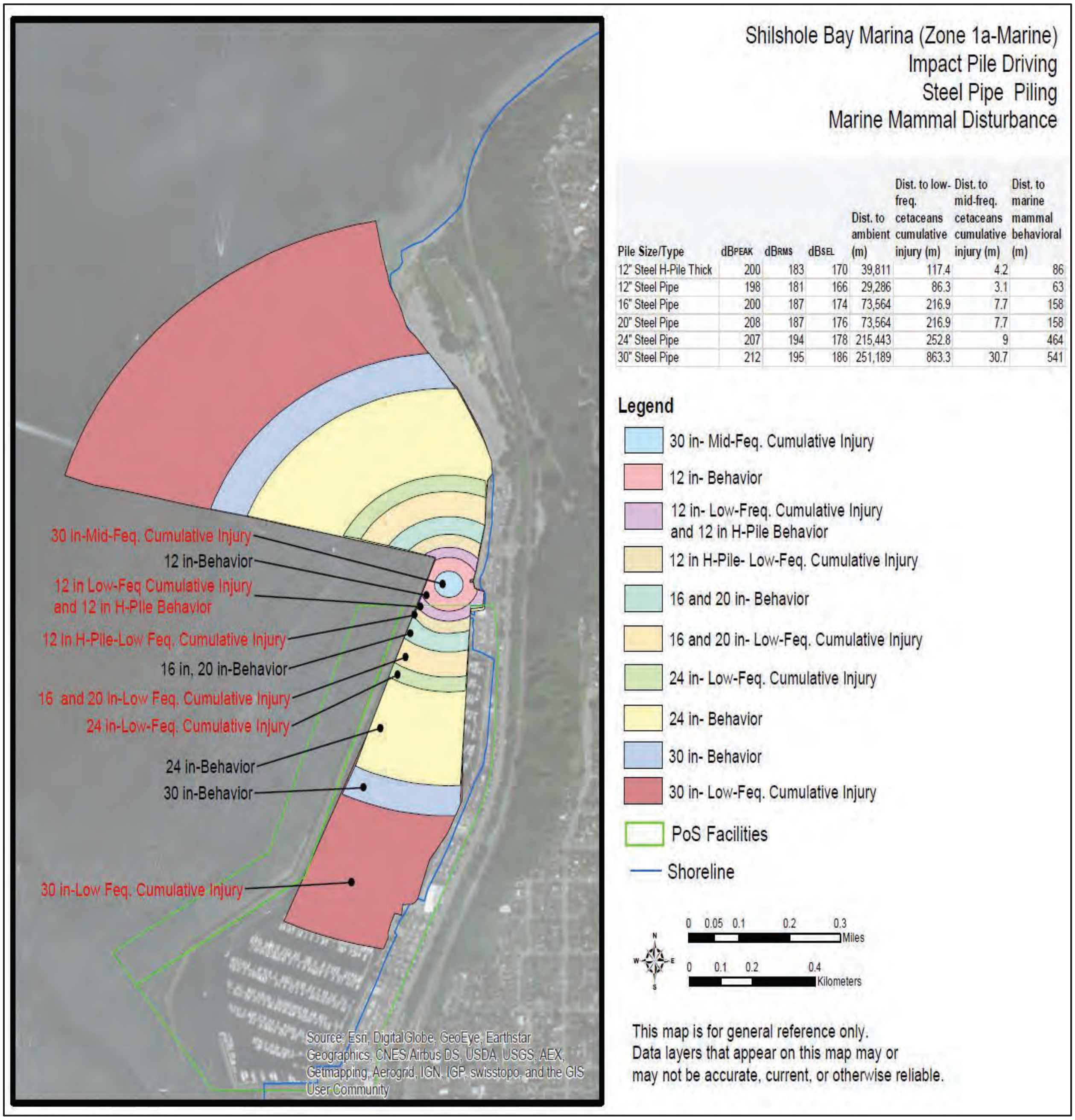
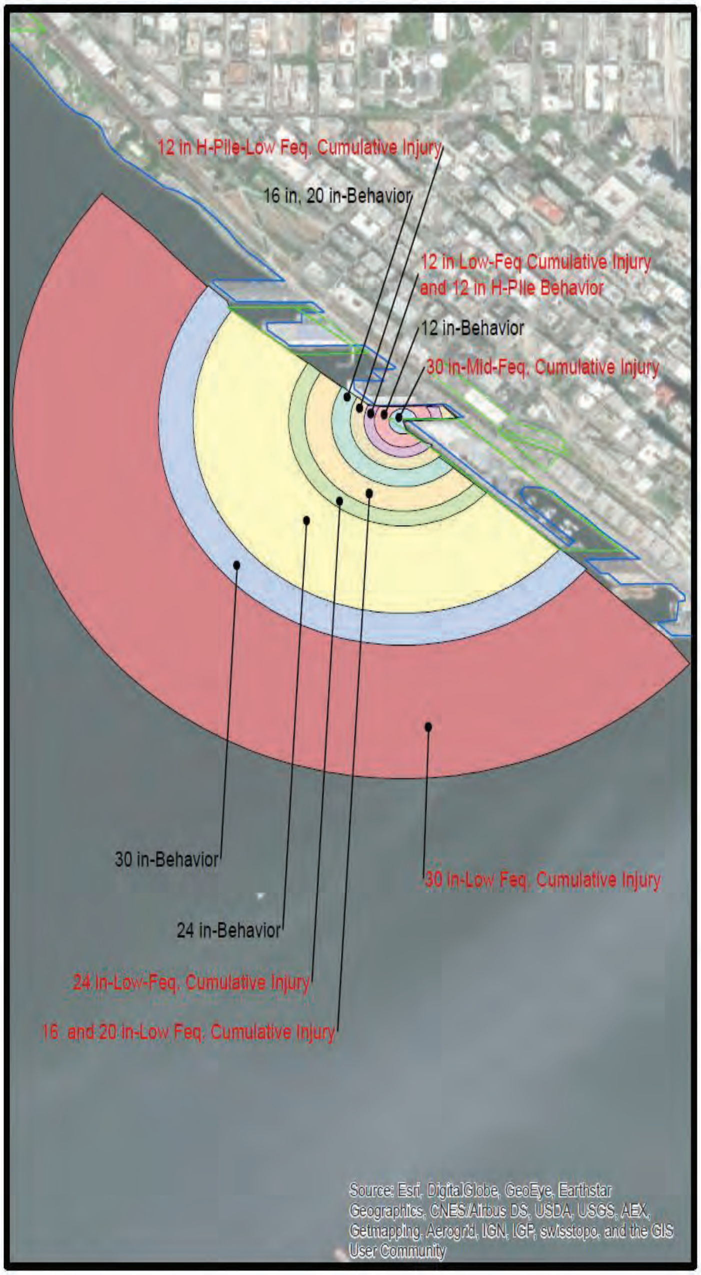


Figure 5. Typical impact pile driving noise extents within Zone 1A, cetaceans (Shilshole Bay Marina).



Pier 66 (Zone 1a-Marine)
Impact Pile Driving
Steel Pipe Piling
Marine Mammal Disturbance

Pile Size/Type	dBPEAK	dBRMS	dBSEL	Dist. to ambient (m)	Dist. to low-freq. cetaceans cumulative injury (m)	Dist. to mid-freq. cetaceans cumulative injury (m)	Dist. to marine mammal behavioral (m)
12" Steel H-Pile Thick	200	183	170	39,811	117.4	4.2	86
12" Steel Pipe	198	181	166	29,286	86.3	3.1	63
16" Steel Pipe	200	187	174	73,564	216.9	7.7	158
20" Steel Pipe	208	187	176	73,564	216.9	7.7	158
24" Steel Pipe	207	194	178	215,443	252.8	9	464
30" Steel Pipe	212	195	186	251,189	863.3	30.7	541

Legend

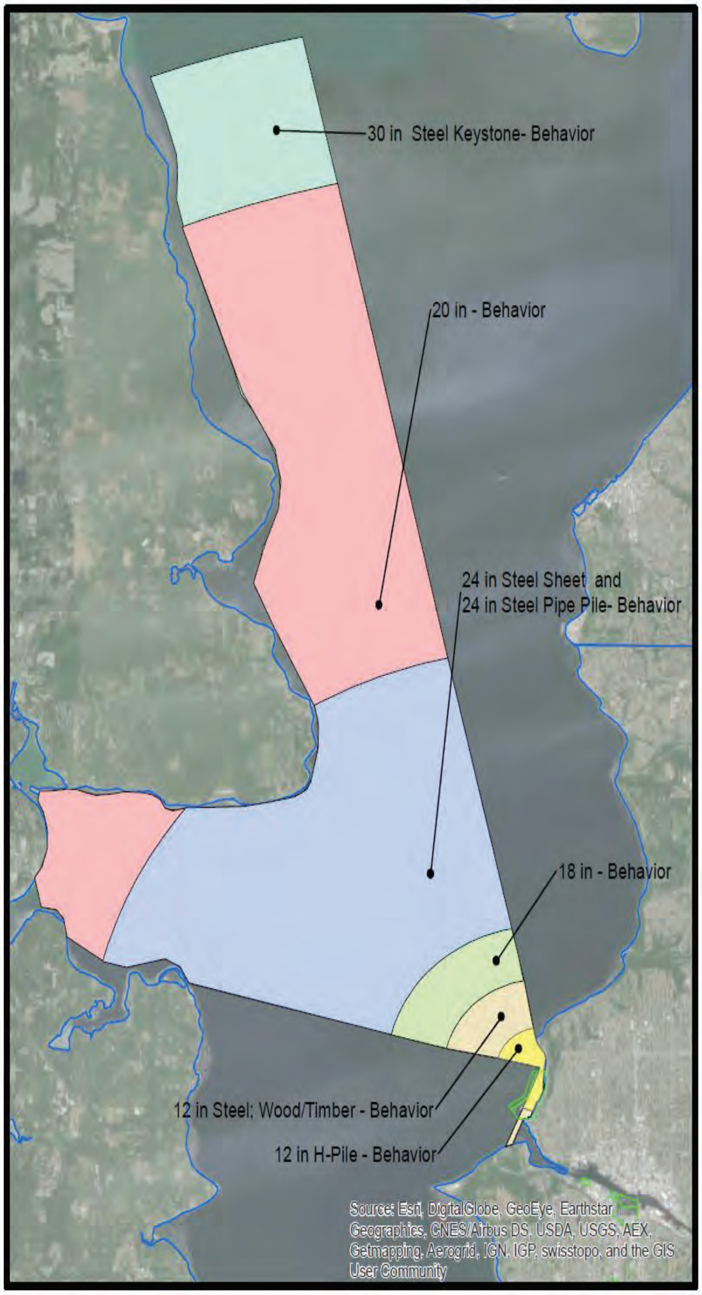
- 30 in- Mid-Feq. Cumulative Injury
- 12 in- Behavior
- 12 in- Low-Freq. Cumulative Injury and 12 in H-Pile Behavior
- 12 in H-Pile- Low-Feq. Cumulative Injury
- 16 and 20 in- Behavior
- 16 and 20 in- Low-Feq. Cumulative Injury
- 24 in- Low-Feq. Cumulative Injury
- 24 in- Behavior
- 30 in- Behavior
- 30 in- Low-Feq. Cumulative Injury
- PoS Facilities
- Shoreline

0 0.05 0.1 0.2 0.3 Miles

0 0.1 0.2 0.4 Kilometers

This map is for general reference only.
Data layers that appear on this map may or may not be accurate, current, or otherwise reliable.

Figure 6. Typical impact pile driving noise extents within Zone 1A, cetaceans (Pier 66).



Shilshole Bay Marina (Zone 1a-Marine)
Vibratory Pile Driving
Steel Pipe Piling
Marine Mammal Disturbance

Pile Size/Type	dBRMS	Dist. to marine mammal disturbance/ambient 120 dBRMS(m)
24" Steel Sheet Pile-Loudest and 24" Steel Pipe Pile	165	10,000
12" Steel H-Pile	150	1,000
12" Steel	155	2,154
18" Steel	158	3,414
20" Steel	170	21,544
30" Steel-Keystone	171	25,119
18" Wood/Timber	155	2,154

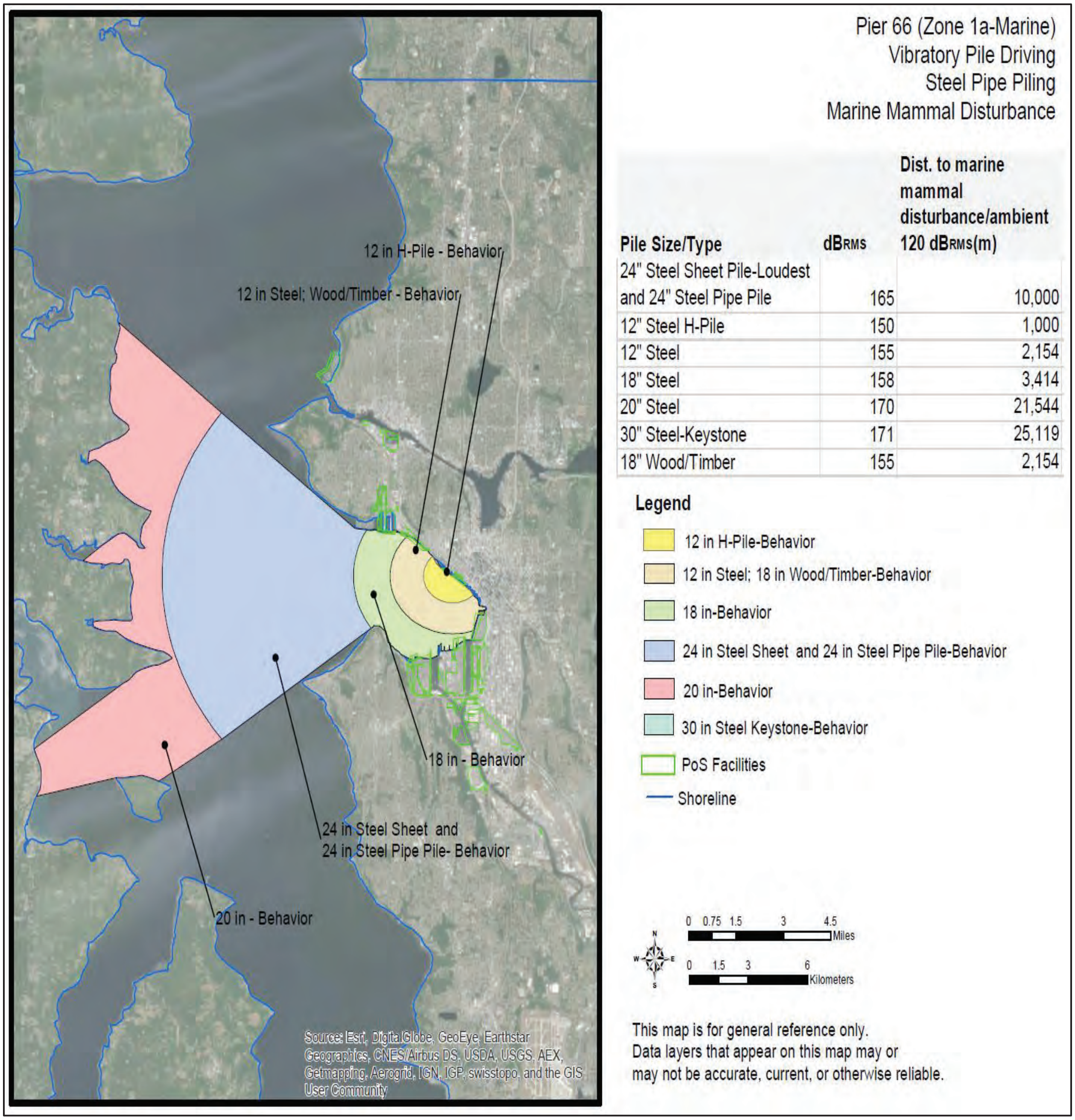
Legend

- 12 in H-Pile-Behavior
- 12 in Steel; 18 in Wood/Timber-Behavior
- 18 in-Behavior
- 24 in Steel Sheet and 24 in Steel Pipe Pile-Behavior
- 20 in-Behavior
- 30 in Steel Keystone-Behavior
- PoS Facilities
- Shoreline

0 0.5 1 2 3 Miles
0 1 2 4 Kilometers

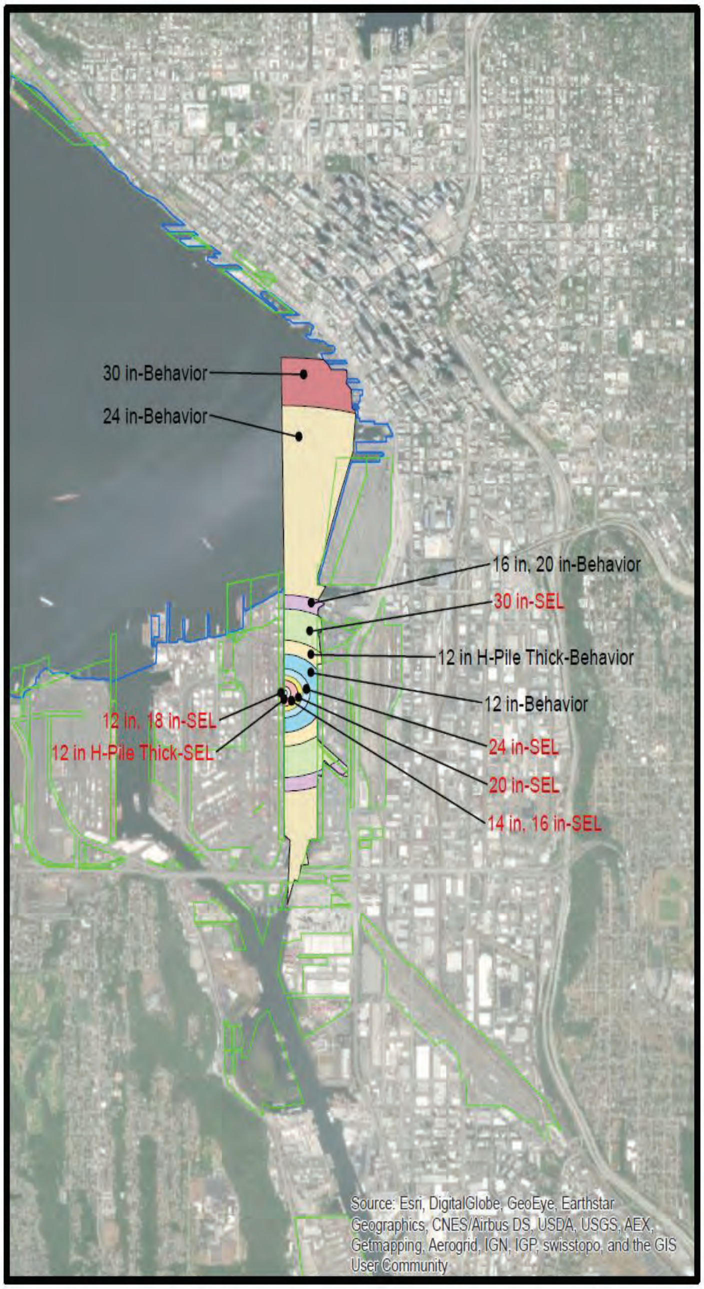
This map is for general reference only.
Data layers that appear on this map may or may not be accurate, current, or otherwise reliable.

