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 Nos:
WCRO-2022-02773 (Chandler's Cove)
WCRO-2022-02774 (HC Henry)

February 7, 2025

P. Allen Atkins
Chief, Regulatory Branch
Seattle District, United States Army Corps of Engineers
4735 East Marginal Way South, Bldg. 1202
Seattle, Washington 98134

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson–Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Repairs to Chandler's Cove Marina and HC Henry Pier, Lake Union, King County, Washington

Dear Mr. Atkins:

Thank you for your letter of October 20, 2022, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for Repairs to Chandler's Cove Marina and HC Henry Pier, Lake Union, King County, Washington.

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 Salmon Fishery Management Plan*. Therefore, we have included the results of that review in this document.

The enclosed document contains the biological opinion (opinion) prepared by NMFS pursuant to section 7 of the ESA on the effects of the proposed action. In this opinion, NMFS concludes that the proposed action would adversely affect but is not likely to jeopardize the continued existence of Puget Sound (PS) Chinook salmon and PS Sound steelhead. NMFS also concludes that the proposed action is likely to adversely affect designated critical habitat for PS Chinook salmon but is not likely to result in the destruction or adverse modification of that designated critical habitat. This opinion also documents NMFS's conclusion that the proposed action may affect, but is not likely to adversely affect southern resident killer whales (SRKW) and their designated critical habitat.

This opinion includes an incidental take statement (ITS) that describes reasonable and prudent measures (RPMs) NMFS considers necessary or appropriate to minimize the incidental take associated with this action, and sets forth nondiscretionary terms and conditions that the U.S. Army Corps of Engineers (USACE) must comply with to meet those measures. Incidental take from actions that meet these terms and conditions will be exempt from the ESA's prohibition against the take of listed species.

Section 3 of this document includes NMFS' analysis of the action's likely effects on EFH pursuant to Section 305(b) of the MSA. Based on that analysis, NMFS concluded that the action would adversely affect designated freshwater EFH for Pacific Coast Salmon. Therefore, NMFS has provided three conservation recommendations that can be taken by USACE to avoid, minimize, or otherwise offset potential adverse effects on EFH. NMFS also concluded that the action would not adversely affect EFH for Pacific Coast groundfish and coastal pelagic species. Therefore, consultation under the MSA is not required for EFH for Pacific Coast groundfish and coastal pelagic species.

Section 305(b) (4) (B) of the MSA requires Federal agencies to provide a detailed written response to NMFS within 30 days after receiving this recommendation. If the response is inconsistent with the EFH conservation recommendations, USACE must explain why the recommendations will not be followed, including the scientific justification for any disagreements over the effects of the action and recommendations. In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we request that in your statutory reply to the EFH portion of this consultation you clearly identify the number of conservation recommendations accepted

Please contact Cody Payne in the North Puget Sound Branch of the Oregon–Washington Coastal Office at (503) 230-5422, or by electronic mail at cody.payne@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Kathleen Wells

Kathleen Wells
Assistant Regional Administrator
Oregon Washington Coastal Office

cc: Jennifer Casper, USACE

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

Repairs to Chandler's Cove Marina and HC Henry Pier
Lake Union, King County, Washington

NMFS Consultation Numbers: WCRO-2022-02773 (Chandler's Cove)
WCRO-2022-02774 (HC Henry)

Action Agency: United States Army Corps of Engineers

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	If likely to adversely affect, Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	If likely to adversely affect, is Action Likely to Destroy or Adversely Modify Critical Habitat?
Puget Sound steelhead (*Oncorhynchus mykiss*)	Threatened	No	NA	No	No
Puget Sound Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	Yes	NA
Southern Resident Killer Whale (*Orcinus orca*)	Endangered	No	NA	No	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
Pacific Coast Groundfish	No	N/A

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

Issued By:

Kathleen Wells

Kathleen Wells
Assistant Regional Administrator
Oregon Washington Coastal Office

Date: February 7, 2025

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LIST OF ACRONYMS

AZCA – ammoniacal copper zinc arsenate
BE – biological evaluation
BO – biological opinion
CFR – code of federal regulations
DDE – dichlorodiphenyldichloroethylene
DDT – ichloro-diphenyl-trichloroethane
DIP – distinct individual population
DPS – distinct population segment
DQA – Data Quality Act
EFH – essential fish habitat
ESA – Endangered Species Act
ESU – ecologically significant unit
FR – Federal Register
ITS – incidental take statement
LAA – likely to adversely affect
MPG –major population group
MSA – Magnuson-Stevens Fishery Conservation and Management Act
NLAA – not likely to adversely affect
NMFS – National Marine Fisheries Service
NOAA- National Oceanic and Atmospheric Administration
NTU -- Nephelometric Turbidity Unit
OWC – over-water coverage
PAH – polycyclic aromatic hydrocarbon
PBF – physical or biological feature
PCB – polychlorinated biphenyl
PDC – project design criteria
PFMC – Pacific fishery Management Council
PS – Puget Sound
PSTRT – Puget Sound Technical Recovery Team
PSSTRT – Puget Sound Steelhead Technical Recovery Team
RPM – reasonable and prudent measure
SAV – submerged aquatic vegetation
SRKW – southern resident killer whale
USACE – United States Army Corps of Engineers
VAP – viable salmonid population
WA-DNR – Washington Department of Natural Resources
WCR – West Coast Region
WDFW – Washington Department of Fish and Wildlife
WDOE – Washington State Department of Ecology

1. INTRODUCTION

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

1.1. Background

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

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

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

1.2. Consultation History

On October 20, 2022, NMFS received two letters and Biological Evaluations from the United States Army Corps of Engineers (USACE) on behalf of the applicant, Lyn Saucier, Chiles and Company, requesting informal consultation for two projects to complete repairs to Chandler's Cove Marina and HC Henry Pier. Both project sites are located on the south shore of Lake Union in King County, Washington.

NMFS staff subsequently determined that both projects would require formal consultation under both ESA Section 7(a)(2) and MSA EFH. The formal ESA consultation requirement was due to the projects' likely adverse effects to Puget Sound (PS) Chinook salmon (*Oncorhynchus tshawytscha*) and designated critical habitat for PS Chinook salmon, and to PS steelhead (*Oncorhynchus mykiss*). Formal MSA consultation was required due to both project sites being located within Pacific salmon EFH. NMFS staff also determined that the projects could be covered (batched) in a single consultation due their similar nature/activities and close proximity, with the project sites located on land parcels adjacent to one another.

Additional information was requested from USACE for the Chandler's Cove Marina repair project on March 11, 2024, and was received on March 19, 2024. Additional information was requested from USACE for the HC Henry Pier repair project on April 3, 2024, and was received on April 18, 2024. Formal consultation for both ESA Section 7(a)(2) and MSA EFH was initiated on September 23, 2024.

The present biological opinion (BO) is based on the information contained in the project BEs (USACE 2022a; 2022b); the follow up information provided by USACE (USACE 2024a; 2024b); a site visit conducted by NMFS staff on Sept. 26, 2024; recovery plans, status reviews, viability assessments, and critical habitat designations for PS Chinook salmon and PS steelhead; published and unpublished scientific information on the biology and ecology of those species; and relevant scientific and gray literature.

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

1.3. 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).

Under the proposed action considered in this opinion, USACE would authorize the applicant, Lyn Saucier, Chiles and Company, to perform repairs to two adjacent boating dock complexes on the south shore of Lake Union, WA (Figures 1 – 3). The names of the properties are Chandler's Cove Marina, and HC Henry Pier. The proposed repairs to each property were submitted as separate projects; however, the activities and features of both projects are identical or very similar. Due to the proximity of the project sites, the high degree of similarity in project operations and features, and the common applicant shared by both projects, it was decided that both could be covered under the same opinion.

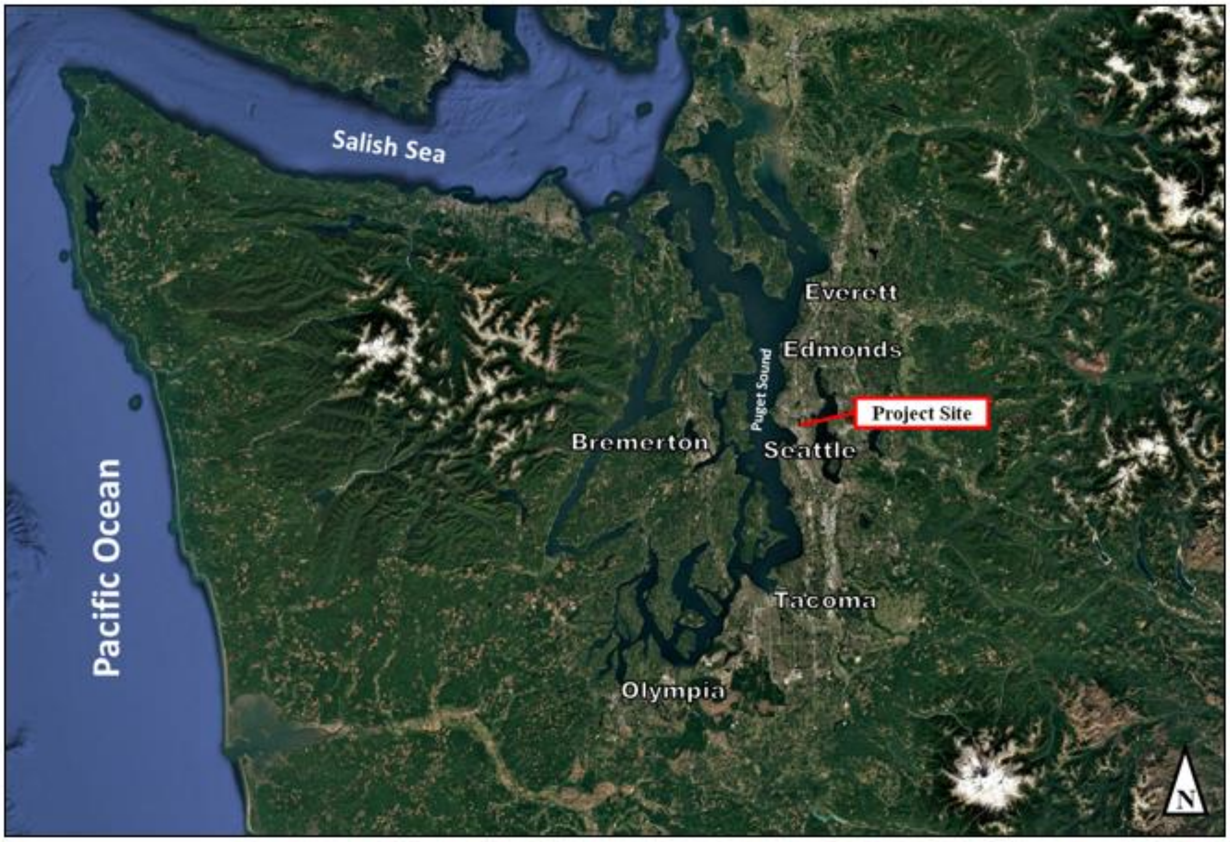

Figure 1. Regional Chandler's Cover Marina and HC Henry Pier project site location map

Figure 2. Map showing key waterbodies of the Lake Washington Ship Canal and in relation to Chandler's Cove Marina and HC Henry Pier project sites

Figure 3. Map showing locations of Chandler's Cove Marina and HC Henry Pier project sites on south shore of Lake Union; dotted lines are intended to show general project sites, not exact parcel boundaries

1.3.1 Chandler's Cove Marina

Location and site description: Chandler's Cove Marina is located on the south shore of Lake Union in King County, WA. The project site is in the NW ¼ of Section 26 in Township 5 N, Range 5 E, at approximately latitude and longitude (lat./long.): 47.6288, -122.3334. The property address is: 901 Fairview Ave. N, Seattle, WA 98109.