Figure 7. Typical vibratory pile driving noise extents within Zone 1A, cetaceans (Shilshole Bay Marina).



Pile Size/Type	dBRMS	Dist. to marine mammal disturbance/ambient 120 dBRMS(m)
24" Steel Sheet Pile-Loudest and 24" Steel Pipe Pile	165	10,000
12" Steel H-Pile	150	1,000
12" Steel	155	2,154
18" Steel	158	3,414
20" Steel	170	21,544
30" Steel-Keystone	171	25,119
18" Wood/Timber	155	2,154

Figure 8. Typical vibratory pile driving noise extents within Zone 1A, cetaceans (Pier 66).



T18 (Zone 1b-Waterways)
Impact Pile Driving
Steel Pipe Piling
Salmonid Thresholds

Pile Size/Type	dBPEAK	dBRMS	dBSEL	Dist. to salmonid cum.SEL injury-mass<2g(m)	Dist. to salmonid behavioral (m)
12" H-Pile-Thick	200	183	170	54	398
12" Steel Pipe	198	181	166	29	293
16" Steel Pipe	200	187	174	100	736
20" Steel Pipe	208	187	176	136	736
24" Steel Pipe	207	194	178	185	2,154
30" Steel Pipe	212	195	186	631	2,512

Legend

- 12 and 18 in- SEL
- 12 in H-Pile Thick- SEL
- 14 and 16 in- SEL
- 20 in- SEL
- 24 in- SEL
- 12 in- Behavior
- 12 in H-Pile Thick- Behavior
- 30 in- SEL
- 16 and 20 in- Behavior
- 24 in- Behavior
- 30 in- Behavior
- PoS Facilities
- Shoreline

0 0.175 0.35 0.7 1.05 Miles

0 0.375 0.75 1.5 Kilometers

This map is for general reference only.
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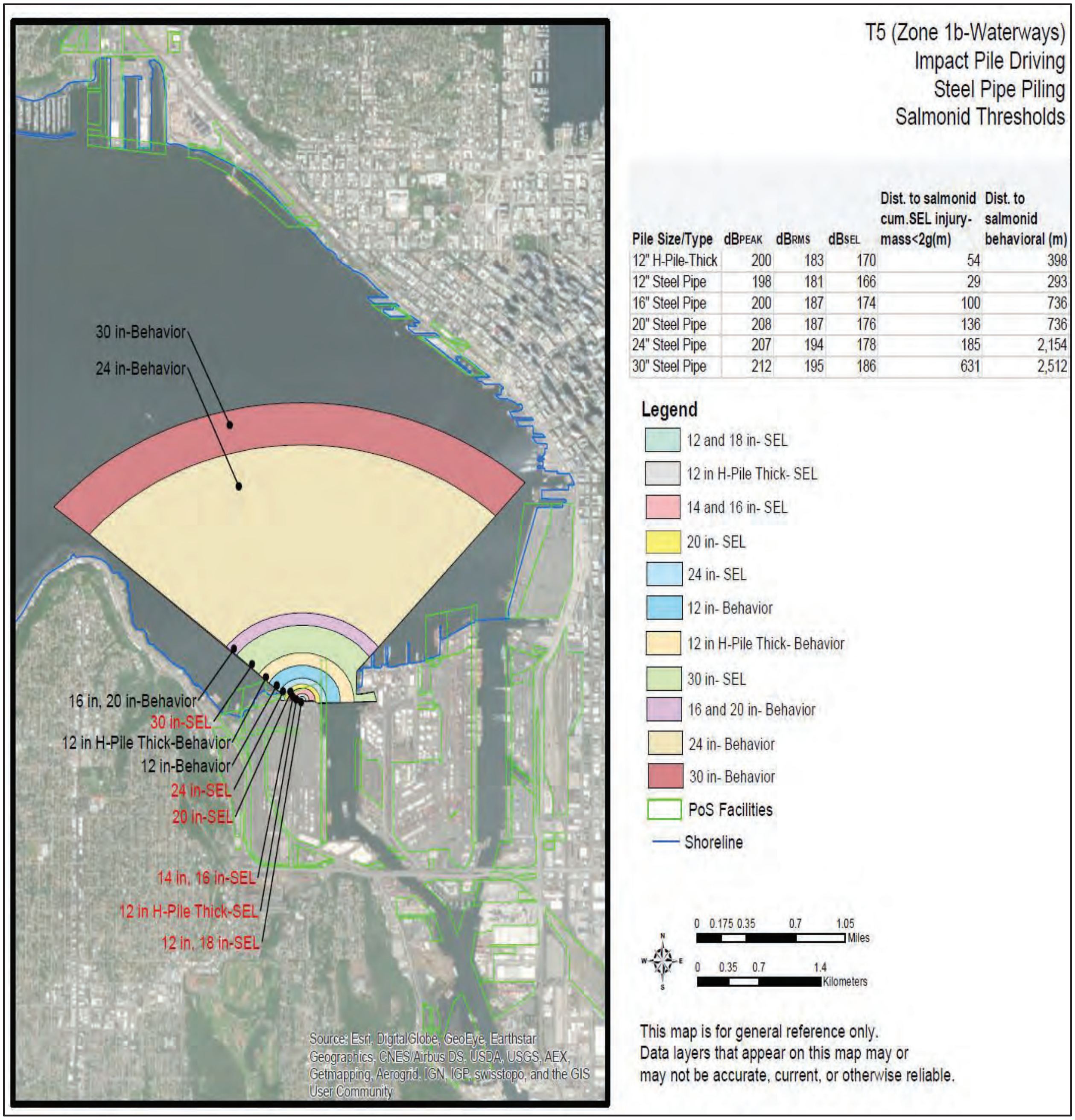
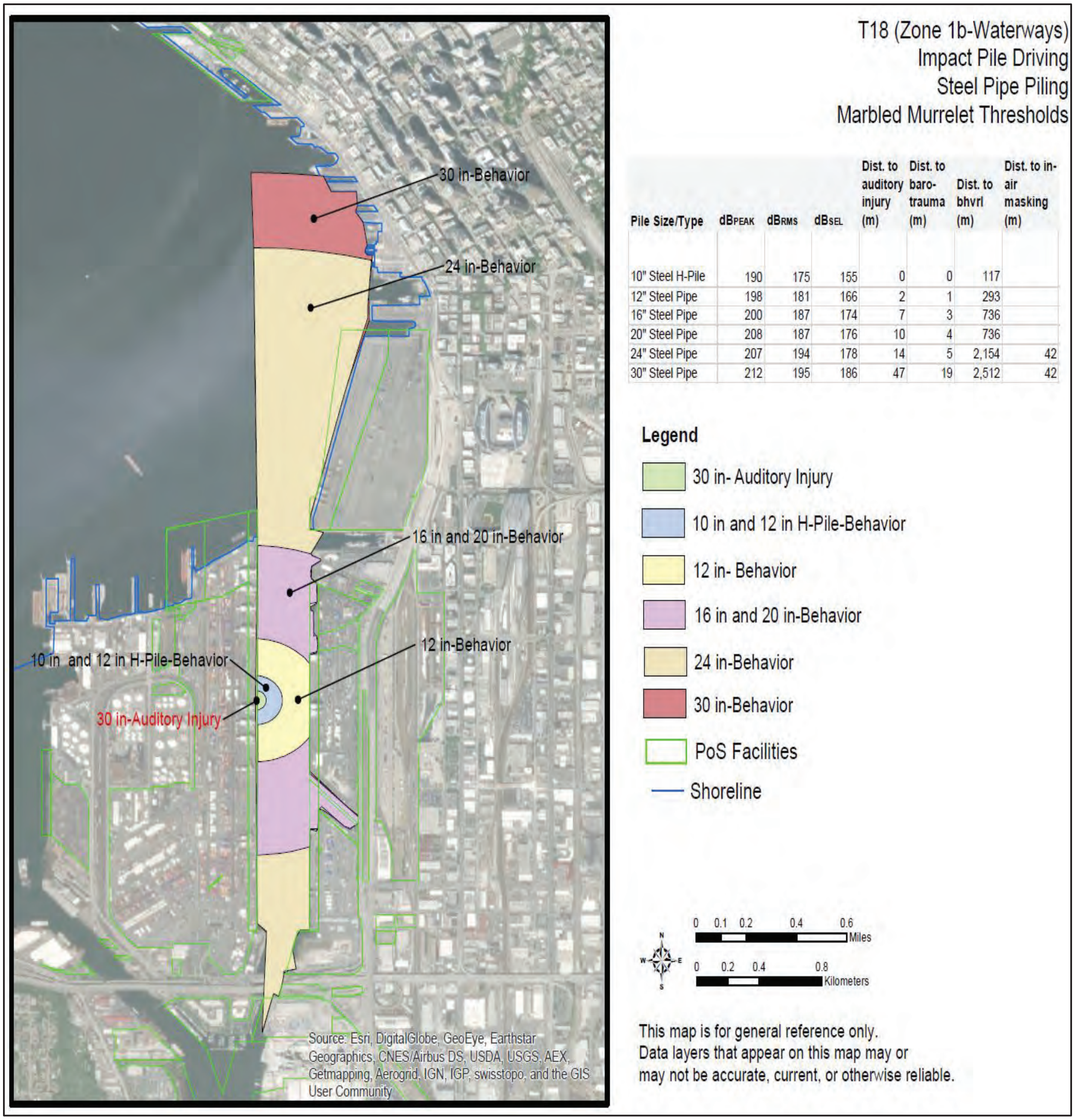
may not be accurate, current, or otherwise reliable.

Figure 9. Typical impact pile driving noise extents within Zone 1B, salmonids (Terminal 18).



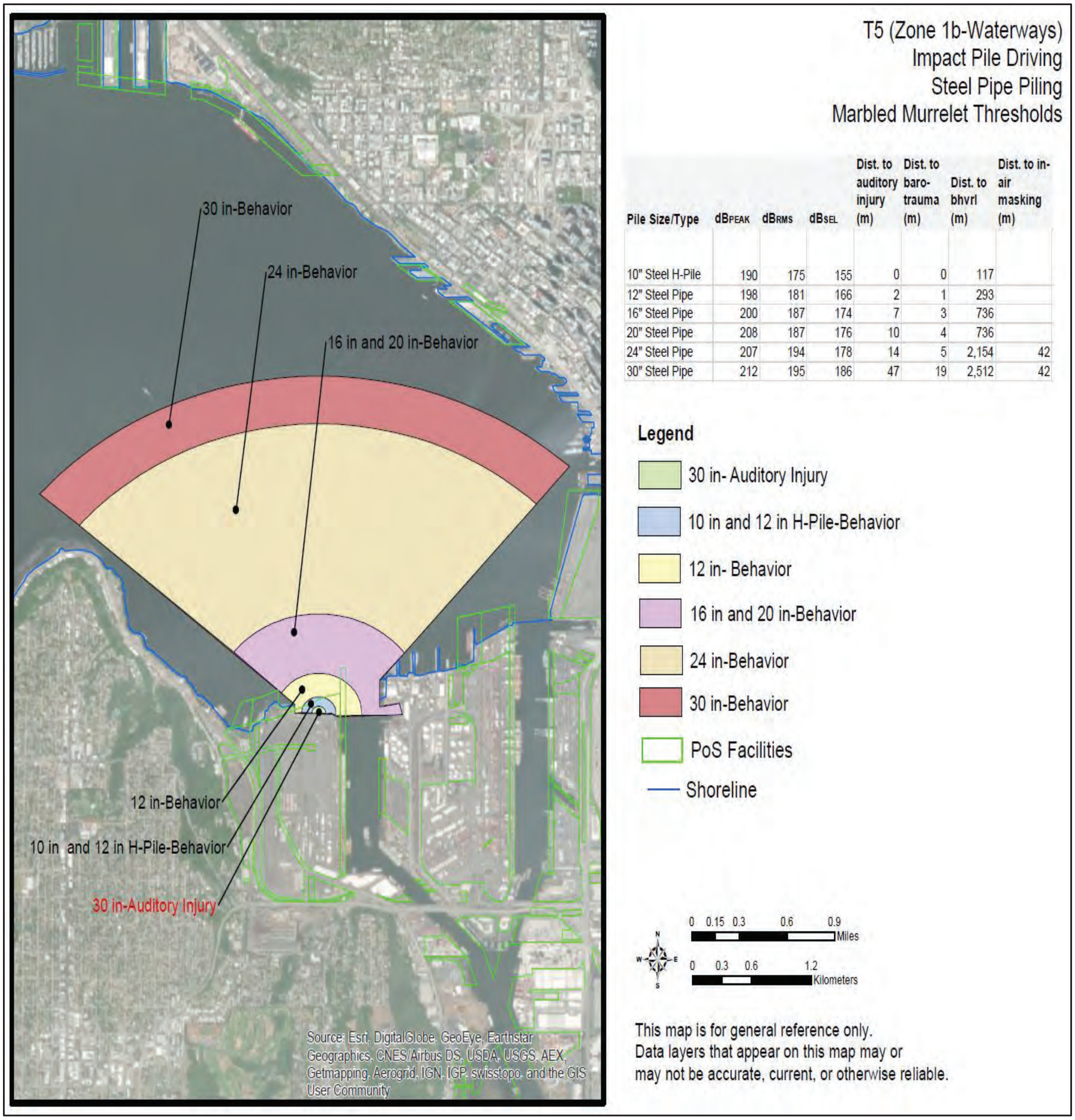
Pile Size/Type	dB_{PEAK}	dB_{RMS}	dB_{SEL}	Dist. to salmonid cum.SEL injury-mass<2g(m)	Dist. to salmonid behavioral (m)
12" H-Pile-Thick	200	183	170	54	398
12" Steel Pipe	198	181	166	29	293
16" Steel Pipe	200	187	174	100	736
20" Steel Pipe	208	187	176	136	736
24" Steel Pipe	207	194	178	185	2,154
30" Steel Pipe	212	195	186	631	2,512

Figure 10. Typical impact pile driving noise extents within Zone 1B, salmonids (Terminal 5).



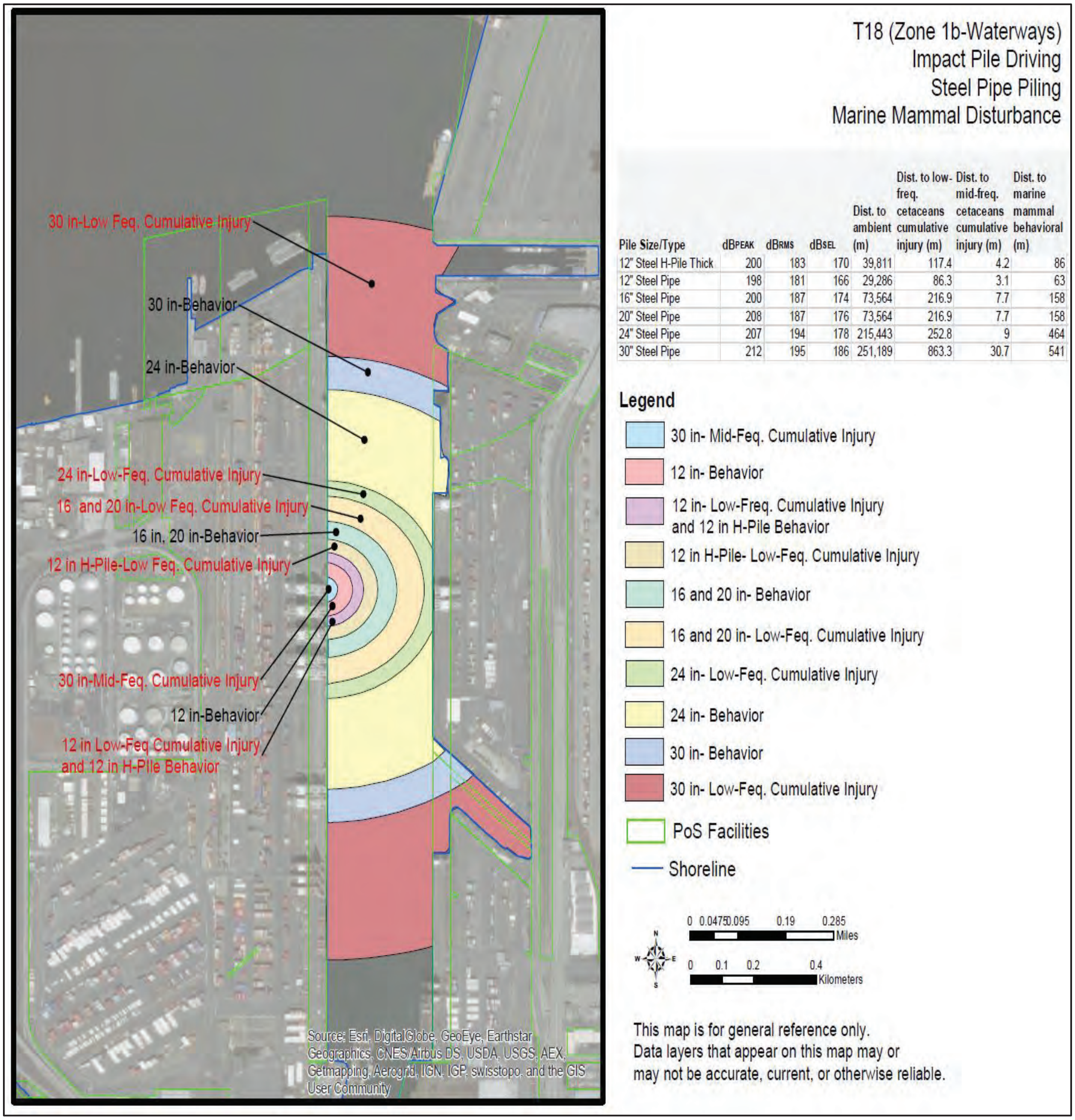
Pile Size/Type	dBPEAK	dBRMS	dBSEL	Dist. to auditory injury (m)	Dist. to baro-trauma (m)	Dist. to bhvrl (m)	Dist. to in-air masking (m)
10" Steel H-Pile	190	175	155	0	0	117	
12" Steel Pipe	198	181	166	2	1	293	
16" Steel Pipe	200	187	174	7	3	736	
20" Steel Pipe	208	187	176	10	4	736	
24" Steel Pipe	207	194	178	14	5	2,154	42
30" Steel Pipe	212	195	186	47	19	2,512	42

Figure 11. Typical impact pile driving noise extents within Zone 1B, marbled murrelets (Terminal 18).



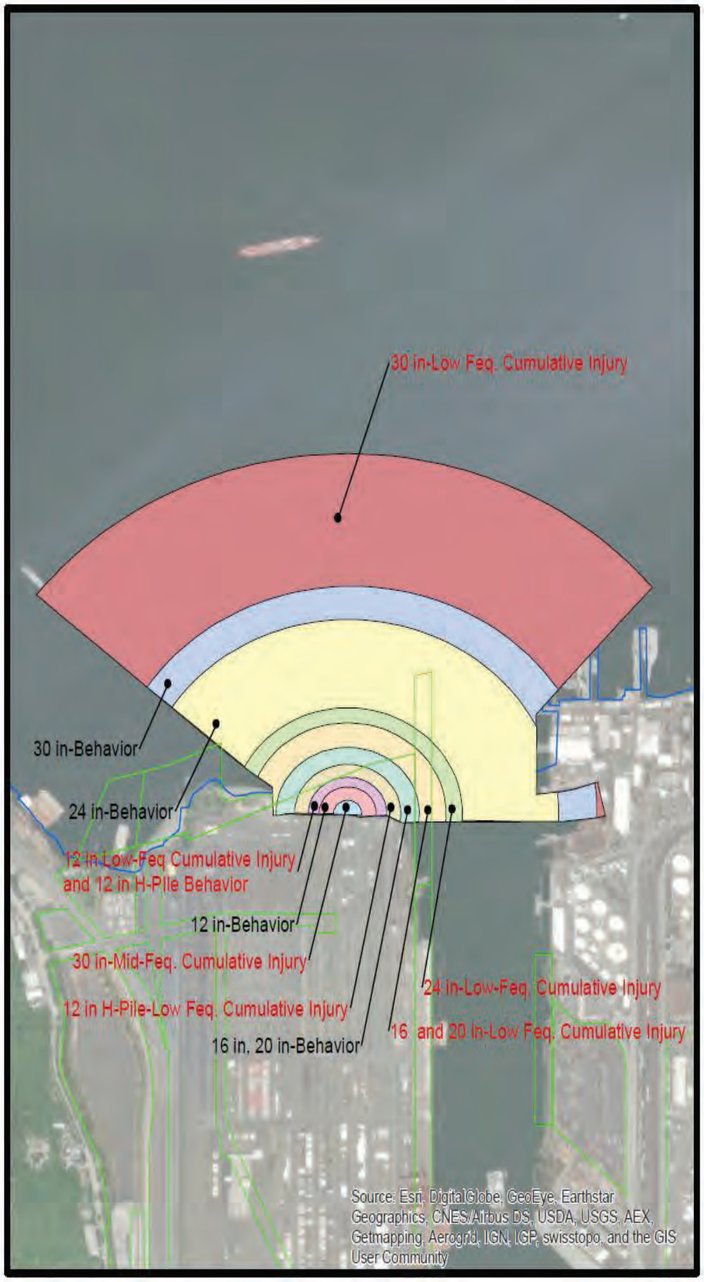
Pile Size/Type	dB_{PEAK}	dB_{RMS}	dB_{SEL}	Dist. to auditory injury (m)	Dist. to baro-trauma (m)	Dist. to bhvrl (m)	Dist. to in-air masking (m)
10" Steel H-Pile	190	175	155	0	0	117	
12" Steel Pipe	198	181	166	2	1	293	
16" Steel Pipe	200	187	174	7	3	736	
20" Steel Pipe	208	187	176	10	4	736	
24" Steel Pipe	207	194	178	14	5	2,154	42
30" Steel Pipe	212	195	186	47	19	2,512	42

Figure 12. Typical impact pile driving noise extents within Zone 1B, marbled murrelets (Terminal 5).



Pile Size/Type	dBPEAK	dBRMS	dBSEL	Dist. to ambient (m)	Dist. to low-freq. cetaceans cumulative injury (m)	Dist. to mid-freq. cetaceans cumulative injury (m)	Dist. to marine mammal behavioral (m)
12" Steel H-Pile Thick	200	183	170	39,811	117.4	4.2	86
12" Steel Pipe	198	181	166	29,286	86.3	3.1	63
16" Steel Pipe	200	187	174	73,564	216.9	7.7	158
20" Steel Pipe	208	187	176	73,564	216.9	7.7	158
24" Steel Pipe	207	194	178	215,443	252.8	9	464
30" Steel Pipe	212	195	186	251,189	863.3	30.7	541

Figure 13. Typical impact pile driving noise extents within Zone 1B, cetaceans (Terminal 18)



T5 (Zone 1b-Waterways)
Impact Pile Driving
Steel Pipe Piling
Marine Mammal Disturbance

Pile Size/Type	dB_{PEAK}	dB_{RMS}	dB_{SEL}	Dist. to ambient (m)	Dist. to low-freq. cetaceans cumulative injury (m)	Dist. to mid-freq. cetaceans cumulative injury (m)	Dist. to marine mammal behavioral (m)
12" Steel H-Pile Thick	200	183	170	39,811	117.4	4.2	86
12" Steel Pipe	198	181	166	29,286	86.3	3.1	63
16" Steel Pipe	200	187	174	73,564	216.9	7.7	158
20" Steel Pipe	208	187	176	73,564	216.9	7.7	158
24" Steel Pipe	207	194	178	215,443	252.8	9	464
30" Steel Pipe	212	195	186	251,189	863.3	30.7	541

Legend

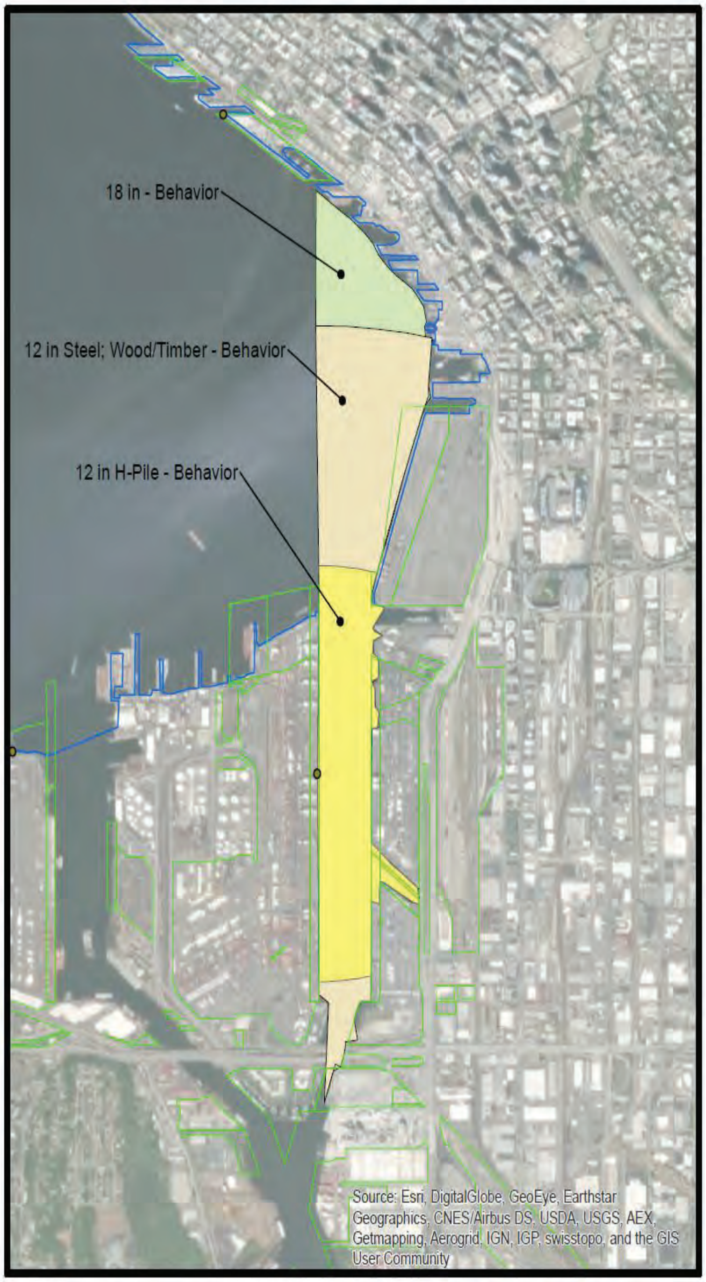
- 30 in- Mid-Feq. Cumulative Injury
- 12 in- Behavior
- 12 in- Low-Freq. Cumulative Injury and 12 in H-Pile Behavior
- 12 in H-Pile- Low-Feq. Cumulative Injury
- 16 and 20 in- Behavior
- 16 and 20 in- Low-Feq. Cumulative Injury
- 24 in- Low-Feq. Cumulative Injury
- 24 in- Behavior
- 30 in- Behavior
- 30 in- Low-Feq. Cumulative Injury
- PoS Facilities
- Shoreline

0 0.05 0.1 0.2 0.3 Miles
0 0.1 0.2 0.4 Kilometers

This map is for general reference only.
Data layers that appear on this map may or may not be accurate, current, or otherwise reliable.

Figure 14. Typical impact pile driving noise extents within Zone 1B, cetaceans (Terminal 5).

T18 (Zone 1b-Waterways)
Vibratory Pile Driving
Steel Pipe Piling
Marine Mammal Disturbance



Pile Size/Type	dBRMS	Dist. to marine mammal disturbance/ambient 120 dBRMS(m)
24" Steel Sheet Pile-Loudest and 24" Steel Pipe Pile	165	10,000
12" Steel H-Pile	150	1,000
12" Steel	155	2,154
18" Steel	158	3,414
20" Steel	170	21,544
30" Steel-Keystone	171	25,119
18" Wood/Timber	155	2,154

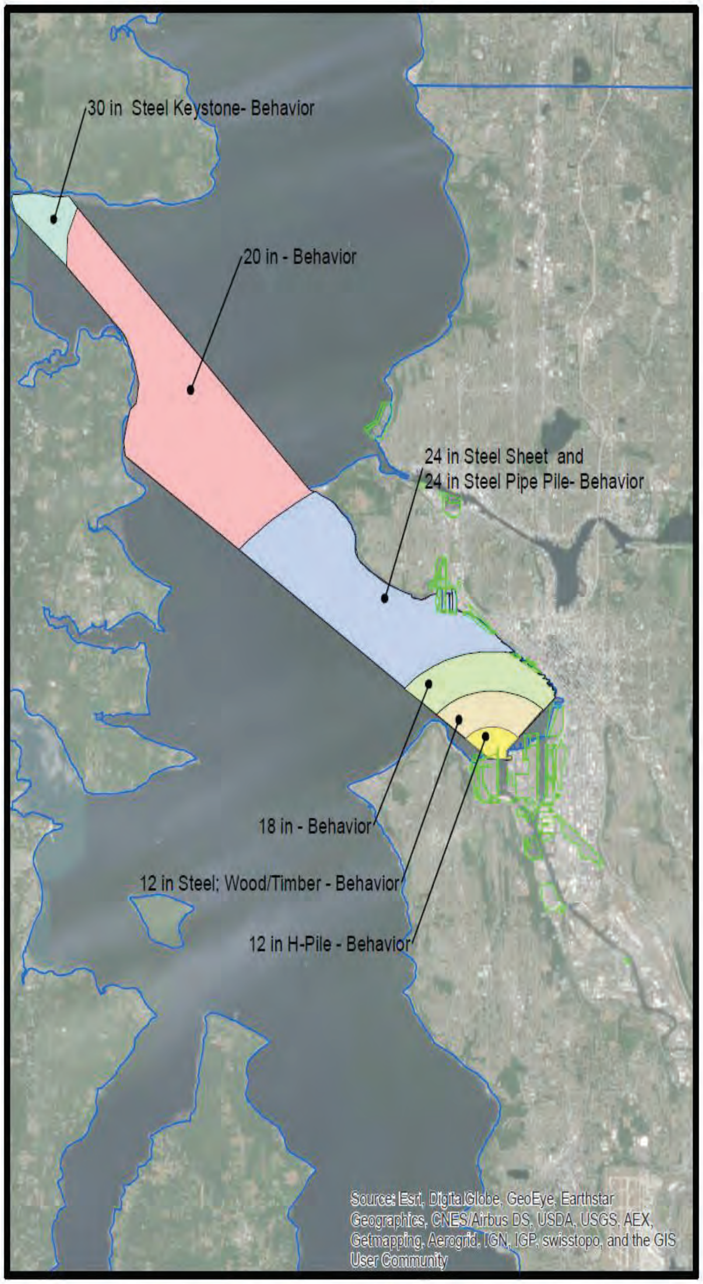
Legend

- 12 in H-Pile-Behavior
- 12 in Steel; 18 in Wood/Timber-Behavior
- 18 in-Behavior
- 24 in Steel Sheet and 24 in Steel Pipe Pile-Behavior
- 20 in-Behavior
- 30 in Steel Keystone-Behavior
- PoS Facilities
- Shoreline

0 0.1 0.2 0.4 0.6 Miles
0 0.225 0.45 0.9 Kilometers

This map is for general reference only.
Data layers that appear on this map may or may not be accurate, current, or otherwise reliable.

Figure 15. Typical vibratory pile driving noise extents within Zone 1B, cetaceans (Terminal 18).

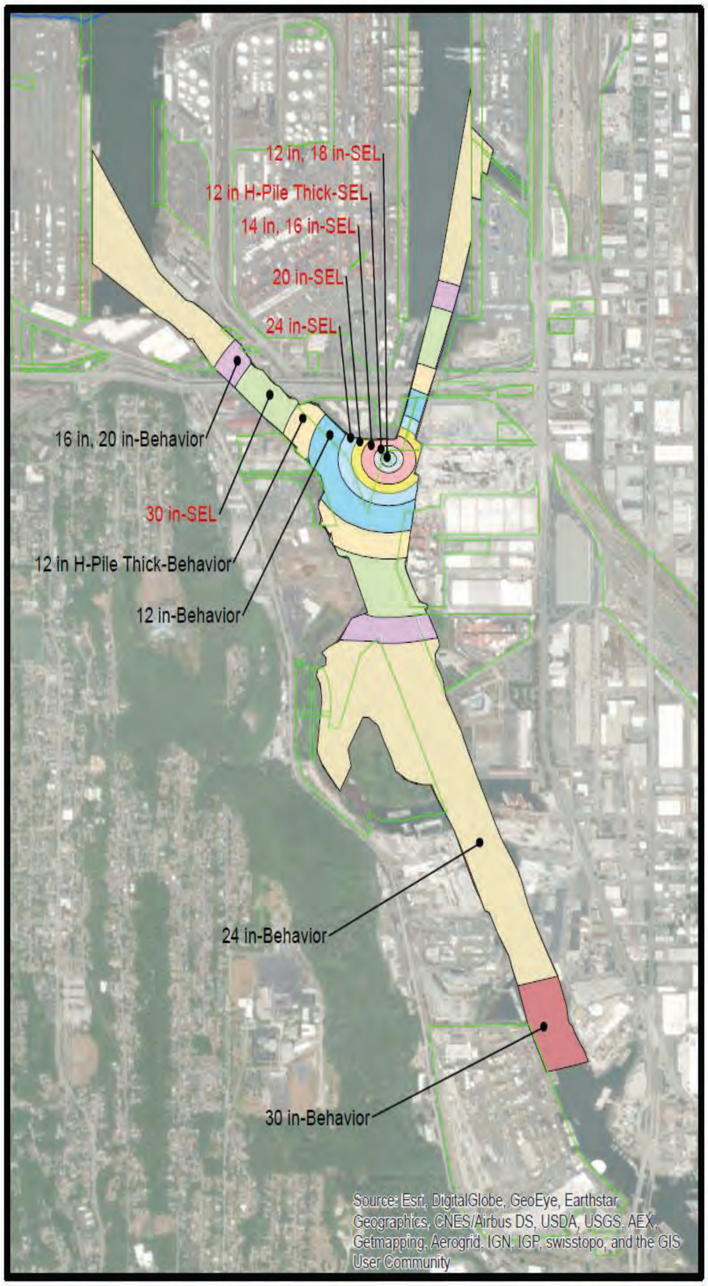


T5 (Zone 1b-Waterways)
Vibratory Pile Driving
Steel Pipe Piling
Marine Mammal Disturbance

Pile Size/Type	dBRMS	Dist. to marine mammal disturbance/ambient 120 dBRMS(m)
24" Steel Sheet Pile-Loudest and 24" Steel Pipe Pile	165	10,000
12" Steel H-Pile	150	1,000
12" Steel	155	2,154
18" Steel	158	3,414
20" Steel	170	21,544
30" Steel-Keystone	171	25,119
18" Wood/Timber	155	2,154

This map is for general reference only.
Data layers that appear on this map may or
may not be accurate, current, or otherwise reliable.