The Marina complex is comprised of a wide platform mounted on pilings that extends from the bank over the water surface (Figure 4). Three commercial buildings which house waterfront businesses have been constructed on the platform. At its waterward end, the platform bifurcates into two sections/structures. On the west side, there is an extension of the platform farther offshore, on which one of the three commercial buildings has been constructed. A walkway rings the lakeside border of this extension, and hence this section is referred to as "Chandler's Walkway," or alternatively, "the walkway." The walkway connects to the east structure, which is a pier complex that extends farther onto the lake from end of the platform (Figure 5). The main pier is 301' in length by 30'-8" [301' × 30'-8" ('= feet, "= inches); Table 1]. A narrower 194'-3" × 7'-11" finger pier extends from the far end of the main pier, which has been termed, the "main finger pier." A further eight finger piers extend diagonally in a northwest direction from the west side of the main pier and main finger pier. These finger piers are 5'-11" in width and range from 37'-4" to 95'-11" in length. A 401'-11" × 14' floating dock runs along the east side of the main pier and part of the large platform; the floating dock is set farther towards the shore than the main pier.

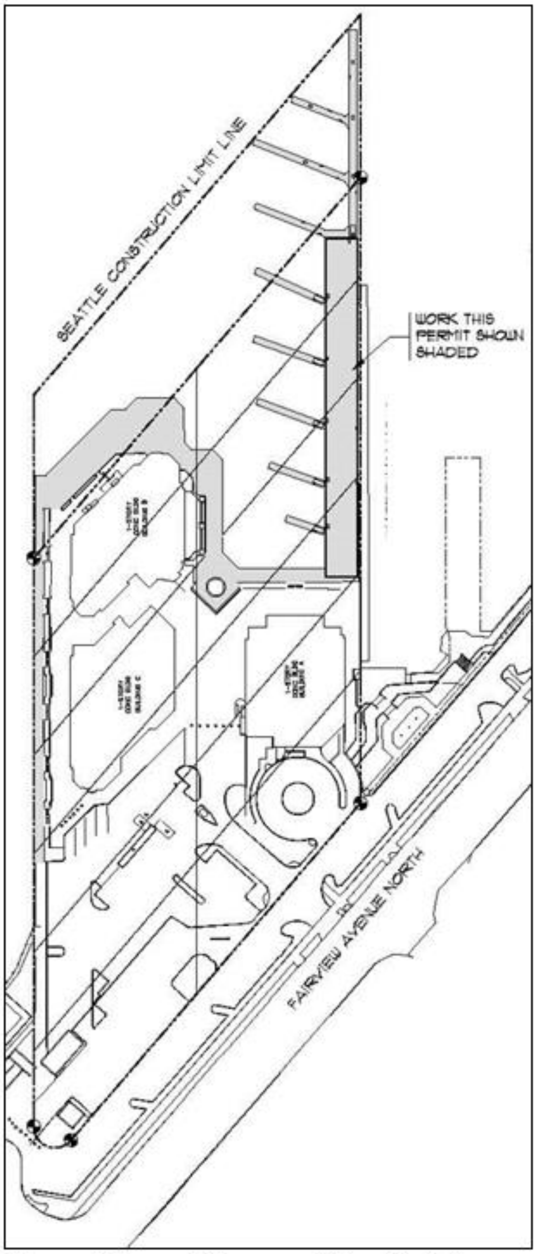

Figure 4: General diagram of Chandler's Cove Marina structures [taken from provided design plans (Pacific Engineering Technologies, Inc. 2021a)]

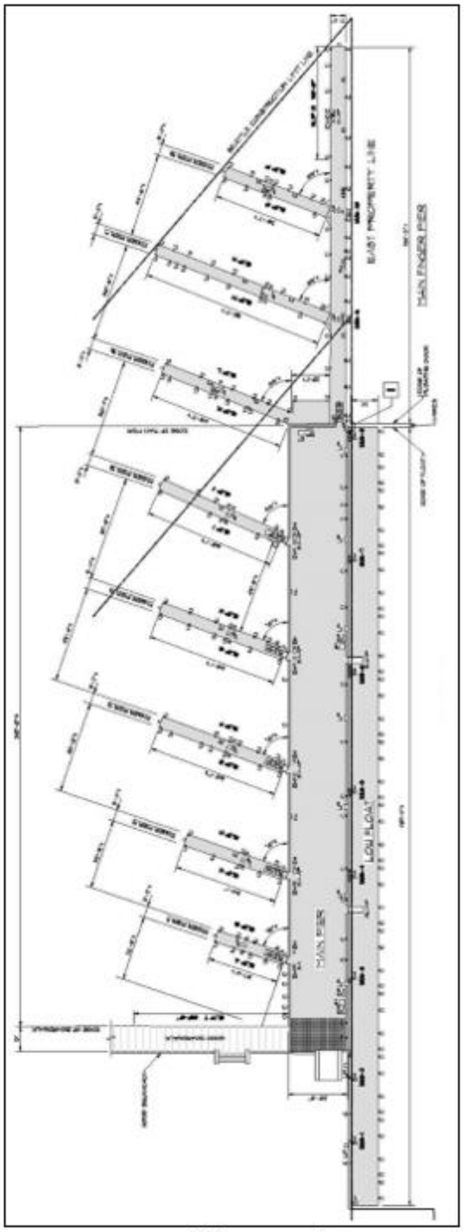

Figure 5: General diagram of east structure of Chandler's Cove Marina [taken from provided design plans (Pacific Engineering Technologies, Inc. 2021a)]

Table 1. Dimensions of major structures and total over-water coverage (OWC) of Chandler’s Cove Marina; length and width given in feet (ft) and inches (in), area given decimal square feet (ft2)

Structure	Length (ft–in)	Width (ft–in)	Area (ft^2)	Decking type
Boardwalk		13’		Wood boards, solid
Main pier	310’	30’–8”	9506.67	Wood boards, solid
Low float	401’–11”	14’	5626.83	Wood boards, solid
Main finger pier	194’–3”	7’–11”	1537.81	Wood boards, solid
Finger pier 1	37’–4”	5’–11”	220.89	Wood boards, solid
Finger pier 2	54’–1”	5’–11”	319.99	Wood boards, solid
Finger pier 3	68’–1”	5’–11”	402.83	Wood boards, solid
Finger pier 4	68’–1”	5’–11”	402.83	Wood boards, solid
Finger pier 5	68’–1”	5’–11”	402.83	Wood boards, solid
Finger pier 6	69’–1”	5’–11”	408.74	Wood boards, solid
Finger pier 7	96” –11”	5’–11”	573.42	Wood boards, solid
Finger pier 8	56’–11”	5’–11”	336.76	Wood boards, solid
Total OWC[1] (ft^2) = 25,961				
[1]Total OWC does not equal sum of individual structure areas due to presence of small structures/features not listed here				

The total overwater coverage (OWC) of Chandler’s Cove Marina is 25,961 square feet (ft^2). Chandler’s walkway has an OWC of 2877 ft^2. The pier complex on the east side of the property has an OWC 19,068 ft^2 - 9 in^2 (square inches).

The water depth at the project site is approximately 5.5’ at the nearshore portion and 38’ at the farthest offshore portion. The BE states that work will be done in water up to 25’ deep. The lake bottom at the project site and surrounding area has been modified by historical dredging. The bottom substrate at the project site is comprise of sand and mud. Invasive Eurasian milfoil (*Myriophyllum* sp.) is the dominant vegetation on the lakebed. This was confirmed in a site visit conducted by NMFS staff, during which an extensive presence of Eurasian milfoil was observed on the lake bottom at the project site. A large amount of unidentified green algae was also observed growing on the lakebed substrate, as well as on the foliage of the milfoil. Where the lakebed was exposed, the substrate appeared to be comprised of sand mixed with mud, interspersed with large cobble and refuse.

The entire shoreline at the project site, as well as for the majority of Lake Union, has been heavily modified. At the project site and surrounding area, there is no natural shoreline or riparian habitat. The entire shoreline in the area has been developed into condominiums, office buildings, and other infrastructure for various water-dependent industries. As such, the shoreline has been heavily armored and has extensive coverage of artificial overwater structures.

Lake Union has been placed on the Washington State Department of Ecology (WDOE) “303d list” of impaired waters. The project area has been listed as Category 5 (polluted) for lead and elevated temperature (WDOE 2024; see https://apps.ecology.wa.gov/approvedwqa/approvedpages/viewapprovedlisting.aspx?ListingId=8066). Sediment in the area to the west of Chandler’s Cove has been listed as Category 4B (polluted, with control program in place) for arsenic, cadmium, chromium, copper, lead, mercury, various types of PAHs (polycyclic aromatic hydrocarbons), PCBs (polychlorinated biphenyls), silver, and zinc. The BE describes the project area as also being listed as Category 5 for bacteria, DDE [dichlorodiphenyldichloroethylene, a breakdown product of DDT (ichloro-diphenyl-trichloroethane)], dioxin, and PCBs, and as Category 2 (of concern) for chloride, although this could not be independently verified.

Proposed work: The project will maintain the existing configuration of the marina and will not change its existing footprint. The proposed work includes the replacement of 57 damaged pile sections with new sections (Figures 6). Pile sections will be replaced by "stubbing," in which damaged pile sections are sawed off, and a new section of pile is spliced onto the old section left behind. The two pile sections are held together by steel splice plates (Figure 7). Using this technique, no piles will be fully removed from the bed substrate, and now new piles will be installed. Of the 57 new pile sections, 35 are fender piles and will be untreated wood. The other 22 are structural piles and will be either epoxy-coated steel or polymer-coated wood. The pile replacement stubs will not be treated with ammoniacal copper zinc arsenate (ACZA). The splice plates will also be epoxy-coated steel, as opposed to galvanized steel. An underwater saw will be used for pile cutting. In the event a pile needs to be cut below the mudline, water jets will not be used to clear the substrate; instead, the base of the pile will be exposed by hand digging. A barge-mounted crane will be used to remove the old pile sections and move the new sections into place. The old pile sections will be placed on the barge, which will be fitted with filtration material to prevent sediment from the pile sections from washing back into the Lake. The removed pile sections will be disposed at a licensed upland facility.

Additional information provided to NMFS indicated that there was no known creosote in the work area (USACE 2024a); however, during a follow-up site visit, creosote was observed on every timber pile that was examined (also see Echelon Engineering 2020). Therefore, the impacts associated with the cutting and removal of creosote-treated pile sections was included in the effects analysis.

In addition to pile repair, 2,143 ft^2 of existing solid dock decking will be replaced with fiberglass grated decking. Eighty percent (80%) of the grating is open area, which allows for the transmission of at least 43% of ambient light.

The two outermost finger docks will also be replaced. The new docks will be the same size as the existing ones, with a combined total area of 920 ft^2, but will be made of steel framing with grated fiberglass decking instead of the timber construction of the existing docks.

An unspecified number of damaged dock stringers (supports) and other damaged above- and below-water components will also be replaced. New framing material above the waterline will be ACZA-treated wood; however, no ACZA-treated material will be installed below the waterline. Additionally, as stated in the Washington State Department of Natural Resources (WA-DNR), the cutting of any treated wood must be completely contained to prevent any dust or debris from entering the water, or performed in an upland location if possible (in USACE 2022a).

The in-water work window is from October 1 to April 15. Work is expected to take two to three weeks to complete. The worksite will be accessed via the marina parking lot and through the normal vessel route. If necessary, the marina parking lot will be used as a staging area for any equipment or materials.