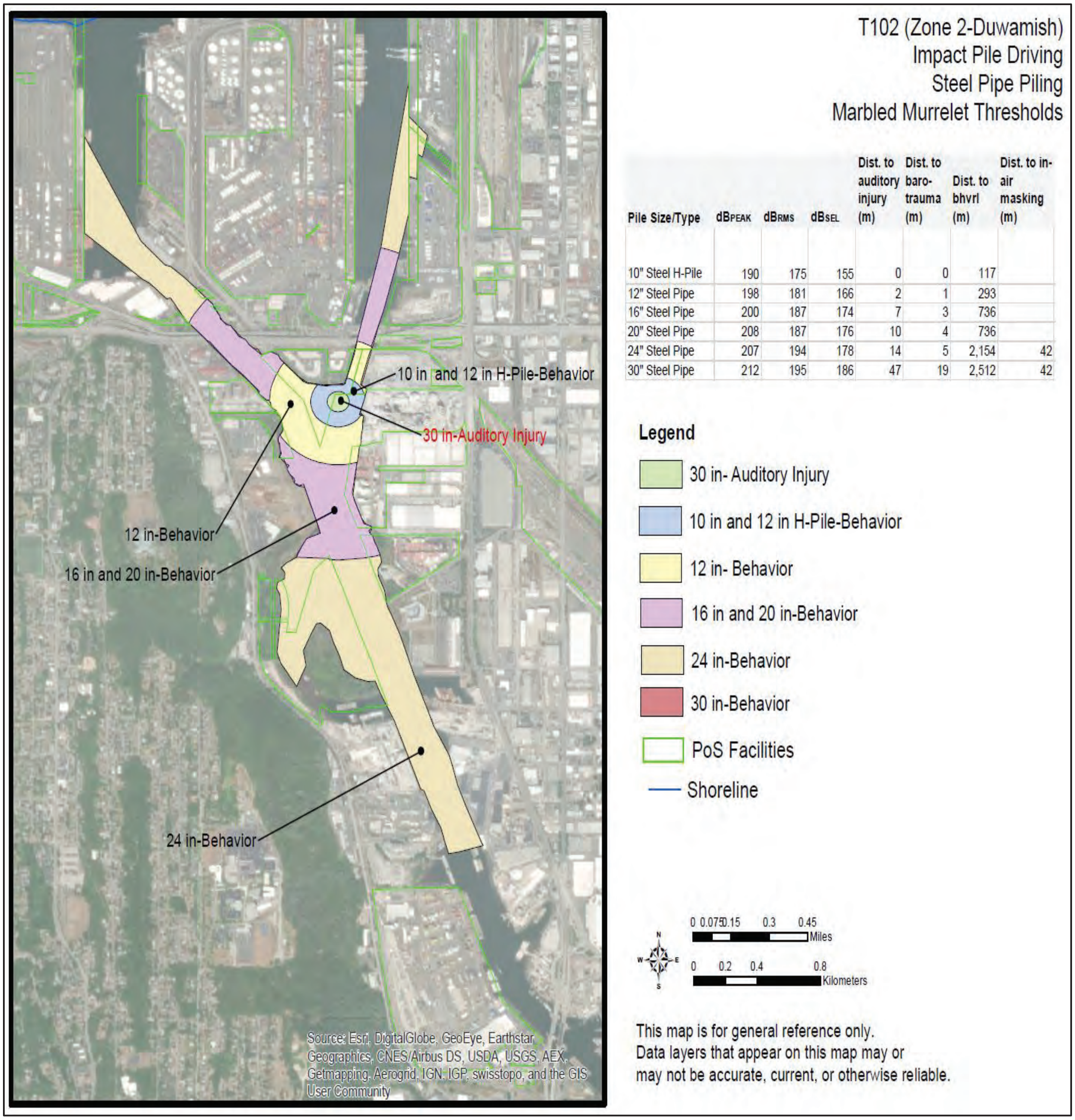
Figure 16. Typical vibratory pile driving noise extents within Zone 1B, cetaceans (Terminal 5).



T102 (Zone 2-Duwamish)
Impact Pile Driving
Steel Pipe Piling
Salmonid Thresholds

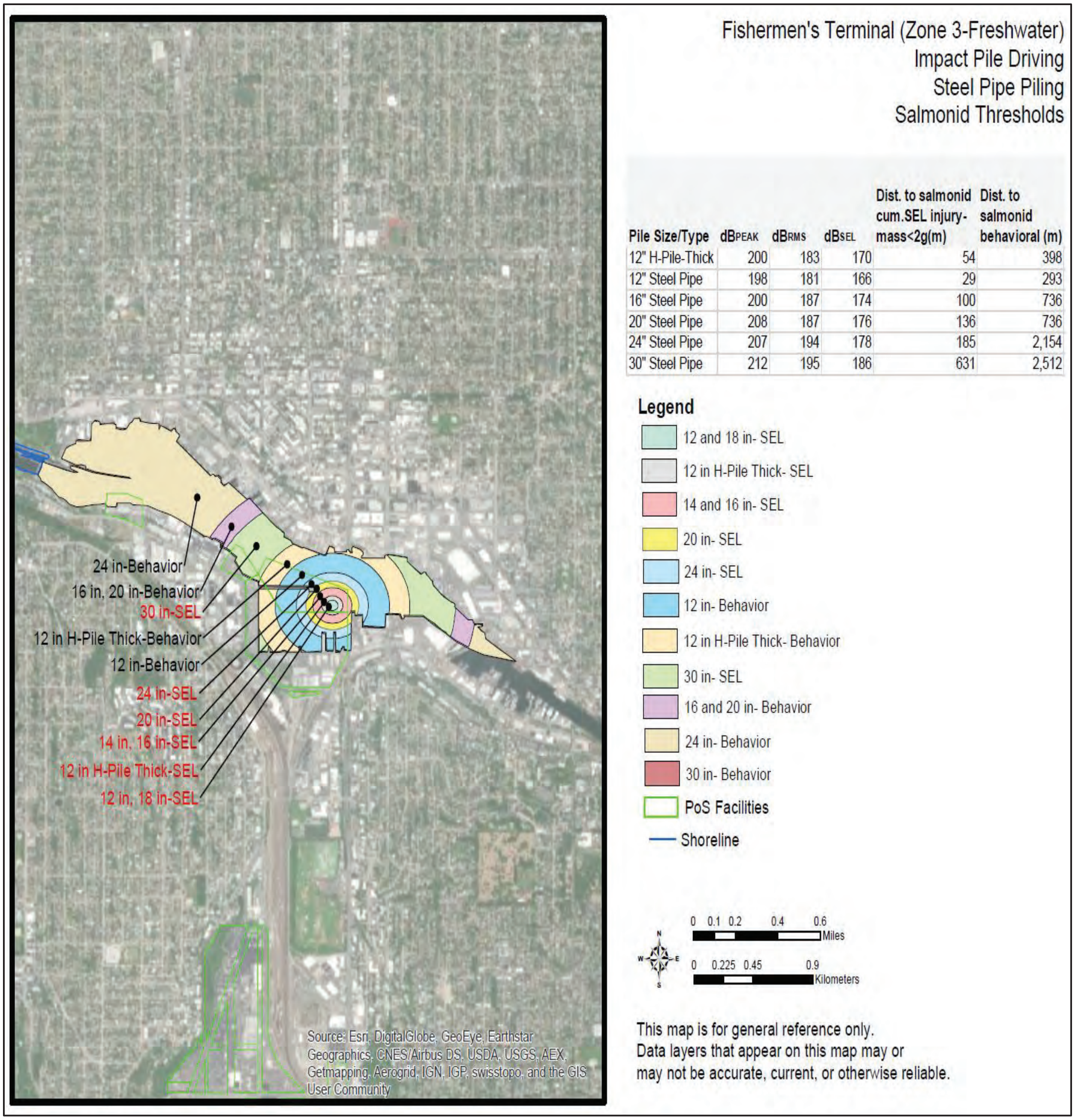
Pile Size/Type	dBPEAK	dBRMS	dBSEL	Dist. to salmonid cum.SEL injury-mass<2g(m)	Dist. to salmonid behavioral (m)
12" H-Pile-Thick	200	183	170	54	398
12" Steel Pipe	198	181	166	29	293
16" Steel Pipe	200	187	174	100	736
20" Steel Pipe	208	187	176	136	736
24" Steel Pipe	207	194	178	185	2,154
30" Steel Pipe	212	195	186	631	2,512

Figure 17. Typical impact pile driving noise extents within Zone 2, salmonids (Terminal 102).



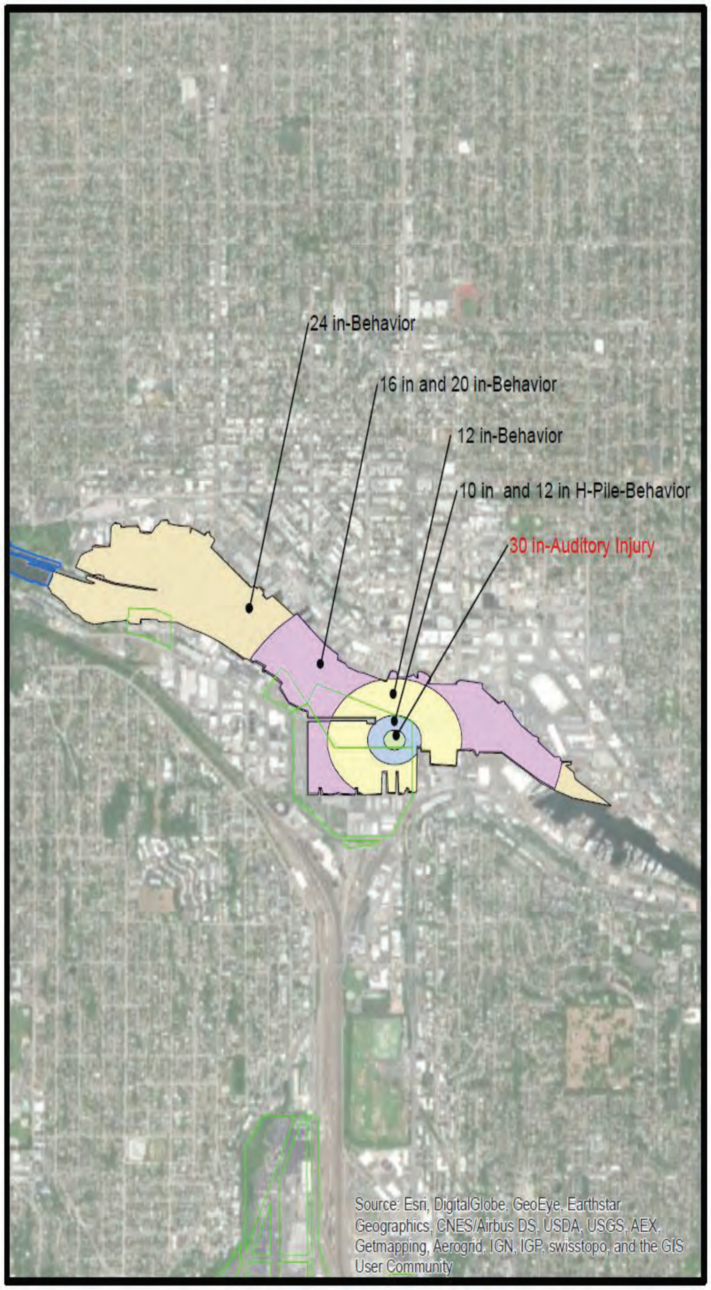
Pile Size/Type	dB_{PEAK}	dB_{RMS}	dB_{SEL}	Dist. to auditory injury (m)	Dist. to baro-trauma (m)	Dist. to bhvrl (m)	Dist. to in-air masking (m)
10" Steel H-Pile	190	175	155	0	0	117	
12" Steel Pipe	198	181	166	2	1	293	
16" Steel Pipe	200	187	174	7	3	736	
20" Steel Pipe	208	187	176	10	4	736	
24" Steel Pipe	207	194	178	14	5	2,154	42
30" Steel Pipe	212	195	186	47	19	2,512	42

Figure 18. Typical impact pile driving noise extents within Zone 2, salmonids (Terminal 102).



Pile Size/Type	dBPEAK	dBRMS	dBSEL	Dist. to salmonid cum.SEL injury-mass<2g(m)	Dist. to salmonid behavioral (m)
12" H-Pile-Thick	200	183	170	54	398
12" Steel Pipe	198	181	166	29	293
16" Steel Pipe	200	187	174	100	736
20" Steel Pipe	208	187	176	136	736
24" Steel Pipe	207	194	178	185	2,154
30" Steel Pipe	212	195	186	631	2,512

Figure 19. Typical vibratory pile driving noise extents within Zone 3, salmonids (Fishermen's Terminal).



Fishermen's Terminal (Zone 3-Freshwater)
Impact Pile Driving
Steel Pipe Piling
Marbled Murrelet Thresholds

Pile Size/Type	dBPEAK	dBRMS	dBSEL	Dist. to auditory injury (m)	Dist. to baro-trauma (m)	Dist. to bhvrl (m)	Dist. to in-air masking (m)
10" Steel H-Pile	190	175	155	0	0	117	
12" Steel Pipe	198	181	166	2	1	293	
16" Steel Pipe	200	187	174	7	3	736	
20" Steel Pipe	208	187	176	10	4	736	
24" Steel Pipe	207	194	178	14	5	2,154	42
30" Steel Pipe	212	195	186	47	19	2,512	42

Legend

- 30 in- Auditory Injury
- 10 in and 12 in H-Pile-Behavior
- 12 in- Behavior
- 16 in and 20 in-Behavior
- 24 in-Behavior
- 30 in-Behavior
- PoS Facilities
- Shoreline

0 0.1 0.2 0.4 0.6 Miles
0 0.225 0.45 0.9 Kilometers

This map is for general reference only.
Data layers that appear on this map may or
may not be accurate, current, or otherwise reliable.

Figure 20. Typical vibratory pile driving noise extents within Zone 3, murrelets (Fishermen's Terminal).

Marine Mammal Monitoring Plan Specifications for the Comprehensive Routine Maintenance, Repair and Scientific Sampling Program

June 5, 2024
Revised January 16, 2025

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Port of Seattle
Marine Mammal Monitoring Plan Specifications

Background

The Comprehensive Routine Maintenance, Repair and Scientific Sampling Program (Program) consists of routine maintenance, repair, relocation, replacement and/or demolition of its structures (e.g., piling, outfalls, bulkheads, fender systems, slope protection, etc.) and utilities (e.g., water, storm, electrical, etc.), maintenance dredging, and sediment sampling. The Program generally consist of maintenance and repair conducted within the existing footprint of the facility. The Program includes replacement of structural, fender, dolphin, float, and other types of piles ranging in size between 12 – 30 inches in diameter. Pile materials will include ACZA-treated timber, steel, concrete, and HDPE plastic. Pile system repair and maintenance will occur within three zones (Figure 1):

- Zone 1 – Marine (Elliott Bay, Puget Sound) including the East and West Duwamish Waterways
- Zone 2 – Tidally influenced portions of the Duwamish River (RM 0.0 to RM 5.0)
- Zone 3 – Freshwater (Salmon Bay and Lake Washington Ship Canal)

Two Endangered Species Act (ESA) listed marine mammals are known to occur in Puget Sound and Elliott Bay: southern resident killer whales (SRKW) and humpback whales. All three pods of SRKW will enter Puget Sound during fall months to search for chum salmon (Orca Network 2023a). NMFS presents SRKW sighting data based on quadrats (NMFS 2024). There were 42,016 total unique SRKW sightings within all the quadrats between 1999-2022, and 711 total unique SRKW sightings within the Action Area (Quadrats 407-410) during the same time (NMFS 2024). This represents approximately 1.7 percent of the total unique SRKW sightings during the 23-year reporting period (NMFS 2024). Most sightings within the Action Area occurred in November and December (196 and 187, respectively). In Quadrat 409 (Elliott Bay), approximately 70 unique SRKW sightings were documented during the 23-year reporting period (NMFS 2024). No sightings were reported in May, June, or July of any year, and January and October had the highest number of unique sightings (15) (NMFS 2024); therefore, it is possible but unlikely that SRKWs will be present in the Action Area when in-water work activities are underway.

Since the late-2000s, numbers of humpbacks in the Salish Sea, including Puget Sound, have been steadily increasing (Calambokidis et al. 2018). Based on a review of the Orca Network sightings map, humpbacks were sighted within the Action Area a total of 17 days within the last two years during the in-water work window (August 2022-February 2024). Only two months had four or more sightings: September (n = 4) and November (n = 9). Given the infrequency of observations in Elliott Bay, it is possible but unlikely for humpbacks to be present in the Action Area.

The National Oceanic and Atmospheric Administration (NOAA) Marine Protected Resources Division (MPRD) has indicated that underwater noise associated with use of a vibratory pile hammer may alter the behavior of ESA-listed marine mammals, including SRKW and humpback whales, within the Program Action Area. The MPRD has established an underwater noise disturbance threshold of 120 dB_{RMS} for non-impulse, continuous noises for cetaceans. Vibratory pile driving is considered to produce non-impulse, continuous noise. Piles that may be removed/replaced range from 12–30-inch diameter and are timber, concrete, steel or plastic. Underwater noise associated with both vibratory and impact methods has been analyzed thoroughly by the Port. The analysis is summarized in the attached report *Modeling Underwater Noise Associated with Pile Driving Activities* (2011, revised 2021) which includes maps that illustrate the range of underwater noise generated by different size/type piles at each facility in each zone.