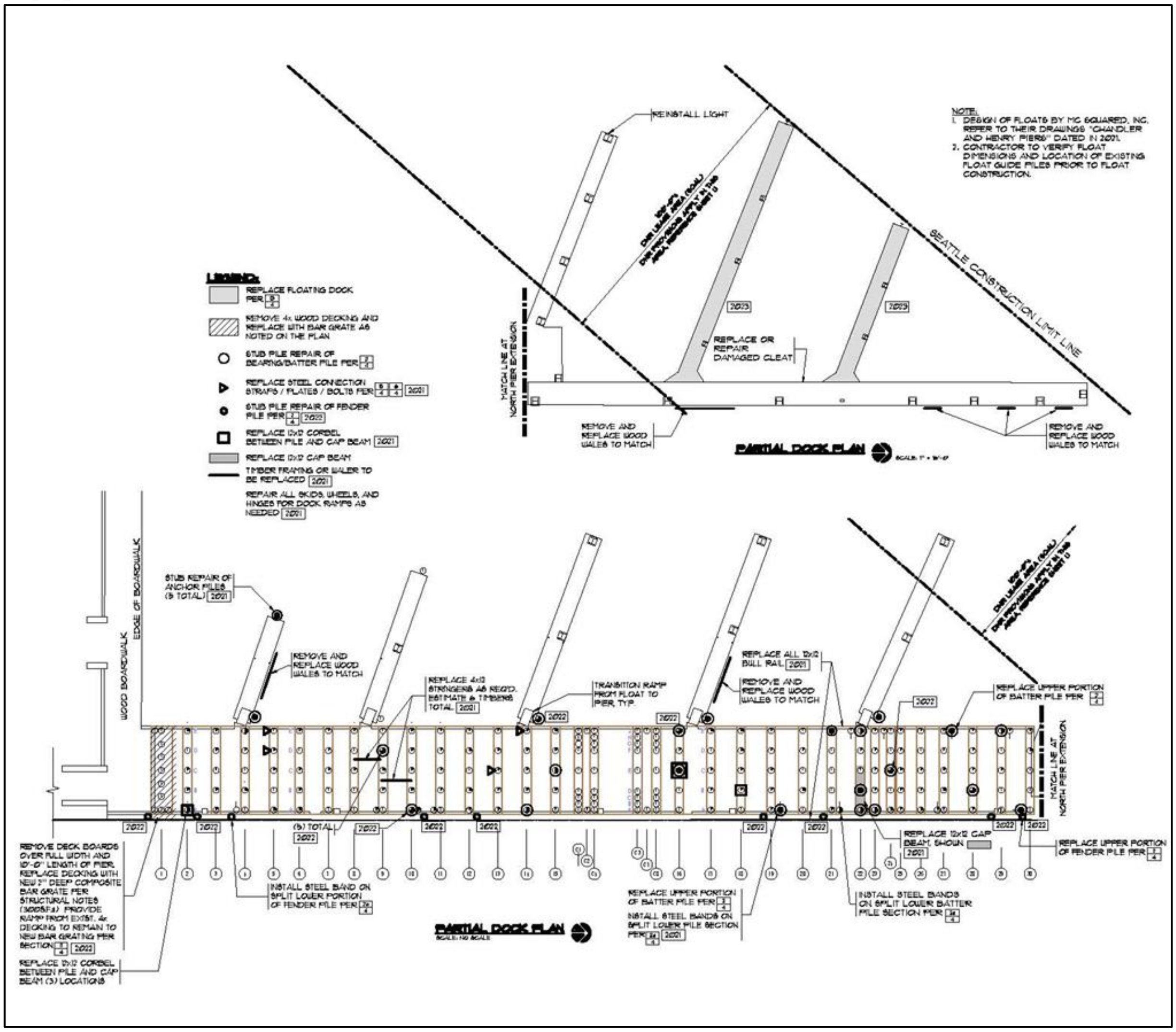

Figure 6. Excerpt from design plans showing proposed repairs at Chandler's Cove Marina (Pacific Engineering Technologies, Inc. 2021b)

Conservation measures: The proposed project at Chandler's Cove Marina will include the following project design criteria (PDCs), which will help minimize its adverse effects:

- Pile repair
    - Damaged pile sections will be replaced via stubbing, as described above. This technique avoids the removal of any piles from the lake bed substrate, reducing sediment disturbance.
    - No new piles will be installed. This avoids any harmful sound impulses generated by pile driving.
    - Water jets will not be used to clear the substrate around the base of a pile in the event it needs to be cut below the mudline. Instead the base of the pile will be exposed via hand digging, helping to minimize disturbance of the lakebed and resuspension of sediment.
    - The loudest piece of equipment (other than the engine of barge tugboat) that will be use will be an underwater chainsaw, which produces a maximum sound impulse of 85 decibels (dB).
    - A full-depth sediment curtain will be installed around the work area when pile repair work is being performed.
    - Upon removal, old pile sections will be placed on the work barge, which will be fitted with filtration material to prevent sediment runoff from the pile sections from washing back into the Lake. The removed pile sections will be disposed at a licensed upland facility.
    - All new pile sections will either be untreated wood, polymer-coated wood, or epoxy-coated steel. No new pile sections will be ACZA-treated wood.
    - The splicing plates will be epoxy-coated steel. Galvanized steel will not be used.
    - The work barge will not be permitted to ground on the lake bed at any time.
- Dock frame and component repair
    - No ACZA-treated wood will be installed below the waterline. Wood installed below the waterline will either be untreated or polymer-coated.
    - The cutting of any treated wood must be completely contained to prevent dust or debris from entering the water, or performed at an upland location if possible.
- General measures
    - All work will be performed within the October 1 to April 15 in-water work window. This will minimize the chance of temporal overlap between work activities and salmonid adult or juvenile migration.
    - Pile repair, or any other project activities, will not require the placement of fill, dredging, or any excavation apart from possible minor hand digging around the base of stubbed piles. This will minimize disturbance of the lakebed and reduce suspension of sediment in the water column.
    - A floating boom will be placed around the project area while work is being performed. The area inside the boom will be cleared of floating debris before the boom is removed.
    - Spill containment and removal materials will be kept onsite while work is being performed.

1.3.2 HC Henry Pier

Location and site description: HC Henry Pier is located on the south shore of Lake Union in King County, WA. The project site is in the NE ¼ of Section 30 in Township 5 N, Range 5 E, at approximately lat./long.: 47.6270, -122.3351. The property address is: 809 Fairview Ave. N, Seattle, WA 98109. HC Henry Pier is located on the property immediately adjacent to the west side of the Chandler's Cover Marina property.

HC Henry Pier is comprised of a main pier that extends from a pile-mounted platform along the lakeshore (Figure 8). Seven smaller docks extend perpendicularly on either side of the main pier. Four of the docks extend from the west side of the main pier, and three extend from the east side. On the east side of the pier, the docks are sequentially labeled "B" through "D," with B-dock being the closest to shore and D-dock the farthest. B-, C- and D-docks are all floating docks. The docks on the west side are labeled sequentially from "H" to "E," with H-dock being the closest to shore and E-dock the farthest. H- and G-dock are fixed, whereas F- and E-docks are floating. The is also an A-dock, which is used to indicate moorage space along the platform parallel to the shore. Docks B through G also have varying numbers of floating fingers (finger docks) used to create boat slips.

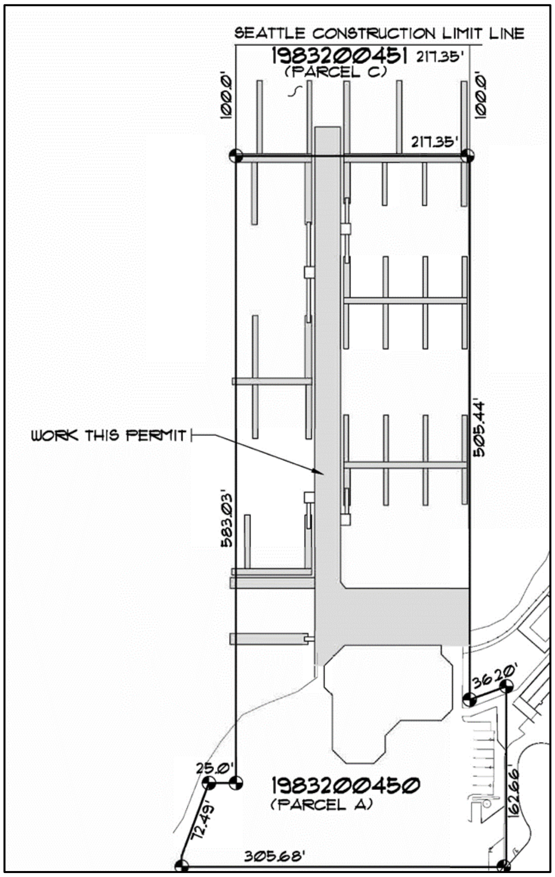

Figure 8. General diagram of HC Henry Pier structures [taken from provided design plans (Pacific Engineering Technologies, Inc. 2021b)

The platform along the shore from which the main pier extends is approximately 143’-3” × 53’-0.5” (Table 2). The main pier is 428’-6” × 24’. The secondary docks range in length from approximately 72’-2” to 110’-7”, and range in width from 5’-7” to 10’-2.5”. The total OWC of HC Henry Pier is 33,659 ft^2. Site conditions are the same as those for Chandler’s Cove Marina, described above, except the BE (USACE 2022b) states that that work will be performed in water between 6 and 30’ deep.

Table 2. Dimensions of major structures and total over-water coverage (OWC) of HC Henry Pier; length and width given in feet (ft) and inches (in), area given decimal square feet (ft2)

Structure	Length (ft–in)	Width (ft–in)	Area (ft$^{2)}$	Decking type	Fingers
Pier base	53’ – ½”	143’–3”		Wood boards, solid	N/A
Main pier	428’–6”	24’	10284	Wood boards, solid	N/A
B Dock[1]	114’–9’	6’	688.5	Wood boards, solid	8
C Dock[1]	114’–10”	5’–7”	641.15	Wood boards, solid	8
D Dock[1,2]	113’–13”	5’–8”	646.47	Wood boards, solid	7
E Dock	72’–3”	6’	433.5	Wood boards, solid	4
F Dock	73’–10”	6’	443	Wood boards, solid	4
G Dock	78’–4”	10’–1’	789.86	Wood boards, solid	0
H Dock	72’–2”	10’–2 ½”	736.7	Wood boards, solid	0
Total OWC[3] (ft^2) = 33,659					

[1] Length dimensions calculated from design plans and may not be exact, area my not be exact accordingly

[2] Inches value of width measurement is illegible in design plans, value shown here represents best guess

[3] Total OWC does not equal sum of individual structure areas due to presence of finger piers and other small structures/features not listed here

Proposed work: The project will maintain the existing configuration of the pier complex and existing footprint will remain the same. Thirty-five (35) damaged piles will be replaced via stubbing. Stubbing will follow the same process and precautions as described above for Chandler’s Cove Marina. In addition to pile stubbing, the hardware on 49 fender piles will be replaced.

It was claimed there was no known creosote in the work area (USACE 2024b); however, in a follow-up site visit, creosote was observed on every timber pile that was examined (also see Echelon Engineering 2019). Therefore, the impacts associated with the cutting and removal of creosote-treated pile sections was included in the effects analysis.

A total of 3,615 ft^2 of existing solid decking will be replaced with grated fiberglass decking at E-Dock and G-Dock (Figure 9). As described for Chandler’s Cove Marina, the new grated decking will have 80% open space, which allows for transmission of at least 43% ambient light. In addition to decking replacement, G-dock will require pile and structural repairs. Structural repairs will follow the same precautions as described for Chandler’s Cove Marina. Three fingers on E-Dock will be replaced with new fingers fitted with grated decking.

The in-water work window will be from October 1 to April 15. Work is expected to take two to three weeks to complete. The worksite will be accessed via the marina parking lot and through the normal vessel route. If necessary, the marina parking lot will be used as a staging area for any equipment or materials.

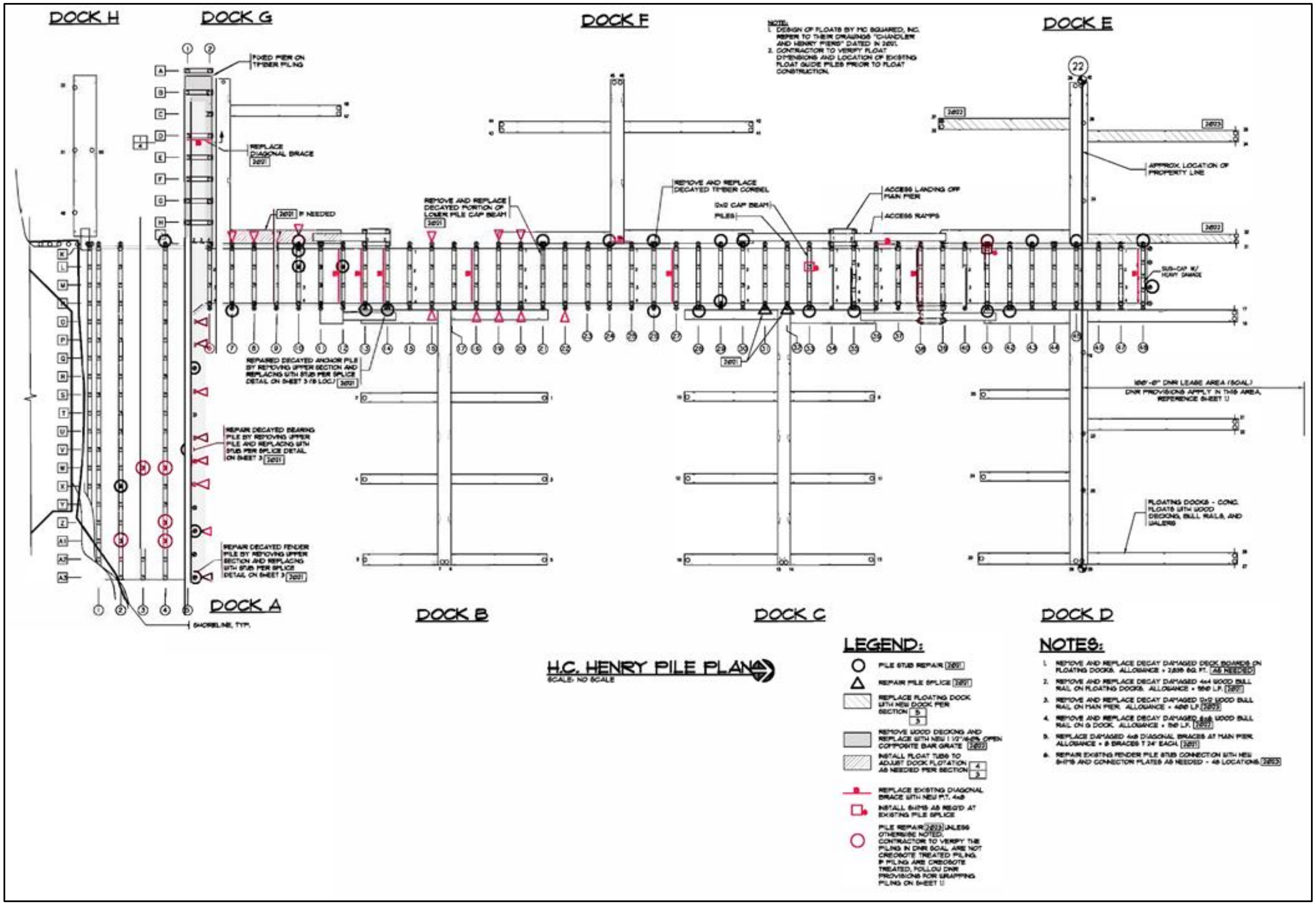

Figure 9. Excerpt from design plans showing proposed repairs to HC Henry Pier (Pacific Engineering Technologies, Inc. 2021b)

Conservation measures: The proposed project at HC Henry Pier will include the same conservation measures and PDCs as those for the project at Chandler’s Cove Marina, described above, and are therefore not restated here.

For both projects, we considered, under the ESA, whether or not the proposed action would cause any other activities and determined that it would cause the following activities: The proposed action would extend the useful life of the applicant’s docks/marina by several decades. Both facilities are intended for boat moorage. Therefore, in addition to perpetuating the presence of the structures, the action would also perpetuate associated vessel activity for decades to come. We have included an analysis of the effects of the continued existence of the structures and of the concomitant vessel operation in the effects section of this opinion.

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.

USACE determined that the proposed action is not likely to adversely affect PS Chinook salmon or designated habitat for PS Chinook salmon. USACE determined that the proposed action is not likely to adversely affect PS steelhead or designated habitat for PS steelhead. USACE did not address southern resident killer whale (SRKW) or their designated critical habitat. NMFS has concluded that the proposed action is likely to adversely affect PS Chinook salmon and designated critical habitat for PS Chinook salmon, and PS steelhead (Table 3), and has therefore proceeded with formal consultation. Due to the trophic relationship between PS Chinook salmon and SRKW, NMFS analyzed the action’s potential effects on SRKW and their designated critical habitat. NMFS’s analysis ultimately resulted in a determination of “Not Likely to Adversely Affect” (NLAA), which is documented in Section 2.13.

Table 3. ESA-listed species and critical habitats that may be affected by the proposed action

ESA-listed species and critical habitat likely to be adversely affected (LAA)				
Species	**Status**	**Species**	**Critical Habitat**	**Listed / CH Designated**
Chinook salmon (*Oncorhynchus tshawytscha*) Puget Sound	Threatened	LAA	LAA	06/28/05 (70 FR 37160) / 09/02/05 (70 FR 52630)
Steelhead (*Oncorhynchus mykiss*) Puget Sound	Threatened	LAA	LAA	05/11/07 (72 FR 26722) / 02/24/16 (81 FR 9252)
ESA-listed species and critical habitat not likely to be adversely affected (NLAA)				
Species	**Status**	**Species**	**Critical Habitat**	**Listed / CH Designated**
Killer Whales (*Orcinus orca*) Southern Resident (SR; SRKW)	Endangered	NLAA	NLAA	11/18/05 (70 FR 57565)/ 11/29/06 (71 FR 69054)

2.1. Analytical Approach

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

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

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

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

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

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

2.2. Rangewide Status of the Species and Critical Habitat

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

Listed Species

As managed under the ESA, steelhead and salmon species are divided into what are referred to as Distinct Population Segments (DPSs) for steelhead and Ecologically Significant Units (ESUs) for salmon species. Both are roughly analogous terms used to describe isolated population enclaves within the overall range of the particular species to which they belong. A steelhead DPS is defined as, "a group of steelhead that is uniquely adapted to a particular area or environment," that is: 1) discrete "in relation to the remainder of the species to which it belongs;" and 2) significant "to the species to which it belongs," (NMFS 2019). An ESU is defined as a population or group or populations that is: 1) "substantially reproductively isolated from other conspecific population units;" and 2) represents "an important component in the evolutionary legacy of the species," (Waples 1991; also see Waples 1995). Thus, although multiple DPSs or ESUs may fall under the same taxonomic species, they are considered sufficiently distinct from one another that they are listed and managed as individual "species" under the ESA. For example, Puget Sound Chinook Salmon and Lower Columbia River Chinook Salmon are both of the taxonomic species, *Oncorhynchus tshawytscha*, but are managed as separate species under the ESA because they are different ESUs. Therefore, from an ESA Section 7 analysis standpoint, and for the purposes of this opinion, a DPS or ESU is treated as an individual species.

Within DPSs and ESUs, respectively, steelhead and salmon are further divided into major population groups (MPGs), described as "groupings of populations that are isolated from one another over a longer time scale than that defining the individual populations, but retain some degree of connectivity greater than that between different DPSs [or ESUs],"(NMFS 2019), or, alternatively, "an aggregate of independent populations within an ESU [or DPS] that share similar genetic and spatial characteristics," (NMFS 2017a; also see Meyers et al. 2015). NMFS follows Ricker's (1972) definition of an individual population as, "a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season," (also see McElhany et al. 2000).

Viable Salmonid Population Criteria: McElhany et al. (2000) define a viable salmonid population (VSP) as, "an independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame." To determine whether a particular salmonid population is viable, NMFS commonly evaluates four VSP Criteria (McElhany et al. 2000). These four criteria include:

1. Spatial structure – Spatial structure "refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population's spatial structure depends on habitat quality and spatial configuration, and the dynamics and dispersal characteristics of the individuals in the population," (McElhaney et al. 2000).
2. Diversity – "Diversity refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation in single genes to complex life history traits," (McElhaney et al. 2000).
3. Abundance – Abundance generally refers to the number of naturally-produced (as opposed to hatchery-produced) adults that return to their natal spawning grounds.
4. Productivity – As applied to viability factors, productivity is "the average number of surviving offspring per parent. Productivity is used as an indicator of a population's ability to sustain itself or its ability to rebound from low numbers," (NMFS 2017b). When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining. McElhany et al. (2000) use the terms "population growth rate" and "productivity" interchangeably when referring to production over the entire life cycle. They also refer to "trend in abundance," which is the manifestation of the long-term population growth rate.

Together, the VSP Criteria encompass the DPS/ESU's "reproduction, numbers, or distribution" as described in 50 CFR 402.02. Keeping these parameters, collectively, at appropriate levels maintains a population's capacity to adapt to various environmental conditions and allows it to sustain itself in the natural environment.

For DPSs and ESUs with multiple populations, NMFS assesses the status of the entire DPS/ESU based on the biological status of the constituent populations, using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and ensuring that some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as metapopulations (McElhany et al. 2000). The status of ESA-listed species and their respective designated critical habitat that occur within the action area, and are thus considered in this opinion, are summarized below. More detailed information on the biology, habitat, conservation status, and trends of these listed resources can be found in the listing regulations and critical habitat designations published in the Federal Register, and in the recovery plans and other sources incorporated here by reference and at: https://www.fisheries.noaa.gov/species-directory/threatened-endangered.

General Life History of Anadromous Salmonids: Pacific salmon and steelhead are anadromous salmonids. Salmonids are fish species in the family *Salmonidae*. The family includes the groups colloquially termed salmon, trout, char, grayling, whitefish, in addition to others. Species in the *Salmonidae* family share the common characteristics of being bony (as opposed to cartilaginous like sharks and rays) and ray-finned [as opposed to spiny-finned like many perciform (perch-like) fishes]; however, not all salmonids are anadromous. “Anadromous” refers to a lifecycle regime of certain fish species (including species other than salmonids) that mature in marine environments and migrate to freshwater to spawn.

Thus, Pacific salmon and steelhead (with the exception of landlocked populations) follow a lifecycle that begins in freshwater streams. They then migrate to the Pacific Ocean where they grow to full maturity, before returning to their natal freshwater streams (the streams in which they hatched) to spawn. During spawning, female salmon and steelhead excavate a depression in the streambed substrate (with preference for gravel) in which they deposit their eggs. The eggs are then fertilized by males and covered up with the gravel by the female. These depressions, or nests, in which the eggs are deposited are referred to as “redds.” After a period of incubation (which varies by species and environmental factors, such as water temperature), salmon and steelhead hatch and emerge from their respective redds as “alevin.” Alevin is the life history stage of salmonids during which they are still connected to the yolk sac from the egg. Alevin absorb all their nutrition from the attached yolk sac and do not feed exogenously. As they mature, they deplete their yolk sac and begin exogenous feeding, eventually progressing to the next life history stage, referred to as “fry.” As they continue to mature, they transition to the life history stage referred to as “parr,” during which time they grow in size and develop characteristic vertical markings along their body, called “parr marks.”

Depending on the species and environmental conditions, juvenile (alevin, fry, and parr) salmonids rear in freshwater, in some cases up to one year or more, before traveling downstream to estuarine environments, where they begin the transformation to living in saltwater. The physical transformation juvenile salmonids undergo to adapting to live in saltwater is referred to as “smoltification,” and salmonids undergoing this transformation are referred to as “smolts.” After completing smoltification, salmon and steelhead emigrate to the ocean where they spend most of their adult lives (typically 1 – 6 years, depending on the species and environmental conditions), before returning to freshwater and migrating back to their natal streams to spawn. Salmon are semelparous, that is, they make one return trip back to freshwater, where they spawn once and then die, whereas steelhead are iteroparous, with the ability to make multiple trips between the ocean and freshwater and to spawn multiple times throughout their life.