Monitoring

A marine mammal monitoring plan (MMMP) will be implemented during all impact hammer pile installation and vibratory pile installation and removal activities within Zone 1, for the protection of ESA-listed marine mammals, including SRKW and humpback whales. Zones 2 and 3 and other in-water activities will not require formal marine mammal monitoring; however, the Port will ensure the contractor is aware and understands that marine mammals may be present near the Action Area at any time. The MMMP will outline specific measures, including monitoring station locations and selected methodologies, on an individual project basis for projects completed under the Program. The Port proposes the following general measures to prevent disturbance to marine mammals within the Action Area for each project permitted under the Program.

1) Qualified monitors will be stationed at observation stations that are adequate to clearly view the outer boundaries of the project Action Area located in Zone 1. The Action Area shall include all marine areas within acoustic line of site to the pile driving activity.
2) For projects occurring in Zone 1, a vessel may be required. The vessel transect or observation station shall be planned in advance and presented in the MMMP, and designed to adequately cover the Action Area. A GPS will be used to accurately position the vessel at its observation station or transect. Projects in Zone 1 may also require land-based observation. The land-based observation strategy shall also be planned in advance and shall include sufficient stations to ensure that the Action Area can be adequately monitored.
3) Assigned monitors will contact Orca Network (1-866-672-2638 or on social media, according to Orca Network's preference) before pile driving and removal work begins each day to get an update on the latest SRKW sightings data.
4) Assigned monitors will scan the waters within and outside the Action Area using binoculars (Vector 10X42 or equivalent) and record their visual observations.
5) The waters will be scanned 20 minutes prior to pile removal/driving activities and during all pile removal/driving activities. If SRKW(s) or humpback whale(s) enter or are observed within the Action Area during or 20 minutes prior to pile driving, the biologists will notify the on-site Port of Seattle inspector, and the inspector will require the contractor to not initiate or temporarily cease work until the animals have moved outside of the Action Area.
6) The 20-minute clear will not commence until there is sufficient daylight to allow for visibility of the entire monitoring zone.
7) If weather conditions prevent visibility of the monitoring zone (fog, rain, sea state, etc.), operations may be suspended at the discretion of the monitoring team. If the zone has been cleared and work has commenced before visibility is lost, operations may continue.

Minimum Qualifications for Marine Mammal Observers

Marine mammal monitors employed to implement the Port's marine mammal monitoring requirements shall meet the following minimum qualifications:

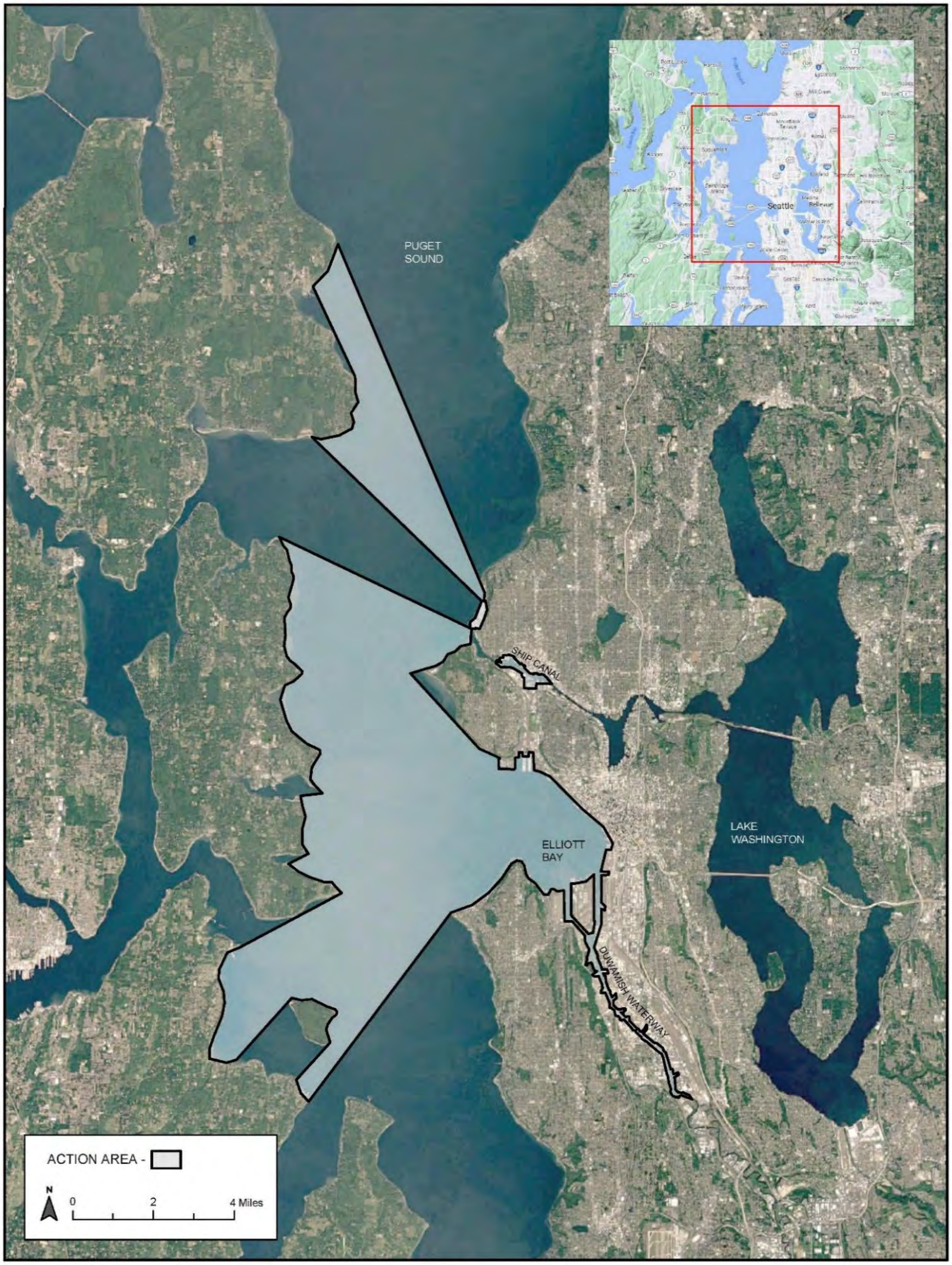
1) Visual acuity in both eyes (correction is permissible) sufficient for discernment of moving targets at the water surface with ability to estimate target size and distance. Use of binoculars may be necessary to correctly identify the target.
2) Lead or supervisory monitor(s) shall have advanced education in biological science, wildlife management, mammalogy or related fields (bachelor's degree or higher is preferred). Non-supervisory monitors shall be trained to identify SRKW and humpback whales accurately.
3) Experience and ability to conduct field observations and collect data according to assigned protocols (this may include academic experience).
4) Experience or training in the field identification of marine mammals (cetaceans and pinnipeds).
5) Sufficient training, orientation, or experience with the construction project to provide for personal safety during observations. This includes appropriate training, certifications, and insurance for operation of the marine mammal monitoring vessel.
6) Supervisory or lead-monitors shall have writing skills sufficient to prepare a report of observations that include such information as the number and type of marine mammals observed; the behavior of marine mammals in the project area during construction; dates and times when observations occurred; dates and times when in-water construction activities were conducted; dates and times when marine mammals were present at or within the defined disturbance zone; dates and times when in-water construction activities were suspended to avoid disturbance to the marine mammals.
7) Ability to communicate orally, by radio, telephone, and/or in person, with project personnel to provide real-time information on marine mammals observed in the area as necessary.

Documentation

All projects that require marine mammal monitoring shall be required to produce a written plan prior to construction that outlines a monitoring strategy consistent with these specifications (the MMMP). Following construction, a written report shall be drafted that summarizes the monitoring conducted for the project. Monitoring reports shall be maintained by the Port for the duration of the permit authorization (10 years) and made available upon request.

Figure 1. Program Zones

Figure 2. Program Action Area



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PORT OF TACOMA
MARINE MAMMAL MONITORING PLAN
FOR PROGRAMMATIC PILE REPLACEMENT AND REPAIR ACTIVITIES

INTRODUCTION

The Port of Tacoma (Port) proposes to conduct pile replacement and repair activities (the proposed action) at 15 wharf/dock structures located in the Blair, Hylebos, and Sitcum Waterways, and in inner Commencement Bay in Tacoma, Washington (Figure 2).

The action area for the proposed action has been established based on the extent of the zones of influence from the following components of the project (Temporary Effects Areas):

- Project footprint (in-water)
- Terrestrial noise
- Underwater noise during impact pile installation (Impact Temporary Effect Area)
- Underwater noise during vibratory pile removal and installation (Vibratory Temporary Effect Area)

Noise levels during both impact pile installation and vibratory pile removal and/or installation could exceed the noise thresholds National Marine Fisheries Service (NMFS) has established for underwater disturbance of marine mammals within portions of the action area at each of the 15 sites. The Programmatic Biological Evaluation (PBE) prepared for this project states that a marine mammal monitoring plan will be implemented during pile removal and installation conducted between October 1 and February 14, to avoid impacts to marine mammals. The areas in which monitoring is proposed in this plan is dependent upon the location and type of activity being conducted (vibratory removal and/or installation, or impact installation). Some sites will not require monitoring.

DISCUSSION

In-Water Vibratory Pile Removal and Installation

NMFS has established an underwater noise disturbance threshold of 120 dB_{RMS} (decibels root mean square) for non-impulse, continuous industrial noises for cetaceans and pinnipeds. Noise levels during vibratory pile removal and installation would exceed this threshold within a portion of the action area (Vibratory Temporary Effect Area) at each of the 15 sites.

The proposed action will consist of the removal and installation of up to 200 piles annual in each year of the program (July 16, 2018 – February 14, 2023). The proposed action will replace a combination of load-bearing structural piles and fender piles. Most of the piles are treated timber piles (including creosote-treated and ACZA-treated piles); however, some are concrete. The proposed action will not install creosote-treated timber piles. ACZA-treated timber piling of a similar size and diameter will replace both creosote-treated and ACZA-treated timber piling. The largest timber piling to be replaced is approximately 18 inches in diameter. Concrete piling of a similar size and diameter will replace existing concrete piling. The largest concrete piling that will be replaced is 24 inches in diameter. Most of the piling to be replaced is less than 18 inches in diameter and the proposed action will replace no more than an estimated four concrete piles with diameters of 18 inches or greater in a single year.

New research associated with pile driving has been published since the previous permit cycle. A review of existing literature including project-specific data published by WSDOT (Laughlin 2007; 2011; 2015) California Department of Transportation's (CalTrans) Technical Guidance for Assessment and Mitigation of the Hydroacoustic Effects of Pile Driving on Fish, which includes the Compendium of Pile Driving Sound Data (Buehler et al. 2015, CalTrans 2015), and project-specific data published by the U.S. Navy (NSWCCD 2016), indicate that 160 dB_{RMS} is still an appropriate worst case estimate of the maximum sound levels likely to be produced during vibratory removal or installation of timber or concrete piles, for the following reasons:

- WSDOT reports that, on average, vibratory noise levels are between 10 and 20 dB lower than those produced by impact pile driving (WSDOT 2017).
- In 2015, the U.S. Navy collected hydroacoustic data during vibratory removal of timber piles and impact driving of concrete piles at Pier 6 of its naval shipyard in Bremerton. The results of this monitoring indicate that average values during vibratory removal of the timber piles ranged between 138 dB_{RMS} and 158 dB_{RMS}, with an overall average of 152 dB_{RMS}. The average values during impact pile driving of 24-inch concrete piles ranged from 168 dB_{RMS} to 183 dB_{RMS} with an overall average of 178 dB_{RMS} (NSWCCD 2016). The average impact noise was approximately 35 dB to 40 dB higher across the analysis bandwidth when compared to the site's quiet ambient condition (NSWCCD 2016).
- CalTrans' Compendium of Pile Driving Data provides information regarding vibratory installation of: 12-inch H-type steel pipe piles (150 dB_{RMS}), 12-inch steel pipe piles (155 dB_{RMS}), 24-inch AZ steel sheet pile (160 dB_{RMS}), and 36-inch steel pipe piles (170 dB_{RMS}) (CalTrans 2015). Concrete and timber piles produce much lower underwater sound pressures than similarly sized steel piles. Given these sound pressure levels, for purposes of this consultation, the sound pressure levels associated with vibratory removal and/or installation of 12–18-inch timber piles or 12–24-inch concrete piles would not exceed 160 dB_{RMS} on average.

The following assumptions underlay the vibratory pile removal and installation noise attenuation analysis:

- Background in-water noise levels in the action area are not available, so the analysis used a marine mammal vibratory guideline threshold of 120 dB_{RMS}.
- A worst-case estimate of noise level from vibratory removal and installation of concrete and timber piles is 160 dB_{RMS}.
- Noise will attenuate at a rate of 4.5 dB per doubling distance (meters).
- Sound will stop when it reaches the nearest land mass.

The distance at which 160 dB_{RMS} is expected to attenuate to 120 dB_{RMS} using the practical spreading loss model is approximately 4,642 meters, or 2.9 miles.

$R_1 = R_2 * (10^{(TL/15)}) = 10 * (10^{((160\text{-}120)/15)}) = 4{,}641.6$ meters.

Figures 3-17 show the Vibratory Temporary Effect Area for each of the 15 sites.

The Port may collect site-specific, in-water noise background data before the start of the project to determine if the monitoring can be reduced.

In-Water Impact Pile Installation

NMFS has established impact pile driving underwater noise injury thresholds of 180 dB_{RMS} for cetaceans and 190 dB_{RMS} for pinnipeds, and impact pile driving disturbance thresholds of 160 dB_{RMS} for both cetaceans and pinnipeds. Noise levels during impact pile installation are not expected to exceed injury thresholds for either pinnipeds or cetaceans, but will likely temporarily exceed the disturbance threshold of 160 dB_{RMS} within a portion of the action area at each of the 15 sites (Impact Temporary Effect Area).

Data published by WSDOT indicate that impact installation of timber piles has been measured as producing underwater noise levels as high as 180 dB_{Peak}, 170 dB_{RMS}, and 160 dB SEL (sound exposure level) (WSDOT 2016). These same data indicate that impact installation of 36-inch concrete piles typically produces single strike sound pressure levels of 192 dB_{Peak}, 176 dB_{RMS}, and 174 dB SEL (WSDOT 2017). CalTrans has published project-specific data documenting lower decibel levels during impact driving of 24-inch concrete piles (188 dB_{Peak}, 176 dB_{RMS}, and 166 dB SEL) (CalTrans 2015); however, for purposes of making a conservative estimate of the extent of underwater noise produced, the higher decibel levels have been used to determine the extent of underwater noise.

The distance at which 176 dB_{RMS} is expected to attenuate to 160 dB_{RMS} using the practical spreading model is approximately 117 meters or 383 feet.

$R_1 = R_2 * (10^{(TL/15)}) = 10 * (10^{((176-160)/15)}) = 116.6$ meters.

Figures 3-17 show the Impact Temporary Effect Area for each of the 15 sites.

SPECIES PRESENCE

ESA-listed marine mammal species (Southern Resident killer whale and humpback whale) are not expected to be present within the Blair, Hylebos, or Sitcum Waterways at any time, and are therefore unlikely to be exposed to elevated underwater noise associated with any pile removal or installation conducted at Parcels 86, 99, and 105 (Sites 15, 13, and 14, respectively on Figures 15-17).

Additionally, pile removal or installation conducted at Washington United Terminal (WUT), Blair Dock, Pierce County Terminal (PCT), East Blair 1 (EB-1), and Puget Sound Energy (PSE) (Sites 5-8 and 12, respectively on Figures 7-10 and 14) is only expected to elevate sound levels within Commencement Bay within a small area where ESA-listed marine mammals are unlikely to be present, or within such a small area that the noise would be insignificant.

As presented in the PBE, Southern Resident killer whales and humpback whales are not expected within Commencement Bay between July 16 and September 30, and pile removal and installation conducted during this time period would not be expected to affect any ESA-listed marine mammals (Osborne 2008; Mongillo 2012). Southern Resident killer whales are most commonly observed in Commencement Bay between approximately October and January, with the greatest potential for occurrence being between December and January (Osborne 2008). Humpback whales are sighted only occasionally in south Puget Sound, and are unlikely to occur within the waters of inner Commencement Bay at any time of the year.

MONITORING SCHEDULE

Marine mammal monitoring will be implemented between October 1 and February 14 to avoid impacts to ESA-listed marine mammals as determined by the PBE prepared for this proposed action. The monitoring will be implemented at the pile replacement activity-specific locations identified as Monitoring Areas and as detailed below under Monitoring Protocol.

MONITORING AREAS (VIBRATORY & IMPACT PILE REPLACEMENT ACTIVITY)

The sites at which vibratory pile removal and/or installation could potentially affect ESA-listed marine mammals are West Sitcum Terminal (formerly APMT), Terminal 7, East Sitcum Terminal (formerly OCT), Husky Terminal, Washington United Terminal (WUT), Blair Dock, Parcel 115, Tote Terminal, and Trident Piers 24 and 25 (Sites 1-6 and 9-11 on Figures 3-6 and 11-13). Therefore, during any vibratory pile removal or installation conducted at these sites (Sites 1-4 and 9-11), the Vibratory Monitoring Area within the 120 dB_{RMS} Vibratory Temporary Effect Area identified on Figures 3-6 and 11-13 will be monitored and maintained as a marine mammal buffer area. Vibratory pile removal or installation will not commence or will be suspended temporarily if any orca or humpback whale is present within the Vibratory Monitoring Area (i.e., marine mammal buffer) for the respective site at which vibratory pile replacement activities are being conducted (Sites 1-4 and 10-11).

The only site at which impact pile installation could potentially affect ESA-listed marine mammals is at Trident Piers 24 and 25 (Site 11 on Figure 13). Therefore, during any impact pile installation or proofing conducted at Site 11, the respective Impact Monitoring Area within 160 dB_{RMS} Impact Temporary Effect Area identified on Figure 13 will be monitored and maintained as marine mammal buffer area. Impact pile installation or proofing will not commence or will be suspended temporarily if any orca or humpback whale is present within Site 11 (Figure 13) Impact Monitoring Area (i.e., marine mammal buffer).