While incubating and rearing in freshwater, salmonids eggs and juveniles rely on numerous biotic and abiotic conditions/elements to survive, grow, and successfully emigrate to the Pacific Ocean. Salmonid eggs require high dissolved oxygen concentrations and cool water temperatures for optimal growth and metabolism (Brown and Hallock 2009; Groot and Margolis 1991). Salmonid fry and parr occupy and feed along pool and bank margins and in side channels, where they use the cover provided by woody debris and overhanging banks to avoid predation, and as thermal and hydraulic refugia from elevated water temperatures and stream currents (Cederholm et al. 1997; Roni and Quinn 2001). Developing fry and parr typically move downstream during their freshwater development, occupying different habitats over time to maximize access to food and concealment from predators (Grimm et al. 2005). As juvenile salmonids develop, they may increase the distance they travel away from cover and occupy greater water depths to find refuge from the current and elevated water temperatures (Bjornn et al. 1991; Keeley and Slaney 1996). Thus, freshwater streams require both suitable habitat structure as well as adequate food availability for salmonid populations to maintain sufficient levels of productivity to be self-sustaining.

Puget Sound (PS) Chinook Salmon

The PS Chinook salmon ESU was listed as threatened on June 28, 2005 (70 FR 37160). NMFS adopted the recovery plan for PS Chinook salmon in January 2007. The recovery plan consists of two documents: the *Puget Sound Salmon Recovery Plan* (SSPS 2007) and the *Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan* (NMFS 2006). The recovery plan adopts ESU- and population-level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT) (Ruckelshaus et al. 2002). The PSTRT's biological recovery criteria would be met when all of the following conditions are achieved:

1. The viability status of all populations in the ESU is improved from current conditions, and when considered in the aggregate, persistence of the ESU is assured;
2. Two to four Chinook salmon populations in each of the five biogeographical regions of the ESU achieve viability, depending on the historical biological characteristics and acceptable risk levels for populations within each region;
3. At least one population from each major genetic and life history group historically present within each of the five biogeographical regions is viable;
4. Production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery; and
5. Populations that do not meet the viability criteria for all VSP parameters are sustained to provide ecological functions and preserve options for ESU recovery.

General Life History: Chinook salmon are divided into two races based on their general juvenile development strategies: stream-type and ocean-type. Stream-type Chinook salmon tend to rear in freshwater for a year or more before entering marine waters. Yearling stream-type fish tend to leave their natal rivers from late winter through spring, and move more or less directly to nearshore marine areas and pocket estuaries. Ocean-type juveniles tend to leave their natal streams during their first year of life, and rear in estuarine waters as they transition into their marine life stage. Out-migrating ocean-type fry tend to begin migrating from their natal streams in early-March. They then rear in tidal delta estuaries for approximately two weeks to two months before migrating to nearshore marine areas and pocket estuaries in late May to June. The PS Chinook salmon ESU includes both stream- and ocean-type races, although the ocean-type is predominant.

Chinook salmon are further grouped into different "runs," which are based on the timing of when adults return to freshwater. One run type, early- or spring-run Chinook salmon tend to enter freshwater as immature fish early in the year. They then migrate upriver, reaching maturity while in freshwater, and spawn in late summer and early autumn. Another run type, late- or fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas, and spawn within a few days or weeks. A third classification, summer-run fish show intermediate characteristics between spring- and fall-runs, without the extensive delay in maturation exhibited by spring-run Chinook salmon. In Puget Sound, spring-run Chinook salmon generally enter their natal rivers as early as March, but do not spawn until mid-August through September. Returning summer- and fall-run fish tend to enter their natal rivers from early-June through early-September, with spawning occurring between early-August and late-October.

Spatial Structure and Diversity: As described in Ford et al. (2022), the PS Chinook salmon ESU includes "all naturally spawning populations of Chinook salmon from rivers and streams flowing into Puget Sound, including the Straits of Juan De Fuca from the Elwha River eastward, rivers and streams flowing into Hood Canal, South Sound, North Sound, and the Strait of Georgia in Washington." The ESU also includes the progeny of numerous artificial propagation programs (NWFSC 2015, Ford et al. 2022). The ESU is includes 22 extant populations, which are grouped into 5 MPGs. The MPGs are separated by biogeographical region in the Puget Sound area (Table 4). As described above, delineation of the MPGs was based on similarities in hydrographic, biogeographic, and geologic characteristics. These characteristics include: historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity.

Hatchery-origin spawners are present in high fractions in most populations within the ESU, with the exception of populations in the Whidbey Basin MPG. Whidbey Basin is the only MPG with populations that have consistently high fractions of natural-origin spawners. Between 1990 and 2019, the fraction of natural-origin spawners has declined in many of the populations outside of the Skagit Watershed, and the ESU overall remains at a "moderate" risk of extinction (Ford 2022).

Table 4. Extant Chinook salmon populations in the Puget Sound Ecologically Significant Unit (ESU) in each biogeographic region [alternatively referred to as major population group (MPG); Ruckelshaus et al. 2006, NWFSC 2015]

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

Abundance and Productivity: Available data on total abundance of PS Chinook salmon since 1980 indicate that abundance trends have fluctuated between positive and negative in individual populations; however, there has been a general decline in the abundance of natural-origin spawners in the most recent fifteen-year period (2004 – 2019) for which abundance was calculated, with 16 of the 22 extant populations showing negative abundance trends (Ford et al. 2022). Productivity remains low in most populations, and most populations outside the Skagit Watershed are comprised by a high fraction of hatchery-origin fish. Across the ESU, 10 of the 22 individual populations have shown natural productivity below replacement levels in nearly all years since the mid-1980s (Ford et al. 2022). Further, escapement levels for all individual populations remain well below the PSTRT planning ranges for recovery (see below; Ford 2022). Based on the latest viability assessment, the PSTRT concluded that: 1) the PS Chinook salmon ESU remains at "moderate" risk of extinction; 2) viability is largely unchanged from the prior review; and 3) the ESU should remain listed as threatened under the ESA (Ford 2022).

Limiting Factors: Limiting factors for this ESU include:

- Degraded floodplain and instream channel structure;
- Degraded estuarine conditions and loss of estuarine habitat;

- Riparian area degradation and loss of instream large woody debris (LWD);
- Excessive fine sediment in spawning gravel;
- Degraded water quality and temperature;
- Degraded nearshore conditions;
- Impaired passage for migrating fish; and
- Altered flow regime.

PS Chinook Salmon Within the Action Area: The action area includes all areas that will be affected by the proposed action. In addition to written references, the distribution of PS Chinook salmon within the action area was analyzed using the WDFW SalmonScape mapping tool (WDFW 2024a; https://apps.wdfw.wa.gov/salmonscape/map.html) and the NMFS Species and Habitat App (NMFS 2024; https://maps.fisheries.noaa.gov/portal/apps/webappviewer/index.html?id=e8311ceaa4354de290fb1c456cd86a7f).

The PS Chinook salmon that occur in the action area are from the Cedar River population and the North Lake Washington / Sammamish River population (NWFSC 2015; NMFS 2024; WDFW 2024a). Both stream- and ocean-type Chinook salmon are present in these populations; however, the majority of individuals are of the latter type.

Lake Union is connected to Lake Washington upstream (eastward) via the Lake Washington Ship Canal (Ship Canal). The Ship Canal includes the Montlake Cut, Portage Bay, Lake Union, Fremont Cut, and Salmon Bay, and extends from Lake Washington to Puget Sound. Access to Puget Sound from the Ship Canal is controlled by the Chittenden Locks (aka Ballard Locks). PS Chinook salmon utilize Lake Union and the other waterbodies of the Ship Canal as a migration corridor (Fresh et al. 1999). As described in Kerwin (2001), “all of the naturally produced anadromous salmonids, both juveniles and adults, residing in the Cedar - Sammamish Basin, use Lake Union as a migratory passageway to and from Puget Sound.” Returning adults and out-migrating juveniles from both populations must pass through Lake Union to complete their life cycles. Adult Chinook salmon pass through Ballard Locks into Puget Sound from mid-June through September, with peak migration occurring in mid-August (City of Seattle 2008). Most adults move through the Lake Union area in less than one day. Spawning occurs well upstream of Lake Union from September to mid-December. Juvenile Chinook salmon migrate out of Lake Washington and into the Ship Canal from late May to early July, with peak outmigration occurring in June, and spend two to four weeks moving through the Ship Canal and Lake Union (DeVries 2005; City of Seattle 2008). Juvenile rearing in Lake Union is highly limited, although some Juvenile Chinook salmon are found in Lake Washington between January and July, primarily in the littoral zone (Tabor et al. 2006). While data regarding the presence and timing of juvenile Chinook salmon in Lake Union are limited, Lake Union is only approximately 2.5 miles upstream of Lake Washington, and the two are directly connected by the Ship Canal. It would therefore be a reasonable assumption that the presences of juvenile Chinook salmon in Lake Union coincides with their presence in Lake Washington. The same coincidental presence has been documented between Lake Washington and Lake Sammamish farther upstream.

Cedar River Chinook Salmon Life History and Status: The Cedar River Chinook salmon population is fall-run, native origin, and with wild production (WDFW 1993). Cedar River chinook salmon begin returning to their natal streams in August and spawn from September through mid-December (WDFW 1993; SSPS 2007).

Using technical models based on estimates of historical environmental carrying capacity and other historical population information, the PSTRT developed recovery planning abundance ranges for individual Chinook salmon populations (Table 5; Ruckelshaus et al. 2002; NMFS 2006; SSPS 2007). The upper and lower values of the planning ranges represent population abundance under high- and low-productivity scenarios. Productivity is measured as the number of fish returning from the sea per spawning adult (spawner). A recovery planning range of abundance is not intended to represent a fixed value, rather, it is intended to represent different points along a population performance curve, which a given planning range is intended to achieve as an average over time for its respective population (SSPS 2007). Under a recovery planning range, population abundance and productivity are expected to vary from year to year due to fluctuations in environmental conditions. As presented in the 2007 *Puget Sound Salmon Recovery Plan* (SSPS 2007) recovery targets for Cedar River Chinook salmon are 2,000 spawners under the high-productivity scenario (3.1 fish returning from the ocean per spawning adult) and 8,200 spawners under the low-productivity scenario (1.0 returning fish per adult).

Table 5. Puget Sound Chinook salmon historic spawner capacity, high- and low-productivity abundance targets for recovery, and 5-year geometric mean (geomean) of natural-origin spawner abundance by population

Population	**High-productivity Abundance Recovery target**[1]	**Low-Productivity Abundance Recovery Target**[2]	**Five-year Natural-origin Spawner Geomeans**[3]					
			1990 – 1994	**1995 – 1999**	**2000 – 2004**	**2005 – 2009**	**2010 – 2014**	**2015 – 2019**
Cedar River	2,000	8,200	385	276	379	1,017	699	889
North Lake Washington/ Sammamish River	1,000	4,000	197	149	336	171	82	126

[1] Values taken from NMFS 2006 / SSPS 2007; the high-productivity scenario assumes 3.1 and 3.0 fish returning from the ocean per adult spawner for the Cedar River and North Lake Washington / Sammamish River populations, respectively.

[2] Values taken from NMFS 2006 / SSPS 2007; the low-productivity scenario assumes 1.0 fish returning from the ocean per adult spawner.

[3] Values taken from Ford et al. 2022

In NMFS' biological viability assessments for Pacific salmon and steelhead, abundance estimates of individual populations are calculated as the geometric mean of natural-origin spawners in 5-year increments (5-year geomean). In the most recent biological viability assessment (Ford et al. 2022), over three decades of sampling (1990 to 2019), the 5-year geomean of natural-origin Cedar River Chinook salmon ranged from a low of 276, from 1995 to 1999, to high of 889, from 2015 to 2019. The period from 2015 to 2019 is the most recent 5-year period for which an abundance geomean is available. This period represents a 27% increase in natural-origin spawners over the next most recent 5-year period, 2010 to 2014, which had a geomean of 699 natural-origin spawners. Even with these improvements, the Cedar River Chinook salmon population remains well below its recovery targets for abundance. The most recent 5-year geomean represents just over 44% of the high-productivity recovery target of 2,000 spawners, and is just under 11% of the low-productivity recovery target of 8,200 spawners. Thus, the Cedar River Chinook salmon population has failed to meet the PSTRT abundance planning target, even under the most optimistic productivity scenario, since at least 1990.

Ford et al. (2022) also show population productivity trends for natural-origin Cedar River Chinook salmon. Productivity trends are measured over 15-year periods, as opposed to the 5-year periods for abundance estimates. Between 1990 and 2005, the population showed negative productivity, meaning that over this period as a whole, the population was not able to replace its numbers through natural production. During the most recent period, from 2004 to 2019, the population showed neutral productivity, meaning that, overall, the population of natural-origin spawners was able to replace itself but did not increase. Between 1975 and 2015, the Cedar River Chinook salmon population has had 12 years with positive production.

Another important indicator of population status is the proportion of natural-origin to hatchery-origin spawners within the population. Hatchery-origin fish may reduce the fitness and compromise the genetic integrity of natural populations when they interbreed with natural-origin individuals (STAG 2000). In NMFS's biological viability assessments, the proportion of natural-origin spawners is calculated as the mean fraction of natural spawners over 5-year increments (5-year mean; Table 6). Since 1990, the Cedar River Chinook salmon population has maintained a relatively high fraction of natural-origin spawners, especially in comparison with other PS Chinook salmon populations (Ford et al. 2022). During this period, the 5-year mean fraction of natural-origin spawners in the Cedar River population has ranged from a low of 0.59, from 2000 to 2004, to a high of 0.82, from 2005 to 2009. During the most recent period, the 5-year mean fraction of natural-origin spawners was 0.71.

Table 6. Puget Sound Chinook salmon 5-year mean fraction of natural-origin (wild) spawners by population

Population	1990 – 1994	1995 – 1999	2000 –2004	2005 – 2009	2010 – 2014
Cedar River	0.61	0.59	0.82	0.78	0.71
North Lake Washington/Sammamish River	0.29	0.36	0.16	0.07	0.16
[1]Values taken from Ford et al. 2022					

North Lake Washington / Sammamish River Chinook Salmon Life History and Status: The North Lake Washington / Sammamish River Chinook salmon population is fall-run, of native origin, and with wild production (WDFW 1993). North Lake Washington / Sammamish River Chinook salmon spawn from September through October. Abundance recovery targets of the North Lake Washington / Sammamish River Chinook salmon population are 1,000 spawners under the high-productivity scenario (3.0 fish returning from the ocean per spawning adult) and 4,000 spawners under the low-productivity scenario (1.0 returning fish per adult). Between 1990 and 2019, the 5-year geomean of natural-origin North Lake Washington / Sammamish River Chinook salmon ranged from 82, from 2010 to 2014, to 336, from 2000 to 2004. The most recent period, 2015 – 2019, had a 5-year geomean of 126 natural-origin spawners. This represents a 54% increase over the previous period, 2010 – 2014, but is only 13 and 3% of the high- and low-productivity abundance recovery targets, respectively.

Productivity of the North Lake Washington / Sammamish River Chinook salmon population was positive from 1990 to 2005, but was negative from 2004 to 2019, meaning that the population has not been able to replace its numbers over the last 15 years as a whole (Ford et al. 2022). Furthermore, the population has not had a single year with positive productivity since at least 1975, as shown in Figure 91 in Ford et al. (2022). This would seem to contrast with Ford et al.'s (2022) finding of positive productivity between 1990 and 2005 [Table 51 in Ford et al. (2022)].

The proportion of natural-origin spawners in the North Lake Washington / Sammamish River Chinook salmon population has remained low since at least 1990, and has shown a downward trend in recent years (Ford et al. 2022). During this period, the highest 5-year mean fraction of natural-origin spawners was 0.36, from 2000 to 2004. The 5-year mean fraction of natural-origin spawners was 0.16 from 2005 to 2009, dropping to 0.07 from 2010 to 2014, before rising back to 0.16 during the most recent sampling period, 2015 to 2019. That is, on average, no more than 16 out of every 100 returning adults in the North Lake Washington / Sammamish River Chinook salmon population have been of native origin since 2005. Since 1990, the North Lake Washington / Sammamish River Chinook salmon population has had the lowest, or among the lowest fraction of natural-origin spawners out of all 22 populations in the ESU.

Contribution to the ESU: As described above, the PSTRT developed six recommended ESU- and population-level viability criteria in order for the Puget Sound Chinook salmon ESU to be de-listed as threatened under the ESA (Ruckelshaus et al. 2002). These criteria were adopted and solidified in the *Puget Sound Salmon Recovery Plan* (SSPS 2007) and the *Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan* (NMFS 2006). The second of these criteria states that two to four individual populations in each of the five biogeographical regions (MPGs) within the ESU must achieve viability for the ESU to be delisted. The third criterion builds upon the second by adding the condition that at least one population representing each major genetic and life history group historically present within each of the five MPGs, respectively, attain viability. These life history groups are based on run timing, age distribution, and migration patterns (Ruckelshaus et al. 2002).

Both populations are part of the Central / South Puget Sound Basin MPG, in addition to four other populations (6 populations in Central / South Puget Sound Basin MPG total). As shown in the *Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan* (NMFS 2006), two separate major life history and genetic groups have been identified within the Central / South Puget Sound Basin MPG, and are defined as "early" and "late" run timing (Table 7; Ruckelshaus et al. 2002). Five of the populations within the MPG are "late-run," with sixth being the only "early-run" population. As described above, under recovery criterion three, one population from each major life history group within an MPG must attain viability for the ESU to be delisted.

Table 7. Puget Sound Chinook salmon, Central/South Puget Sound major population group (MPG) populations by life history group (NMFS 2006)

Life History Group[1]	Populations
Very early	N/A
Early	White River
Moderately Early	N/A
Late	North Lake Washington / Sammamish River Green River Puyallup River Nisqually River

[1] Life history groups are labeled by run timing.

The Cedar River and North Lake Washington / Sammamish River Chinook salmon populations are two of the five late-run populations in the Central / South Puget Sound Basin MPG. While, under criterion three, only one late-run population in the Central / South Puget Sound Basin MPG must attain viability for the Puget Sound ESU can be delisted, this does not entail that the other populations are unnecessary or disposable. Among the other viability criteria, the first criterion states that the viability status of all populations must improve from “current” conditions, i.e., conditions circa 2002 – 2007. Additionally, the sixth criterion states that all populations must be sustained even if they do not meet the criteria for all VSP parameters. This is stated more directly in the Puget Sound Salmon Recovery Plan (SSPS 2007) as, “none of the 22 remaining Chinook populations [can] go extinct.” Thus, while an emphasis may be placed on certain individual PS Chinook populations due to the life history traits or genetic diversity they help preserve, none of the remaining populations can be lost, and the condition of all populations must be improved from what it was approximately two decades ago if the ESU is to attain recovery.

PS Steelhead

The PS steelhead distinct population segment (DPS) was listed as threatened on May 11, 2007 (72 FR 26722). In 2013, the Puget Sound Steelhead Technical Recovery Team (PSSTRT) identified 32 demographically independent populations (DIPs) within the DPS, based on genetic, environmental, and life history characteristics. Those DIPs are distributed among three geographically-based MPGs; Northern Cascades, Central and South Puget Sound; and Hood Canal and Strait de Fuca (Table 8; Myers et al. 2015). Critical habitat for the Puget Sound steelhead DPS was designated by NMFS in 2016 (81 FR 9251, February 24, 2016). NMFS adopted the steelhead recovery plan for the Puget Sound DPS in December, 2019 (NMFS 2019).

Table 8. Puget Sound steelhead demographically independent populations (DIPs) and DIP viability estimates by major population group (MPG; modified from Figure 58 in Hard et al. 2015).

Geographic Region (MPG)	Demographically Independent Population (DIP)	Viability
Northern Cascades	Drayton Harbor Tributaries Winter Run	Moderate
	Nooksack River Winter Run	Moderate
	South Fork Nooksack River Summer Run	Moderate
	Samish River/Bellingham Bay Tributaries Winter Run	Moderate
	Skagit River Summer Run and Winter Run	Moderate
	Nookachamps River Winter Run	Moderate
	Baker River Summer Run and Winter Run	Moderate
	Sauk River Summer Run and Winter Run	Moderate
	Stillaguamish River Winter Run	Low
	Deer Creek Summer Run	Moderate
	Canyon Creek Summer Run	Moderate
	Snohomish/Skykomish Rivers Winter Run	Moderate
	Pilchuck River Winter Run	Low
	North Fork Skykomish River Summer Run	Moderate
	Snoqualmie River Winter Run	Moderate
	Tolt River Summer Run	Moderate
Central and South Puget Sound	Cedar River Winter Run	Low
	North Lake Washington and Lake Sammamish Winter Run	Moderate
	Green River Winter Run	Low
	Puyallup River Winter Run	Low
	White River Winter Run	Low
	Nisqually River Winter Run	Low
	South Sound Tributaries Winter Run	Moderate
	East Kitsap Peninsula Tributaries Winter Run	Moderate
Hood Canal and Strait de Fuca	East Hood Canal Winter Run	Low
	South Hood Canal Tributaries Winter Run	Low
	Skokomish River Winter Run	Low
	West Hood Canal Tributaries Winter Run	Moderate
	Sequim/Discovery Bay Tributaries Winter Run	Low
	Dungeness River Summer Run and Winter Run	Moderate
	Strait of Juan de Fuca Tributaries Winter Run	Low
	Elwha River Summer Run and Winter Run	Low

In 2015, the PSSTRT concluded that the DPS is at “very low” viability; with most of the 32 DIPs and all three MPGs at “low” viability based on widespread diminished abundance, productivity, diversity, and spatial structure when compared with available historical evidence (Hard et al. 2015). Based on the PSSTRT viability criteria, the DPS would be considered viable when all three component MPGs are considered viable. An MPG would be considered viable when: 1) 50% or more of its component DIPs are viable; 2) mean DIP viability within the MPG exceeds the threshold for viability; and 3) 40% or more of the historic life history strategies (e.g., summer runs and winter runs) within the MPG are viable. For a given DIP to be considered viable, its probability of persistence must exceed 85%, as calculated by Hard et al. (2015), based on abundance, productivity, diversity, and spatial structure within the DIP.

On December 27, 2019, NMFS published a final recovery plan for PS steelhead (84 FR 71379; NMFS 2019). The plan indicates that within each of the three MPGs, at least 50% of the populations must achieve viability. Of that 50%, certain specific DIPs within each of respective MPG must also be viable. Those DIPs, grouped by MPG, are as follows:

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

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

- North Cascades MPG
    - Of the eleven DIPs with winter or winter/summer runs, five must be viable, including:
        - One from the Nooksack River Winter-Run;
        - One from the Stillaguamish River Winter-Run;
        - One from the Skagit River, either the Skagit River Summer-Run and Winter-Run, or the Sauk River Summer-Run and Winter-Run;
        - One from the Snohomish River Watershed: Pilchuck, Snoqualmie, or Snohomish/Skykomish River Winter-Run;
        - One other winter or summer/winter run from the MPG.
    - Of the five summer-run DIPs in the North Cascades MPG, three must be viable, one in each of the three major watersheds containing summer-run populations in the MPG (Nooksack, Stillaguamish, Snohomish Rivers), including:
        - The South Fork Nooksack River Summer-Run;
        - One DIP from the Stillaguamish River: Deer Creek Summer-Run or Canyon Creek Summer-Run; and
        - One DIP from the Snohomish River: Tolt River Summer-Run or North Fork Skykomish River Summer-Run.