The Port may collect site-specific in-water noise background data before the start of a pile replacement project to determine if the monitoring areas can be reduced.

MONITORING PROTOCOL

The Port will conduct the following marine mammal monitoring activities during the timeframe indicated under the Monitoring Schedule, at the locations specified under Monitoring Areas and shown on the attached figures.

1. Qualified biologists or other trained marine mammal observers who meet the list of qualifications for marine mammal observers will be present on site at all times during pile removal/driving activities per the Monitoring Schedule and at the specified Monitoring Areas.
2. Two observers will monitor the Vibratory Monitoring Area as required by the Monitoring Schedule and at the specified Monitoring Areas (October 1 to February 14, at Sites 1-6 and 9-11, as shown on Figures 3-6 and 11-13). The first observer will be in the vicinity of the proposed pile replacement activity. The second observer will either be at a land-based location or on a boat traveling within the vibratory disturbance area. The most likely land-based locations for the second observer will be at a location on Browns Point, along Marine

View Drive, or along the southwestern shoreline of Commencement Bay (Schuster Parkway, Ruston Way).

3. A single observer will monitor the Impact Monitoring Area as required by the Monitoring Schedule and at the specified Monitoring Areas (October 1 to February 14 at Site 11, as shown on Figure 13).
4. The observer(s) will use binoculars and visual observation to scan the waters within the respective Monitoring Area.
5. The observer(s) will scan the waters 20 minutes before the beginning of pile removal/driving activities and during all pile removal/driving activities. The observer(s) will notify the on-site operator in charge if Southern Resident killer whales or humpback whales enter or are observed within the respective Monitoring Area 20 minutes prior or during pile driving. The operator in charge will require the contractor to not begin or to cease work until the animal has moved outside the Monitoring Area.

MINIMUM QUALIFICATIONS FOR MARINE MAMMAL OBSERVERS

1. Visual acuity in both eyes (correction is permissible) sufficient to discern moving targets at the water's surface and to estimate target size and distance. Use of binoculars may be necessary to identify the target correctly.
2. Advanced education in biological science, wildlife management, mammalogy, or related field (bachelor's degree or higher is preferred).
3. Experience and ability to conduct field observations and collect data according to assigned protocols (this may include academic experience).
4. Experience or training in the field identification of marine mammals (cetaceans and pinnipeds).
5. Sufficient training, orientation, or experience with construction operation to preserve personal safety during observations.
6. Ability to communicate orally, by radio or in person, with project personnel to provide real-time information on marine mammals observed in the area as necessary.

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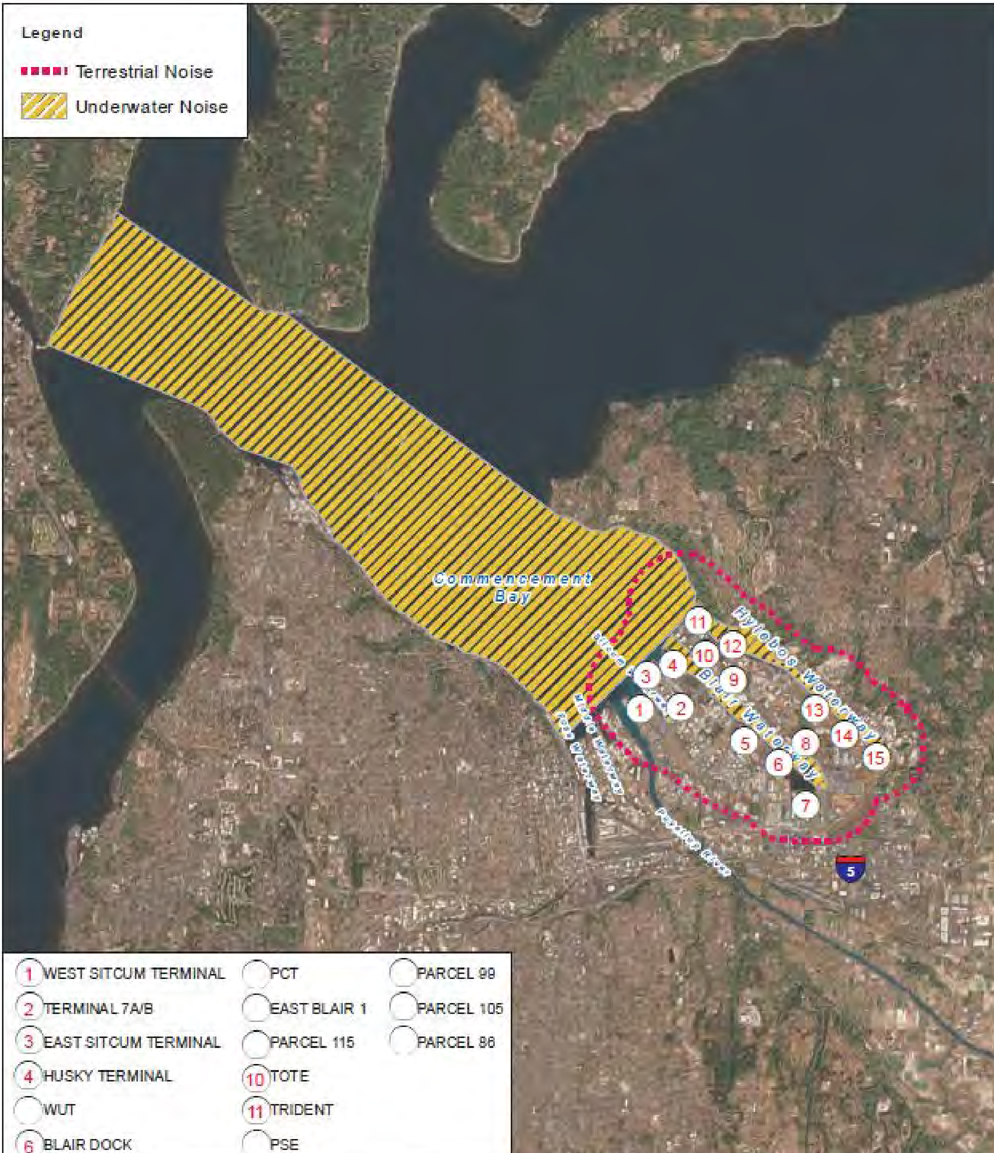

FIGURE 2 - ACTION AREA

PROJECT: Programmatic Piling Repair - Biological Evaluation

REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 2 of 17

0 0.5 1 2 3 Miles

Port of Tacoma
PO Box 1837 Tacoma, WA 98401 (253) 383-5841

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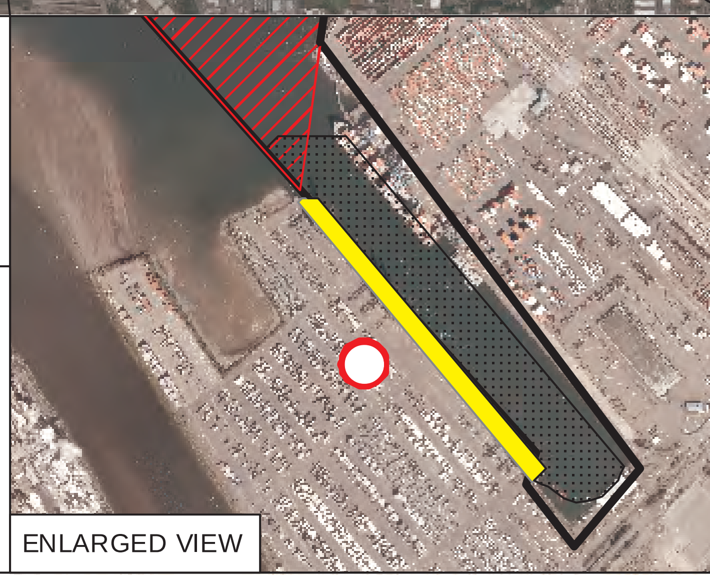
- Site
- Vibratory Temp. Effect Area (Removal/Installation)
- Vibratory Monitoring Area (Removal/Installation)
- Impact Temp. Effect Area (Installation)
- Impact Monitoring Area (Installation)

WEST SITCUM TERMINAL	7 PCT	13 PARCEL 99
TERMINAL 7A/B	8 EAST BLAIR 1	14 PARCEL 105
EAST SITCUM TERMINAL	9 PARCEL 115	PARCEL 86
HUSKY TERMINAL	TOTE	
WUT	TRIDENT	
BLAIR DOCK	PSE	



ENLARGED VIEW

Port of Tacoma

PO Box 1837 Tacoma, WA 98401 (253) 383-5841

FIGURE 3 - SITE 1

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 3 of 17

N
S

0 0.25 0.5 1 1.5 Miles

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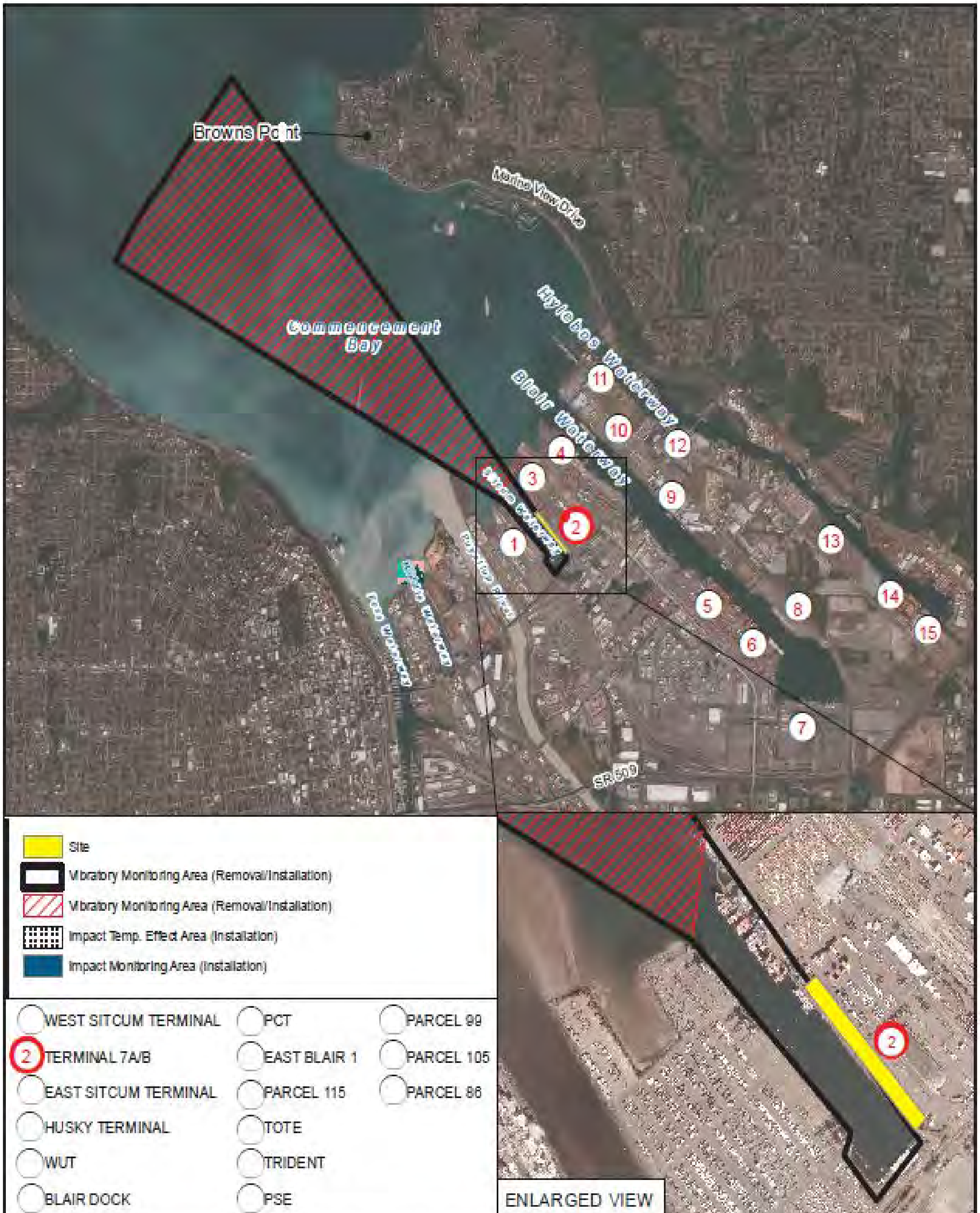

Port of Tacoma
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FIGURE 4 - SITE 2

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 4 of 17

0 0.25 0.5 1 1.5 Miles

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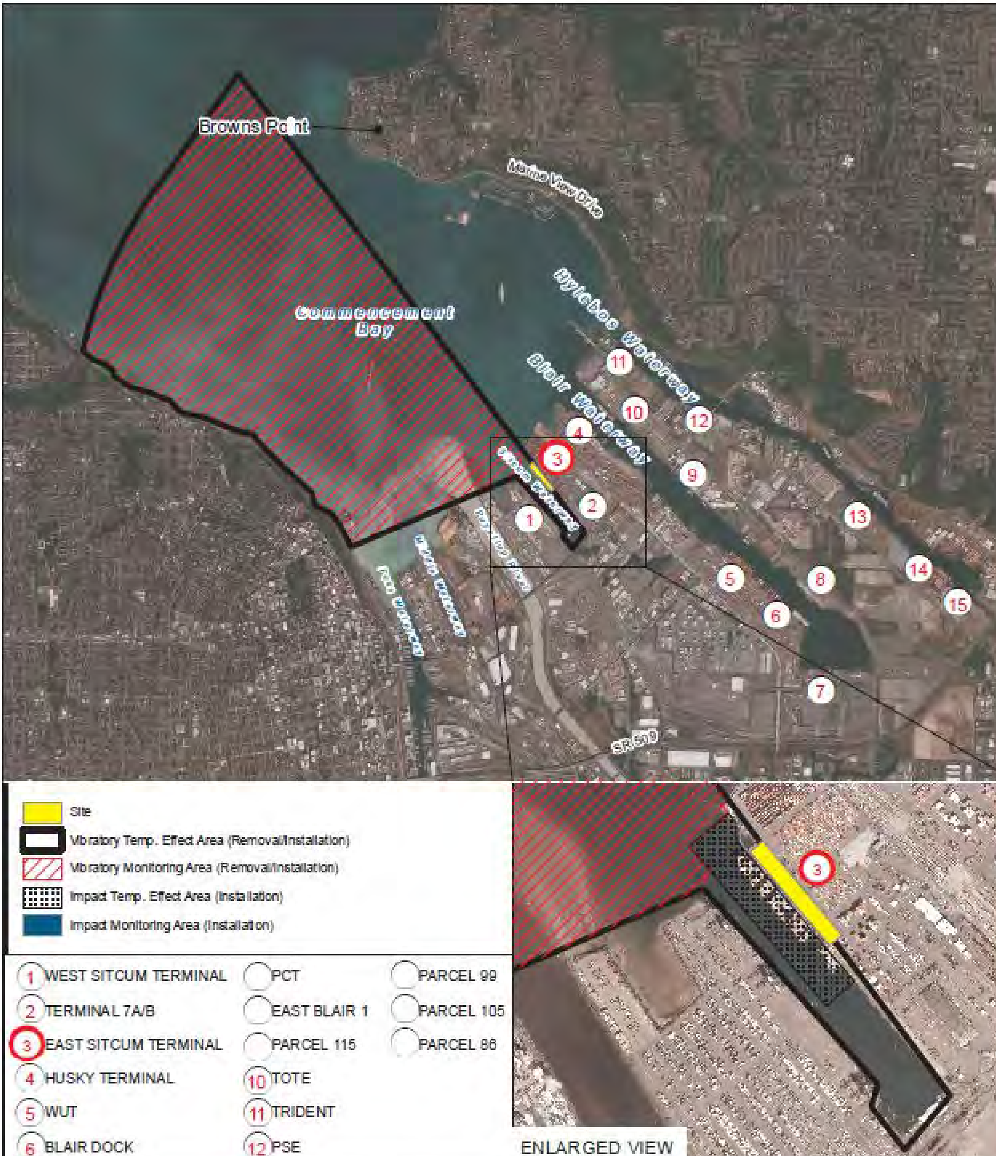

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FIGURE 5 - SITE 3

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 5 of 17

0 0.075 0.15 0.3 0.45 Miles

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Site

Vibratory Temp. Effect Area (Removal/Installation)

Vibratory Monitoring Area (Removal/Installation)

Impact Temp. Effect Area (Installation)

Impact Monitoring Area (Installation)

WEST SITCUM TERMINAL	PCT	PARCEL 99
TERMINAL 7A/B	EAST BLAIR 1	PARCEL 105
EAST SITCUM TERMINAL	PARCEL 115	PARCEL 86
HUSKY TERMINAL	TOTE	
WUT	TRIDENT	
BLAIR DOCK	PSE	

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FIGURE 6 - SITE 4

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 6 of 17

0 0.325 0.65 1.3 1.95 Miles

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Site

Vibratory Temp. Effect Area (Removal/Installation)

Vibratory Monitoring Area (Removal/Installation)

Impact Temp. Effect Area (Installation)

Impact Monitoring Area (Installation)

1 WEST SITCUM TERMINAL	PCT	PARCEL 99
2 TERMINAL 7A/B	EAST BLAIR 1	PARCEL 105
3 EAST SITCUM TERMINAL	PARCEL 115	15 PARCEL 86
4 HUSKY TERMINAL	10 TOTE	
WUT	11 TRIDENT	
6 BLAIR DOCK	12 PSE	