General Life History: PS steelhead are the anadromous form of *Oncorhynchus mykiss* that occur below natural barriers to migration in northwestern Washington State (Ford 2022). Non-anadromous ‘‘resident’’ *O. mykiss* (a.k.a. rainbow trout) occur within the range of PS steelhead, but are not part of the DPS due to marked differences in physical, physiological, ecological, and behavioral characteristics (Hard et al. 2015). PS steelhead exhibit two major life history strategies: Ocean-maturing, or winter-run fish typically enter freshwater from November to April at an advanced stage of maturation, and then spawn from February through June. Stream-maturing, or summer-run fish typically enter freshwater from May to October at an early stage of maturation, migrate to headwater areas, and hold for several months prior to spawning the following spring.

After hatching, steelhead juveniles rear in freshwater from one to three years (two years is typical) prior to migrating to marine waters. Smoltification and seaward migration typically occur from April to mid-May. Smolt lengths vary among watersheds, but typically range from 4.3” to 9.2” (109 to 235 mm) (Myers et al. 2015). Juvenile steelhead generally become independent of shallow nearshore areas soon after entering marine water, and are not commonly caught in beach seine surveys (Schreiner et al. 1977; Bax et al. 1978; Brennan et al. 2004). Recent acoustic tagging studies have shown that the migration of smolts from rivers to the Strait of Juan de Fuca generally takes from one to three weeks. (Moore et al. 2010). PS steelhead feed in ocean waters for one to three years (two years is typical), before returning to their natal streams to spawn. Unlike Chinook salmon, most female steelhead, and some males, return to marine waters after spawning, and may migrate between fresh and saltwater multiple times over the course of their life (Myers et al. 2015).

Spatial Structure and Diversity: The PS steelhead DPS includes all naturally spawned anadromous steelhead populations in streams in the river basins of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, Washington, bounded to the west by the Elwha River (inclusive) and to the north by the Nooksack River and Dakota Creek (inclusive). As stated above, the DPS consists of 32 DIPs that are distributed among three geographically-based MPGs. An individual DIP may consist of winter-run only, summer-run only, or a combination of both life history types. Winter-run is the predominant life history type within the PS DPS (Hard et al. 2015). The DPS also includes six hatchery stocks that are considered to be no more than moderately diverged from their associated natural-origin counterparts (USDC 2014).

Abundance and Productivity: Available data on total abundance since the late 1970s and early 1980s indicate that abundance trends have fluctuated between positive and negative for individual DIPs; however, the long-term abundance of adult steelhead returning to many rivers in Puget Sound has declined substantially for many DIPs since then. Over the most recent monitoring period, from 2015 to 2019, described in Ford et al. (2022), some improvements in abundance and productivity were seen in certain DIPs, particularly those within the Central and South Puget Sound MPG; however, low productivity persists throughout the DPS overall, with most of the 32 DIPs showing long-term downward trends. Since the mid-1980s, trends in natural spawning abundance have also been temporally variable among DIPs, but have remained predominantly negative, well below replacement levels, and most DIPs remain small (Ford et al. 2022). Between 1990 and 2019, the overall abundance trends, especially for natural spawners, has remained predominantly negative or flat across the DPS, well below the level needed to sustain natural production into the future (Ford et al. 2022). The PSSTRT concluded that the PS steelhead DPS is currently not viable (Hard et al. 2015). The most recent viability assessment reported a slightly increasing viability trend for the PS steelhead DPS, but also reported that the risk of extinction remains moderate and that the DPS should remain listed as threatened (Ford 2022).

Limiting Factors: Factors limiting recovery for PS steelhead include:

- Ongoing destruction and modification of steelhead habitat
- Widespread declines in adult abundance (total run size), despite significant reductions in harvest in recent years
- Threats to diversity posed by the ongoing perpetuation of two hatchery steelhead stocks (Chambers Creek and Skamania hatcheries)
- Declining diversity in the DPS, including the uncertain and weak status of summer-run fish
- Reduction in spatial population structure
- Reduced habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and reduced movement of large woody debris
- Where urban development has occurred (in lower reaches of many rivers and their tributaries in Puget Sound), increased flood frequency and peak flows during storm events and reduced groundwater-driven summer flows resulting in concomitant increases in gravel scour, bank erosion, and sediment deposition
- Reduced river braiding and sinuosity, with a concomitant increase in gravel scour and likely dislocation of rearing juveniles due to the construction of dikes, bank hardening (with riprap), and stream channelization

PS Steelhead Within the Action Area: In addition to written references, the distribution of PS steelhead within the action area was analyzed using the WDFW SalmonScape mapping tool (WDFW 2024a; https://apps.wdfw.wa.gov/salmonscape/map.html) and the NMFS Protected Resources App (NMFS 2024; https://maps.fisheries.noaa.gov/portal/apps/webappviewer/index.html?id=e8311ceaa4354de290fb1c456cd86a7f).

The PS steelhead populations that occur in the action area are the Cedar River and North Lake Washington / Lake Sammamish DIPs (NWFSC 2015; NMFS 2024; WDFW 2024a). Returning adults and out-migrating juveniles of both populations must pass through Lake Union to complete their life cycles. Adult steelhead pass through Ballard Locks and upstream through the Ship Canal between January and May, and may remain within Lake Washington through June (City of Seattle 2008). The timing of steelhead spawning in the basin is uncertain, but spawning occurs well upstream of Lake Union. Juvenile steelhead enter Lake Washington in April, and typically migrate downstream through the Ship Canal and to Ballard Locks between April and May (City of Seattle 2008).

Due to a range of factors, steelhead have become exceedingly scarce in the Lake Washington Subbasin, and may be functionally extirpated. As described in the most recent Pacific salmon and steelhead viability assessment (Ford et al. 2022), “Two DIPs in the Lake Washington watershed, North Lake Washington Tributaries and Cedar River, had adult abundances near zero. Based on fish ladder counts (Chittenden Locks) and Landsburg Dam (Cedar River) and red counts.”

Cedar River Steelhead Life History and Status: The Cedar River DIP includes steelhead from the Cedar River and major tributaries along the southern portion of Lake Washington, primarily Kelsey, May, and Coal Creeks (Meyers et al. 2015; Cram et al. 2018). The Cedar River DIP is a winter-run native population with wild production (Meyers et al. 2015; Ford et al. 2022). The exact run and spawn timing of the Cedar River DIP, as well as the North Lake Washington / Sammamish River DIP, remain unclear in the literature. Therefore, the direct observation records presented in City of Seattle (2008) that adult steelhead pass through Ballard Locks from January through May is taken as a general approximation for the run timing of both DIPs. Additionally, the information presented in Table 3 in Meyers et al. (2015), which lists spawning occurring from March through June in "Lake Washington tributaries" based on a single year of data from 2007, is taken as a general approximation for the spawn timing of both DIPs.

Historical population abundance estimates and abundance planning targets for PS steelhead DIPs are presented in the *ESA Recovery Plan for the Puget Sound Steelhead Distinct Population Segment* (PS Steelhead Recovery Plan; NMFS 2019). Historical abundance estimates of individual DIPs are based on: 1) an estimate of the total historical abundance of PS steelhead (from Hard et al. 2007), which, in turn, is based on historical fisheries catch data (Wilcox 1898); and 2) estimates of historical habitat availability (measured as linear stream kilometers) within each respective DIP (Hard et al. 2015). Hard et al. (2015) used a habitat-based intrinsic potential (IP) model, which used monitoring data collected from Snow Creek, WA [U.S. Fish and Wildlife Service (USFWS) and Washington Department of Game (WDG) 1980], to estimate the amount of habitat historically available to each individual PS steelhead DIP. Using the findings of Hard et al. (2015), each DIP was allocated a fraction of the total estimated historical PS steelhead abundance (Hard et al. 2007). The fraction of total historical population abundance allocated to each DIP was proportional to the fraction of the total habitat (stream kilometers) historically available to the entire PS steelhead DPS present within the area occupied by each DIP, respectively (NMFS 2019). That is, the historical steelhead abundance of each DIP was calculated as a fraction of the total historical abundance of steelhead in the PS DPS. The fraction of the total PS steelhead within each DIP was based on the fraction of historical PS steelhead habitat, measured in stream kilometers, located within the range of that DIP.

Abundance planning targets for each DIP were based upon historical population estimates, and followed the precedent established in the *Puget Sound Salmon Recovery Plan* (SSPS 2007) and the *Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan* (NMFS 2006). Planning targets were not set as a single value, but rather are a range of target abundances under high-productivity/low-abundance and low-productivity/high-abundance scenarios (productivity measured as recruits per spawner) (Table 9). A recovery target of 70% of historical abundance was set for the high-abundance/low-productivity scenario for most DIPs. The target of 70% of historical abundance was "based on stock-recruit productivity and capacity under properly functioning conditions, expressed as a proportion of historical conditions," (NMFS 2019). Recovery abundance targets under the low-abundance/high-productivity scenario were derived for each DIP using a form of the Beverton-Holt (1957) equation, with the low-abundance target set at the point of maximum sustainable yield (MSY; productivity = 2.35).

Table 9. Puget Sound steelhead historic high- and low-productivity abundance targets for recovery, and 5-year geometric mean (geomean) of natural-origin spawner abundance by population

Population	Historic Abundance[1]	High-productivity Abundance Recovery target[2]	Low-Productivity Abundance Recovery Target[3]	Five-year Natural-origin Spawner Geomeans[4]					
				1990–1994	1995–1999	2000–2004	2005–2009	2010–2014	2015–2019
Cedar River	5,694	1,200	4,000	241	295	37	12	4	6
North Lake Washington/ Sammamish River	22,909	4,800	16,000	60	4	–	–	–	–

[1] Values taken from NMFS 2019
[2] Values taken from NMFS 2019; the high-productivity scenario assumes 2.3 fish returning from the ocean per adult spawner.
[3] Values taken from NMFS 2019; the low-productivity scenario assumes 1.0 fish returning from the ocean per adult spawner.
[4] Values taken from Ford et al. 2022

As shown in the PS Steelhead Recovery Plan (NMFS 2019), the historical abundance estimate of the Cedar River DIP is 5,694, giving a 70% recovery target of 3,986 under the high-abundance/low-productivity scenario. Under the low-abundance/high-productivity scenario, the abundance recovery target is 1,200 (Ford et al. 2022). In NMFS's biological viability assessments for Pacific salmon and steelhead, abundance estimates of individual DIPs are calculated as the geometric mean of natural-origin spawners in 5-year increments (5-year geomean). As shown in the most recent biological viability assessment (Ford et al. 2022), the Cedar River steelhead DIP has exhibited a strong and consistent downward trend over three decades of monitoring (1990 to 2019). From 1990 to 1994 the 5-year geomean of natural origin spawners was 241. Spawner abundance reached 295 from 1995 to 1999, before dropping to 37 from 2000-2004, and continuing to fall from there. In the most recent period, 2015 – 2019, the 5-year geomean of natural-origin spawners was 6. Since 2000, the total annual abundance has remained below 50 fish in any given year, with 4 adults returning in 2018, none in 2019, and 4 during each year from 2020 to 2023 (WDFW 2024b). Population productivity for the Cedar River steelhead DIP was negative between 1990 and 2019 (Ford et al. 2022). An abundant population of resident *O. mykiss* exists throughout the Cedar River drainage, which is genetically similar to Cedar River Steelhead (Marshall et al. 2006). While this resident population was found to be capable of producing out-migrating smolts, this has had no effect towards rebuilding the stock (Marshall et al. 2006; Cram et al. 2018).

The rerouting of the Cedar River from its Green/Black River confluence into Lake Washington, paired with heavy pinniped predation on adult steelhead at the Ballard Locks has decimated steelhead the Cedar River DIP (Foley 1995; NMFS 1997; Meyers et al. 2015). Dwindling numbers of returning spawners have produced similarly dwindling numbers of offspring. Since 2009, fewer than 15 out migrating steelhead smolts have been encountered each year in a smolt trap operated by the Washington Department of Fish and Wildlife (WDFW) on the lower Cedar River (in Cram et al. 2018). In their assessment of Washington State steelhead populations, Cram et al. (2018) state that "the population could be considered functionally extirpated," with a 100% calculated risk of extinction.