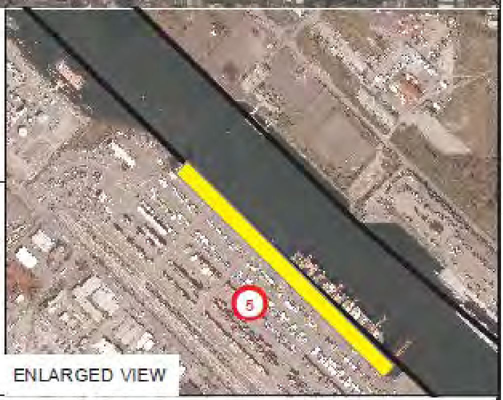

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FIGURE 7 - SITE 5

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 7 of 17

0 0.325 0.65 1.3 1.95 Miles

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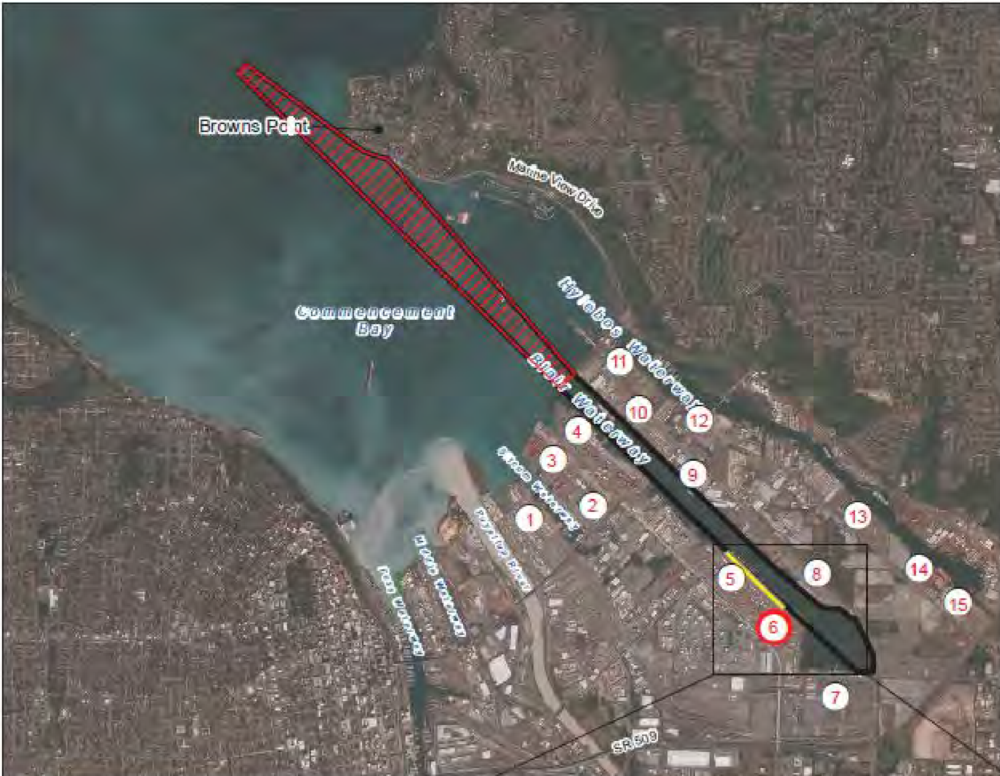

- Site
- Vibratory Temp. Effect Area (Removal/Installation)
- Vibratory Monitoring Area (Removal/Installation)
- Impact Temp. Effect Area (Installation)
- Impact Monitoring Area (Installation)

WEST SITCUM TERMINAL	PCT	13 PARCEL 99
TERMINAL 7A/B	EAST BLAIR 1	14 PARCEL 105
EAST SITCUM TERMINAL	PARCEL 115	PARCEL 86
HUSKY TERMINAL	TOTE	
WUT	TRIDENT	
BLAIR DOCK	PSE	

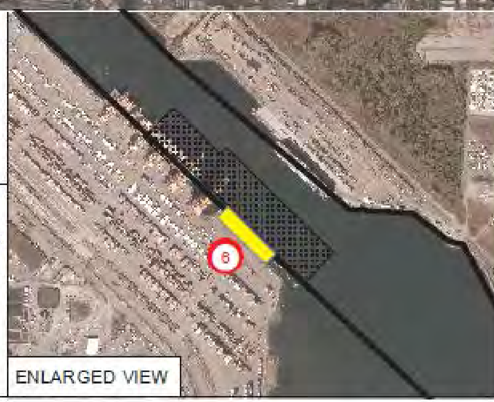

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FIGURE 8 - SITE 6

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 8 of 17

0 0.325 0.65 1.3 1.95 Miles

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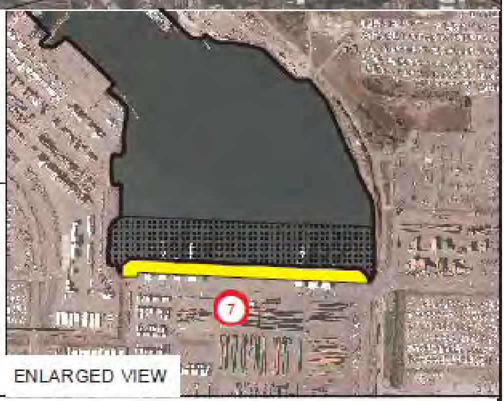

(yellow)	Site
(black outline)	Vibratory Temp. Effect Area (Removal/Installation)
(red hatched)	Vibratory Monitoring Area (Removal/Installation)
(dotted grid)	Impact Temp. Effect Area (Installation)
(blue)	Impact Monitoring Area (Installation)

1 WEST SITCUM TERMINAL	PCT	13 PARCEL 99
2 TERMINAL 7A/B	EAST BLAIR 1	PARCEL 105
3 EAST SITCUM TERMINAL	PARCEL 115	15 PARCEL 86
HUSKY TERMINAL	10 TOTE	
WUT	11 TRIDENT	
BLAIR DOCK	PSE	

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FIGURE 9 - SITE 7

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 9 of 17

0 0.25 0.5 1 1.5 Miles

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Site	
Vibratory Temp. Effect Area (Removal/Installation)	
Vibratory Monitoring Area (Removal/Installation)	
Impact Temp. Effect Area (Installation)	
Impact Monitoring Area (Installation)	

WEST SITCUM TERMINAL	PCT	PARCEL 99
TERMINAL 7A/B	EAST BLAIR 1	PARCEL 105
EAST SITCUM TERMINAL	PARCEL 115	PARCEL 86
HUSKY TERMINAL	TOTE	
WUT	TRIDENT	
BLAIR DOCK	PSE	

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FIGURE 10 - SITE 8

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 10 of 17

0 0.25 0.5 1 1.5 Miles

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FIGURE 11 - SITE 9

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 11 of 17

0 0.25 0.5 1 1.5 Miles

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Site
Vibratory Temp. Effect Area (Removal/Installation)
Vibratory Monitoring Area (Removal/Installation)
Impact Temp. Effect Area (Installation)
Impact Monitoring Area (Installation)

WEST SITCUM TERMINAL	PCT	PARCEL 99
TERMINAL 7A/B	EAST BLAIR 1	PARCEL 105
EAST SITCUM TERMINAL	PARCEL 115	PARCEL 86
HUSKY TERMINAL	TOTE	
WUT	TRIDENT	
BLAIR DOCK	PSE	

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FIGURE 12 - SITE 10

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 12 of 17

0 0.25 0.5 1 1.5 Miles

Site

Vibratory Temp. Effect Area (Removal/Installation)

Vibratory Monitoring Area (Removal/Installation)

Impact Temp. Effect Area (Installation)

Impact Monitoring Area (Installation)

1 WEST SITCUM TERMINAL	PCT	PARCEL 99
2 TERMINAL 7A/B	EAST BLAIR 1	PARCEL 105
3 EAST SITCUM TERMINAL	PARCEL 115	15 PARCEL 86
4 HUSKY TERMINAL	10 TOTE	
5 WUT	TRIDENT	
6 BLAIR DOCK	12 PSE	

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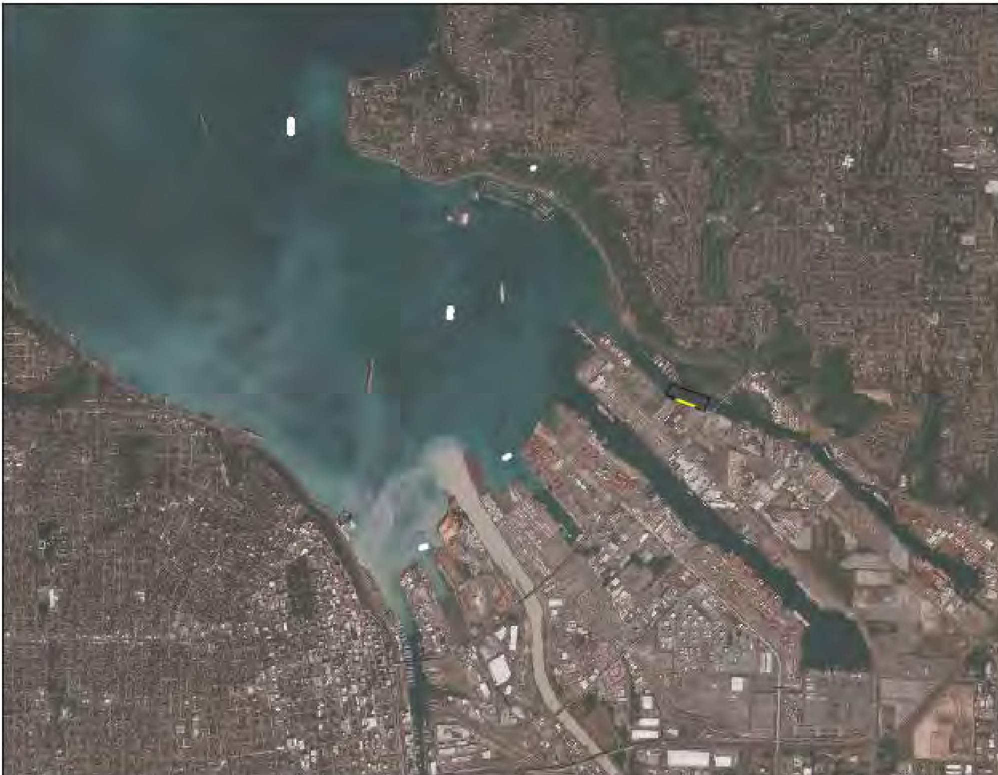
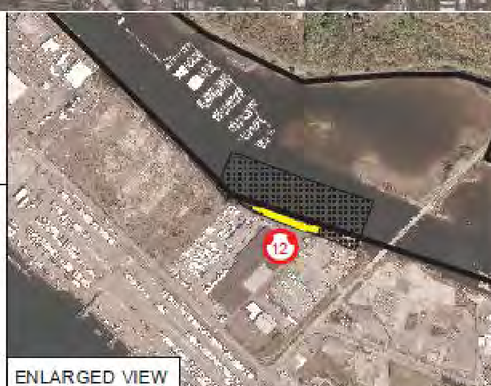
FIGURE 13 - SITE 11

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 13 of 17

0 0.075 0.15 0.3 0.45 Miles





Site
Vibratory Temp. Effect Area (Removal/Installation)
Vibratory Monitoring Area (Removal/Installation)
Impact Temp. Effect Area (Installation)
Impact Monitoring Area (Installation)

WEST SITCUM TERMINAL	PCT	PARCEL 99
TERMINAL 7A/B	EAST BLAIR 1	PARCEL 105
EAST SITCUM TERMINAL	PARCEL 115	PARCEL 86
4 HUSKY TERMINAL	10 TOTE	
5 WUT	TRIDENT	
6 BLAIR DOCK	12 PSE	

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FIGURE 14 - SITE 12

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 14 of 17

0 0.25 0.5 1 1.5 Miles

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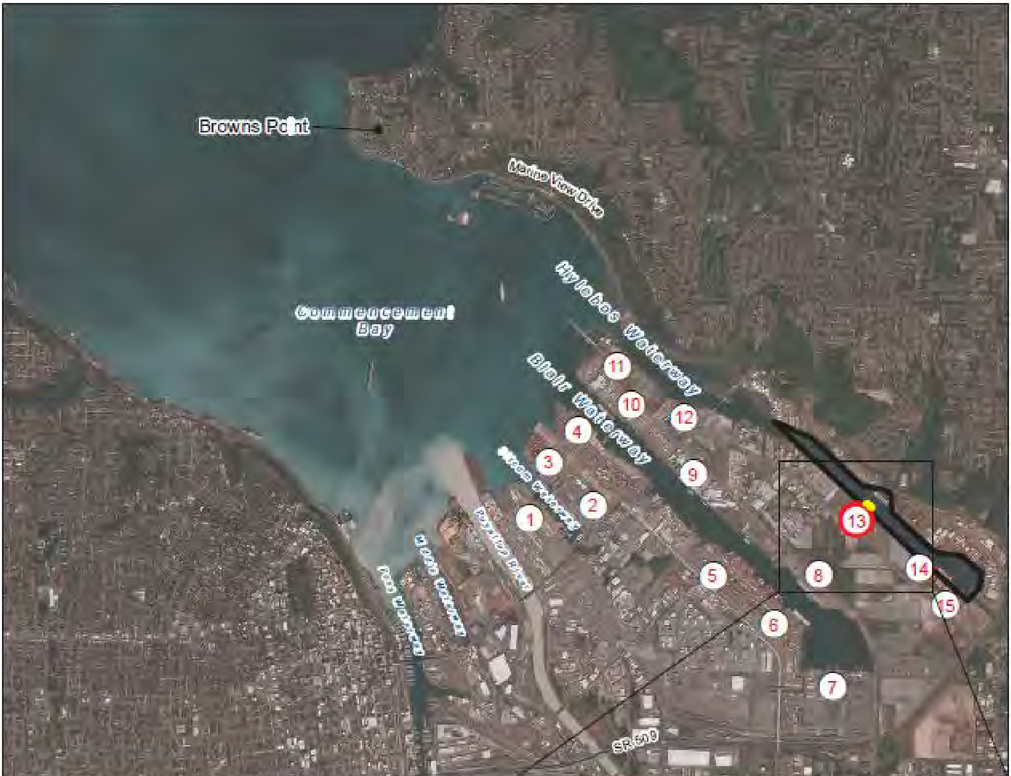

ENLARGED VIEW

Site

Vibratory Temp. Effect Area (Removal/Installation)

Vibratory Monitoring Area (Removal/Installation)

Impact Temp. Effect Area (Installation)

Impact Monitoring Area (Installation)

1 WEST SITCUM TERMINAL	PCT	PARCEL 99
2 TERMINAL 7A/B	8 EAST BLAIR 1	PARCEL 105
3 EAST SITCUM TERMINAL	PARCEL 115	15 PARCEL 86
4 HUSKY TERMINAL	10 TOTE	
5 WUT	11 TRIDENT	
6 BLAIR DOCK	12 PSE	

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FIGURE 15 - SITE 13

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 15 of 17

0 0.25 0.5 1 1.5 Miles

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Site

Vibratory Temp. Effect Area (Removal/Installation)

Vibratory Monitoring Area (Removal/Installation)

Impact Temp. Effect Area (Installation)

Impact Monitoring Area (Installation)

1 WEST SITCUM TERMINAL	7 PCT	13 PARCEL 99
2 TERMINAL 7A/B	8 EAST BLAIR 1	14 PARCEL 105
EAST SITCUM TERMINAL	PARCEL 115	PARCEL 86
HUSKY TERMINAL	TOTE	
WUT	TRIDENT	
BLAIR DOCK	PSE	

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FIGURE 16 - SITE 14

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 16 of 17

0 0.25 0.5 1 1.5 Miles

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- Site
- Vibratory Temp. Effect Area (Removal/Installation)
- Vibratory Monitoring Area (Removal/Installation)
- Impact Temp. Effect Area (Installation)
- Impact Monitoring Area (Installation)

WEST SITCUM TERMINAL	PCT	PARCEL 99
2 TERMINAL 7A/B	EAST BLAIR 1	14 PARCEL 105
3 EAST SITCUM TERMINAL	9 PARCEL 115	15 PARCEL 86
4 HUSKY TERMINAL	10 TOTE	
5 WUT	11 TRIDENT	
BLAIR DOCK	PSE	

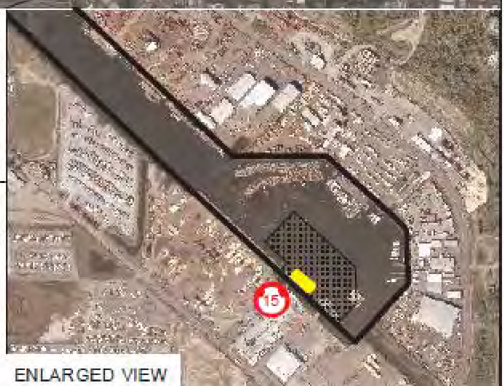

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FIGURE 17 - SITE 15

PROJECT: Programmatic Piling Repair - Biological Evaluation
Temporary Effect and Monitoring Areas
REFERENCE #: NWS-2011-0089-WRD
LOCATION: Port of Tacoma
SHEET: 17 of 17

0 0.25 0.5 1 1.5 Miles

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Appendix F: NMFS Evaluation of and Credit Determination for Place of Circling Waters Advance Compensatory Mitigation Site for Limited use with CMMP Consultation

NMFS has done an evaluation of the Port of Tacoma's Place of Circling Waters ("POCW") advance compensatory mitigation ("ACM") site for the purposes of determining whether credits from this site can appropriately be used to offset debits in the CMMP consultation. This Appendix sets out the details of that evaluation and our conclusions.

Background on POCW ACM site

A. In 2010-2011, the Port undertook a restoration project at 1621 Marine View Drive in Tacoma, Washington, within Commencement Bay and the Puyallup River Watershed. The restoration project involved restoration of an old gravel mine into estuarine habitat. The restored habitat area includes Hylebos Creek and is referred to as the POCW.

B. The primary purpose of the POCW restoration project was to satisfy a claim under the Natural Resource Damages Act, but the Port elected to do more than was required for NRDA and restore additional acreage at the ACM site with the express purpose of creating advance mitigation credits.

C. Construction of the POCW ACM site included removal of an overwater structure, fill material, creosote pilings, and a dike to restore estuarine wetland. Habitats constructed within the site include tidal marsh wetlands, open water, wetland and riparian buffer, and seep (slope) freshwater wetlands. A conservation easement was recorded for the POCW ACM site.

D. The Port worked with professional consultants to develop documentation for the POCW ACM site, including an Advance Permittee-Responsible Mitigation Site Plan and Use Plan involving a credit generating schedule, credit and debit ledgers, and mitigation service area- and, pursuant to those plans, has commissioned regular monitoring reports and has maintained a ledger for the POCW ACM site.

E. The US Army Corps of Engineers ("Corps") has agreed that credits from POCW ACM can be evaluated and applied to offset debits under the Clean Water Act on a project-specific basis, including an analysis of the type of wetland impacts proposed and whether that the advance mitigation site continues to meet its the performance standards. In 2013 the Corps agreed that credits from POCW ACM provided suitable mitigation for the Port's MTCA cleanup action at 3009 Taylor Way. In April 2016, the Corps agreed that credits from POCW ACM provided suitable mitigation for the impact of the Port's North Lead Rail Project.

Document Review, Site Visit, and HEA Analysis

To evaluate the appropriateness of using POCW ACM credits to offset debit incurred by the CMMP program, NMFS conducted a document review, made a site visit, conducted a literature review in order to evaluate the HEA analysis for the POCW ACM site, and verified the ledger.

Specifically, NMFS reviewed and evaluated documentation prepared by the Port and its consultants, and by the Corps, in relation to the POCW ACM, including:

- Mitigation Action and Monitoring Plan: Hylebos Creek and Morningside Ditch, Grette Associates (Feb. 2009)
- Technical Memorandum: Parcel 88 Advanced Compensation Area Existing Condition, Grette Associates (August 30, 2010).
- Parcel 88: Advanced Compensation Mitigation Plan, Grette Associated, Section 3.1 (Sept. 2, 2010)
- Port of Tacoma, Place of Circling Waters: Advanced Compensation Mitigation As-Built Report, Grette Associates (Nov. 2011).
- Technical Memorandum: Port of Tacoma-Place of Circling Water Advanced Compensation Mitigation Area Habitat Equivalency Analysis Methods, Grette Associates (April 9, 2013).
- Place of Circling Waters Advance Permittee-Responsible Mitigation Proposal (4/12/2013).
- Mitigation Use Plan (10/13/2015) (Lead Tracks Project - Erdahl Ditch).
- Email dated July 29, 2013, from O. Romano (Corps) to W. Rehe (Port)
- Corps Permit, Reference NWS-2015-0489-WRD, p. 33 (April 11, 2016)
- 10-year monitoring report (Anchor QAE. 2021)
- Conservation easement for the POCW ACM site.
- Tony Warfiled October 11, 2024. Email to WRDA Project Manager LeeAnn Simmons. Marine Intertidal Mitigation Ledger_POCW-2024

In reviewing these documents, NMFS evaluated the advance mitigation purpose of the site, the integrity of the restoration project (including whether it is meeting its performance standards), applicability of the service area for CMMP, as well as transparency and reliability of the monitoring and ledgering associated with the site.

The following is a summary of agency correspondence/interactions on the POCW ACM:

- In November 2010, the Corps determined that the Port's proposal to construct restoration at the ACM site was authorized under Nationwide Permit 27. The Corps stated that it would work with the Port to develop a credit generation and release schedule. (Olivia Roamano Attachment_5__Letter_from_Corps_to_Port_of_Tacoma_Nov._2010[1])
- December 2010. WDFW informed the Port of Tacoma that: "WDFW will consider restoration work completed by the Port of Tacoma at Parcel 88 and the Saltchuck sites as compensatory mitigation for future unavoidable impacts to fish habitat. WDFW commits to work with the other state and federal agencies and the Port of Tacoma to determine the compensatory mitigation the advance mitigation sites provide to offset a future unavoidable impact. However, WDFW may not accept the advanced mitigation sites as compensatory mitigation for all type of impacts. In general, in-kind mitigation is preferred. If the advanced mitigation sites provided out-of-kind mitigation, other actions to mitigate in-kind for impacts may be requested."
  Attachment_18__Letter_from_DFW_Dec._2010[1]
- On April 11, 2013, the Port submitted for approval a Permittee-Responsible Mitigation Proposal which included elements such as a credit generating schedule, proposed credit and debit ledgers and proposed mitigation service areas. (Attachment_7__Mitigation_Proposal_April_2013[1])n
- On April 12, 2013, the Port submitted an Advance Permittee-Responsible Mitigation Use Plan: "The Port of Tacoma would like to submit the following documents, as outlined in the 'use of the advance mitigation site' section of Ecology Publication Interagency Regulatory Guide: Advance Permittee-Responsible Mitigation (no. 12-06-015). The Advance Mitigation Site Use Plan contains response to questions 1-9."
  Attachment 11 _Mitigation Use Plan_April 2013
- In May 2013, the Corps responded by requesting more detail in the ledger and the Port replied with some additional information "summary and rationale for the advance mitigation we are requesting".
  Attachment_6__Email_from_Port_to_Corps_May_2013[1]
- In July 2013, the Port wrote to the Corps noting it had not received official approval of its Permittee-Responsible Mitigation Proposal and asking if the Corps could plan to use credits from POCW for its upcoming <u>North Lead Tracks</u> project. The Corps responded by saying:

  > The Corps has accepted the use of advance mitigation credits from Place of Circling Water as suitable mitigation for the impact to 4000 square feet (0.09 acres) of intertidal wetland within the Hylebos Waterway for the Port of Tacoma MTCA cleanup action at 3009 Taylor Way. In the future, use of the advance mitigation credits from Place of Circling Waters will continue to be based on the type of wetland impacts proposed and that the advance mitigation site continues to meet its the performance standards.
  > Attachment_14__Email_O._Ramano_Approval__July_2013[1]

- In April 2014, the Port submitted for approval to the City of Tacoma a Permittee-Responsible Mitigation Proposal specific to the North Lead Tracks project._Attachment_12__Mitigation_Use_Plan_April_2014[1]
- On October 13, 2015, the Port submitted for approval to the Corps a revised Permittee-Responsible Mitigation Proposal specific to the North Lead Tracks project.
  Attachment_13__Mitigation_Use_Plan_Lead_Rail_Oct._2015[1]
- ON April 11, 2016, the Corps issued a permit for the North Lead Tracks project and one of the conditions was "You shall implement and abide by the *Place of Circling* Waters *Advance Permittee-Responsible Mitigation* Use *Plan,* dated October 13, 2015, and obtain advanced mitigation credits in accordance with the Port of Tacoma's Place of Circling Waters Advance Permittee-Responsible Mitigation Site Plan.
  Attachment_15__2016_Corps_Approval[1]

NMFS also visited the POCW ACM site on March 7, 2025 and found the site generally in functioning conditions consistent with the description in the Advance Compensatory Mitigation

As-Built Report (Grette, May 2013) and the 10-year monitoring report (Anchor QAE. 2021). See picture below.

NMFS analyzed the HEA analysis previously conducted in relation to the POCW ACM site. Grette (April_2013) performed a cursory HEA analysis based on a 2001 HEA that the NOAA restoration center performed for a Natural Resources Damage Assessment (Iadanza 2001). Iadanza developed habitat service values[1] for three species, Puget Sound Chinook, English sole, and birds as well as combined values across these three species. Iadanza's findings for habitat service values for Chinook are generally consistent with more recent literature on habitat use by Chinook. For example, Davis et al. (2019) found that the growth rate potential in emergent salt marsh along with tidal freshwater forests was the highest among evaluated habitats. This supports the habitat service values of 1 that Iadanza assigned in 2001 to estuarine marsh. However, some of Iadanza's values for Chinook are not applicable for use with Endangered Species Act (ESA) consultations. Vegetated buffer (habitat service value of 0.5 for Chinook) and upland greenbelt habitat (habitat service value of 0.2 for Chinook) are too high when these habitats are outside of Chinook critical habitat[2].

[1] HEA habitat service values range between 0 and 1 with 1 indicating best habitat quality.
[2] Lateral extent of Puget Sound Chinook critical habitat extends to the Ordinary High Water mark or in marine areas the extreme high tide (50 CFR 226).

Only actions that benefit designated critical habitat can be used to provide compensation for impacts to critical habitat based on Ninth Circuit case law (Gifford Pinchot Task Force v USFWS, 378 F.3d 1059, 1075-76 (9th Cir. 2004)). Thus, the value of riparian and upland habitat has to be determined based on the amount of benefit realized within the designated critical habitat itself. Based on findings by Davis et al. (2024), we find values of 0.4 for riparian habitat within 150 feet and of 0.15 for upland greenbelt habitat defensible. Davis et al. (2024) found that allochthonous terrestrial contributions to juvenile salmonid diets ranged between 26 and 43%. The amount of terrestrial input is likely correlated with distance from the estuary. That's why riparian vegetation is more valuable than further distant upland vegetation (upland greenbelt). However, further distant vegetation in the proximity provides some forage to critical habitat and supports water quality functions. While Grette (April_2013) is silent as to which habitat value developed by Iadanza (2001) they are referring to, the combined or a species value, their proposed habitat values of 0.4 for riparian habitat within 150 feet and of 0.15 for upland greenbelt habitat are appropriate for Chinook as outlined above.

Grette (April_2013) values tidally influenced mudflat at 0.9 for without providing rationale. This value is higher than what was determined by Iadanza (2001). Fully functional intertidal habitat values for Chinook as developed by Iadanza (2001) range between 0.4 and 0.75, for sole[3] between 0.15 and 1. Wolotira (2008) valued mudflats in the Snohomish Estuary for Chinook at 0.5 for high-intertidal and at 0.45 for low intertidal. The quantification of habitat value for mudflat is challenging as not much literature to inform this aspect exists (Table 1) and there is nuance to consider as for example relative habitat service value may vary over the season. When looking at forage alone, mudflat on average provides much less value than saltmarsh. Woo et al. (2019) found that Nisqually estuarine emergent saltmarsh provided double the aquatic prey biomass compared to mudflat or eelgrass with eelgrass providing the least. Different from those results, Hosack et al. (2006) and Thom et al. (1989) both found that densities of epifauna were significantly higher in eelgrass compared to mudflat; their studies did not include saltmarsh. Thom et al. (1989) further found that maximum mean fish density in the eelgrass bed exceeded that on the mudflats by 2.8 times. However, Thom et al. (1989) also established that mudflats are important for ecosystem support and especially valuable for juvenile rearing in the spring when their productivity may exceed that of eelgrass.

NMFS reviewed the ledger for POCW provided by the Port of Tacoma (Attachment 22). NMFS and the Port of Tacoma summarized findings regarding the ledger and created a live ledger for future recording in the spreadsheet POCW-HEATable ReConstruction.XLS[4]. The joint ledger shows both 404 universal CWA credits and DSAYs. At the time of this consultation, there were 110.39 DSAYs available. One universal CWA credit equals 32.45 DSAYs. Withdrawal of one credit type will result in the proportional reduction of the other credit type to avoid double dipping.

[3] English sole is a groundfish species for which NMFS administers the Magnusson Stevens Act

[4] Available in the admin record.

Conclusion

As discussed in more detail below, NMFS has concluded that, given the unique circumstances of the POCW ACM, including detailed its historical records demonstrating: the original purpose of the restoration project for advance mitigation; evaluation of the site and its credits by the Corps (and WDFW), including use of a credit ledger; ongoing monitoring and reporting of site conditions – and based on NMFS' present day evaluation of the ecological relevance of the site as well as its HEA analysis, ledger and other documentation, the POCW ACM credits can appropriately be used to offset Port of Tacoma debits from the Program, initially with the ratio discussed below and with the caveat that NMFS can re-evaluate the ratio as new information – such as an estuary calculator - becomes available.

The much lower production of salmonid forage compared to eelgrass and marsh habitats suggests a lower habitat service value than 0.9. However, the seasonal importance of mudflat habitat to juvenile salmonids, provision of unobstructed shallow migratory and rearing habitat, and high overall ecosystem value (for example for EFH species like sole) also needs to be considered. Based on best available information, and the integration of habitat value derived across all these functions, we believe there is a sound basis for applying a 0.7 habitat service value for mudflat habitat for use of credits from POCW with this CMMP consultation. However, we reserve the right to re-evaluate habitat lift when new information becomes available. For example, as of early 2025, the NWFSC is working on an estuary habitat evaluation model incorporating additional science that may provide relevant updates. Along with updates, we expect to develop and apply adjustment factors accounting for landscape scale and likely juvenile use similar to those developed in Wolotira 2008 and Ehinger 2024.

This evaluation and conclusion is applicable solely to the CMMP consultation. For use of credits from POCW ACM with other consultations, NOAA would need to evaluate whether credits from POCW ACM are appropriate for each consultation.

Search Engine	Search Terms	Results	Relevant
AFS ProQuest	(intertidal mudflat) AND salmon AND (Puget Sound) all in Abstract & Summary	1	Smith 1976
AFS ProQuest	(intertidal mudflat) AND salmon, all in Abstract & Summary	9	Hosack et al. 2006
AFS ProQuest	summary(intertidal mudflat) AND summary(Puget Sound), all in Abstract & Summary	8	0
AFS ProQuest	summary(mudflat) AND summary(Puget Sound)	16	Woo et al. 2019
AFS ProQuest	summary(mudflat) AND summary(salmon)	16	No additional relevant resources
Google Scholar	mudflat AND Puget Sound AND salmon since 2021	297	No additional relevant resources
Known by author			Wolotira 2008

Table 1: Reference Search History

References & Reviewed Technical Documents:

1. Grette. February 2009. PARSONS MITIGATION ACTION AND MONITORING PLAN HYLEBOS CREEK AND MORNINGSIDE DITCH – "Parsons Mitigation Action … includes three on-site mitigation Elements;
   (Element A) Parsons-Hylebos Mitigation Action of **1.9 acres of enhanced upland buffer**,
   (Element B) Parsons-Morningside Mitigation Action of **1.4 acres of buffer enhancement** associated with Morningside Ditch, and
   (Element C) Parsons Mitigation Action of **0.02 acre of created emergent wetland** and **0.04 acre of enhanced wetland buffer** as compensation for impacts to Morningside Ditch (Sheet 1 of 10)"
2. Anchor. PARSONS PROJECT YEAR 1 MONITORING REPORT – Anchor no date
3. Grette. August 2010. Technical Memo. Parcel 88 Advanced Compensation Area Existing Conditions
   Attachment_8__Tech._Memo_re_Parcel_88_Existing_Condition_August_2010[1]
4. Grette. September 2010. **ADVANCED COMPENSATION MITIGATION PLAN**. Parcel 88
   "proposes to construct **1.61 acres of tidally-influenced marsh** adjacent to a consolidated habitat area centered on a Natural Resource Damage Assessment (NRD) mitigation site (Parcel 88 site) near the head of the Hylebos Waterway."
5. Grette, May 2013. POCW Advance Compensatory Mitigation **As-Built Report**
6. Grette. April_2013. TECHNICAL MEMORANDUM PORT OF TACOMA-PLACE OF CIRCLING WATER ADVANCED COMPENSATION MITIGATION AREA **HABITAT EQUIVALENCY ANALYSIS METHODS** -
   Attachment_19___Tech._Memo_Mitigation_HEA_April_2013[1]
7. Potter 2025. 250307_POCW_HEATableReConstructfor SE.xls HEA information summarized by Sara Potter for NMFS
8. Tony Warfiled October 11, 2024. Attachment 22_2024 Marine Intertidal Mitigation Ledger_POCW-2024 dredges-combined 1 -. **Updated Ledger 110.395 DSAYs remaining/available**

9. Anchor QAE. 2021. Attachment 23_Year10_MonitoringReport_FINAL

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Davis, M. J., I. Woo, C. S. Ellings, S. Hodgson, D. A. Beauchamp, G. Nakai, and S. E. W. De La Cruz. 2019. Freshwater Tidal Forests and Estuarine Wetlands May Confer Early Life Growth Advantages for Delta-Reared Chinook Salmon. Transactions of the American Fisheries Society 148(2):289-307.

Hosack, G. R., B. R. Dumbauld, J. L. Ruesink, and D. A. Armstrong. 2006. Habitat Associations of Estuarine Species: Comparisons of Intertidal Mudflat, Seagrass (Zostera Marina), and Oyster (Crassostrea Gigas) Habitats. Estuaries and Coasts 29(6B):1150-1160.

Ehinger, S. I., Paul Cereghino, Josh Chamberlin. 2023. The Puget Sound Nearshore Habitat Conservation Calculator Scientific Rationale. NOAA Draft Report.

Iadanza, N. E. 2001. Determining Habitat Value and Time to Sustained Function. Appendix C to NOAAs Damage Assessment, Remediation, and Restoration Program (DARRP) Commencement Bay, Tacoma, WA Case Report.

Smith JE. 1976. Sampling intertidal salt marsh macrobenthos. [1. Pacific Northwest Technical Workshop of Fish Food Habits Studies; Astoria, OR (USA); 13 Oct 1976]

Thom, R. M., C. A. Simenstad, J. R. Cordell, and E. O. Salo. 1989. Fish and their epibenthic prey in a marina and adjacent mudflats and eelgrass meadow in a small estuarine bay.

Woo, I., M. J. Davis, C. S. Ellings, S. Hodgson, J. Y. Takekawa, G. Nakai, and S. E. W. De La Cruz. 2019. A Mosaic of Estuarine Habitat Types with Prey Resources from Multiple Environmental Strata Supports a Diversified Foraging Portfolio for Juvenile Chinook Salmon. Estuaries and Coasts 42(7):1938-1954.

Wolotira, R. 2008. Habitat Evaluation of the Blue Heron Site for a Specific Type of Juvenile Chinook Salmon, Appendix A to Endangered Species Act Section 7 formal consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Blue Heron Slough Conservation Bank Construction, Snohomish County, Washington (Sixth Field HUC: 171100110202, NMFS Tracking No.: 2007/08287. Pages 45 in NMFS, editor, Lacey, Washington.

Appendix G. Report Form/Ledger

Anticipated or Final Construction Completion Date	Project Name	Location (Lat, Long)	DSAYs Credits (+) or Debits (-)	NMFS No.	Corps Permit No.	Comments
-	-	-	-	-	-	-
Totals						