North Lake Washington / Lake Sammamish Steelhead Life History and Status: The North Lake Washington/ Lake Sammamish DIP includes "tributaries draining the northern end of Lake Washington and the Sammamish River/Lake Sammamish basin," (Meyers et al. 2015). The DIP is a winter-run population of native origin with wild production (WDFW 1993). As with the Cedar River DIP, the exact run and spawn timing of the North Lake Washington / Sammamish River DIP is unclear in the literature. Therefore, January through May is taken as a general approximation for the run timing of the DIPs based on the data presented in City of Seattle (2008). March through June is taken as a general approximation for the spawn timing based on the "Lake Washington tributaries" population listed in Table 3 in Meyers et al. (2015).

As shown in the PS Steelhead Recovery Plan (NMFS 2019), the historical abundance estimate of the North Lake Washington/ Lake Sammamish steelhead DIP is 22,909, giving a 70% recovery target of 16,036 under the high-abundance/low-productivity scenario. Under the low-abundance/high-productivity scenario, the abundance recovery target is 4,800 (Ford et al. 2022). In the most recent biological viability assessment (Ford e al. 2022), a calculated 5-year geomean of natural-origin spawner abundance of the North Lake Washington/ Lake Sammamish DIP is not available for the three most recent monitoring periods, from 2000 to 2019. This suggests that annual returns of North Lake Washington/ Lake Sammamish steelhead spawners have been exceedingly low or completely absent since 2000. In the most recent period for which data are available, 1995 – 1999, the 5-year geomean of returning natural-origin spawners was 4 fish. Before that, 1990 – 1994, the 5-year geomean was 60. In 1994, 4 adult fish returned, followed by 0 in 1995, 2 in 1996, 4 in 1997, 8 in 1998, and 4 in 1999, the final year counts are given (WDFW 2024b) Based on these data, it is difficult to reach a conclusion other than that the North Lake Washington/ Lake Sammamish steelhead DIP has been extirpated.

Contribution to the DPS: Both the Cedar River and North Lake Washington / Sammamish River DIPs are part of the Central and South Puget Sound MPG. As described above, among the recovery criteria in the PS Steelhead Recovery Plan (NMFS 2019), certain DIPs within each MPG must achieve viability in order for the entire Puget Sound steelhead DPS to attain viability and be de-listed under the ESA. The criterion for the Central and South Puget Sound MPG as it relates to the two DIPs in the action area is that out of the Cedar River, North Lake Washington/Sammamish Tributaries, South Puget Sound Tributaries, or East Kitsap Peninsula Tributaries DIPs, one must achieve viability.

Critical Habitat

This section describes the status of designated critical habitat that would be affected by the proposed action by examining the condition and trends of physical or biological features (PBFs) that are essential to the conservation of the listed species throughout the designated areas. The PBFs are essential because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration, and/or foraging). The proposed project would affect critical habitat for PS Chinook salmon.

NMFS designated critical habitat for PS Chinook salmon on September 2, 2005 (70 FR 52630). Critical habitat is located in 16 freshwater subbasins and watersheds between, and including, the Dungeness/Elwha Watershed and the Nooksack Subbasin, as well as in nearshore marine waters of Puget Sound south of the US-Canada border and east of the Elwha River out to a depth of 30 meters. Although “offshore marine” is an area type identified in the final rule, it was not designated as critical habitat for PS Chinook salmon.

NMFS designated critical habitat for PS steelhead on February 24, 2016 (81 FR 9252). Critical habitat is located in 18 freshwater subbasins between, and including, the Strait of Georgia Subbasin and the Dungeness-Elwha Subbasin, but does not include marine waters. No designated critical habitat for PS steelhead exists within the action area.

The PBFs of salmonid critical habitat (Table 10) include:

1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development;
2) Freshwater rearing sites with:
    i. Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility;
    ii. Water quality and forage supporting juvenile development; and
    iii. Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks;
3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival;
4) Estuarine areas free of obstruction and excessive predation with:
    i. Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater;
    ii. Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and
    iii. Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation;
5) Nearshore marine areas free of obstruction and excessive predation with:
    i. Water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and
    ii. Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and
6) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

Table 10. Physical or biological features (PBFs) and corresponding life history events of designated critical habitat for Puget Sound (PS) Chinook salmon and PS steelhead

Physical or Biological Features		Life History Event
Site Type	**Site Attribute**	
Freshwater spawning	Water quantity Water quality Substrate	Adult spawning Embryo incubation Alevin growth and development
Freshwater rearing	Water quantity and Floodplain connectivity Water quality and Forage Natural cover	Fry emergence from gravel Fry/parr/smolt growth and development
Freshwater migration	(Free of obstruction and excessive predation) Water quantity and quality Natural cover	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Estuarine	(Free of obstruction and excessive predation) Water quality, quantity, and salinity Natural cover Forage	Adult sexual maturation and "reverse smoltification" Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Nearshore marine	(Free of obstruction and excessive predation) Water quality, quantity, and forage Natural cover	Adult growth and sexual maturation Adult spawning migration Nearshore juvenile rearing
Offshore marine	Water quality and forage	Adult growth and sexual maturation Adult spawning migration Subadult rearing

Major tributary river basins in the Puget Sound basin include the Nooksack, Samish, Skagit, Sauk, Stillaguamish, Snohomish, Lake Washington, Cedar, Sammamish, Green, Duwamish, Puyallup, White, Carbon, Nisqually, Deschutes, Skokomish, Duckabush, Dosewallips, Big Quilcene, Elwha, and Dungeness rivers and Soos Creek. Critical habitat throughout the Puget Sound basin has been degraded by numerous activities, including hydropower development, loss of mature riparian forests, increased sediment inputs, removal of large wood from the waterways, intense urbanization, agriculture, alteration of floodplain and stream morphology (i.e., channel modifications and diking), riparian vegetation disturbance, wetland draining and conversion, dredging, shoreline armoring, marina and port development, road and railroad construction and maintenance, logging, and mining. Changes in habitat quantity, availability, and diversity and altered stream flows, temperature, sediment load and channel instability are common limiting factors of critical habitat throughout the basin.

Land Use Impacts

Land use practices have likely accelerated the frequency of landslides delivering sediment to streams. Fine sediment from unpaved roads also contributes to stream sedimentation. Unpaved roads are widespread on forested lands in the Puget Sound basin, and to a lesser extent, in rural residential areas. Historical logging removed most of the riparian trees near stream channels. Subsequent agricultural and urban conversion permanently altered riparian vegetation in the river valleys, leaving either no trees, or a thin band of trees. The riparian zones along many agricultural areas are now dominated by alder, invasive canary grass and blackberries, and provide substantially reduced stream shade and large wood recruitment (SSPS 2007).

Diking, agriculture, revetments, railroads, and roads in lower stream reaches have caused significant loss of secondary channels in major valley floodplains in the region. Confined main channels create high-energy peak flows that remove smaller substrate particles and large wood. The loss of side channels, oxbow lakes, and backwater habitats has resulted in a significant loss of juvenile salmonid rearing and refuge habitat. When the water level of Lake Washington was lowered 9’ in the 1910s, thousands of acres of wetlands along the shoreline of Lake Washington, Lake Sammamish and the Sammamish River corridor were drained and converted to agricultural and urban uses. Wetlands play an important role in hydrologic processes, as they store water which moderates high and low flows. The interchange of surface and groundwater in complex stream and wetland systems helps to moderate stream temperatures. Thousands of acres of lowland wetlands across the region have been drained and converted to agricultural and urban uses, and forest wetlands are estimated to have diminished by one-third in Washington State (FEMAT 1993; Spence et al. 1996; SSPS 2007). Loss of riparian habitat; elevated water temperatures; elevated levels of nitrogen, phosphorous, and other nutrients; and higher levels of suspended sediment, presumably from urban and highway runoff, wastewater treatment, failing septic systems, and agriculture or livestock impacts, have been documented in many Puget Sound tributaries (SSPS 2007). Peak stream flows have increased over time due to paving (roads and parking areas), reduced percolation through surface soils on residential and agricultural lands, simplified and extended drainage networks, loss of wetlands, and rain-on-snow events in higher elevation clear cuts (SSPS 2007). In urbanized Puget Sound, there is a strong association between land use and land cover attributes and rates of coho salmon spawner mortality likely due to runoff containing contaminants emitted from motor vehicles (Feist et al. 2011).

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

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

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

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

Climate Change

Climate is likely to play an increasingly important role in determining the abundance and distribution of PS Chinook salmon and PS steelhead and the conservation value of designated critical habitats throughout the Pacific Northwest region. The impacts of climate change are not predicted to be spatially homogeneous across the region, and major ecological realignments have already occurred in some areas (IPCC WGII, 2022). Updated projections of climate change are similar to or greater than previous projections (IPCC WGI, 2021). NMFS is increasingly confident in its own projections of changes to freshwater and marine systems, as every year brings stronger validation of previous predictions in both physical and biological realms. In light of ongoing climatic changes, 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 recent scientific literature (e.g., Siegel and Crozier 2020).

Climate change is systemic, influencing the natural processes that determine freshwater, estuarine, and marine conditions, as well as environments. Literature reviews on the impacts of climate change on Pacific salmon (Crozier 2015; Crozier 2016; Crozier 2017; Crozier and Siegel 2018; Siegel and Crozier 2019; Siegel and Crozier 2020) have collected hundreds of papers documenting major trends/themes relevant to salmon populations. Below, habitat changes and the concomitant impacts of these changes to Pacific salmon and steelhead are discussed

Forests: Forests dominate the landscape of many watersheds of the western U.S. Climate change is projected to impact forests throughout the entire region, and some impacts have already become apparent. Forests through the western U.S. have shown evidence of increased drought severity; increased forest fire frequency, magnitude and severity; and an increased occurrence of insect outbreaks due to the effects of climate-induced changes (Halofsky et al. 2020). These effects are projected to become more pronounced as climate change becomes more severe.

Additionally, climate change is projected to affect tree reproduction, growth, and phenology, which would lead to spatial shifts in vegetation. Halofsky et al. (2018) projected that the largest changes would occur at low- and high-elevation forests, with an expansion of low-elevation dry forests, and a contraction of high-elevation cold forests and subalpine habitats.

Holden et al. (2018) examined environmental factors contributing to observed increases in the extent of forest fires throughout the western U.S. Over the study period (1984-2015), they found that there was both a significant decline in the number of dry-season rainy days, as well as a strong correlation between the number of dry-season rainy days and the annual extent of forest fires. Consequently, predicted decreases in dry-season precipitation, combined with increases in air temperature, would likely contribute to the existing trend toward more extensive and severe forest fires and the continued expansion of fires into higher elevation and (previously) wetter forests under climate change (Alizedeh 2021). Forest fires affect salmon streams by altering sediment load, channel structure, and stream temperature through the removal of canopy cover and erosion from the loss of live vegetation.

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. They also suggest that due to complex interacting effects of disturbance and disease, climate impacts would differ by region and forest type.

Freshwater environments– A scientific literature review prepared by Siegel and Crozier (2019) evaluated the effects of climate change on salmon in the Pacific Northwest. In the review, they present a description of 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 [reduced-emission] and 8.5 [normal/high-emission] emission scenarios suggested an increase in water table heights in downstream areas of the basin and a decrease in upstream areas.*
>
> *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 would 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 would likely remain suitable for salmonids in the near future, with some becoming too warm.*

However, it should also be noted that in cases where habitat access is currently restricted by dams and other barriers, salmon and steelhead would be confined to downstream reaches typically most at risk of rising temperatures unless passage is restored (FitzGerald et al. 2020, Myers et al. 2018). Siegel and Crozier (2019) continue:

> *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.*

Regardless of a stream's refuge potential, 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). Thus, these processes may threaten some habitats that are currently considered refugia.]

Estuarine environments: A recent study projects the near complete loss of existing tidal wetlands along the U.S. West Coast, due to sea level rise (Thorne et al. 2018). California and Oregon had the greatest threat to tidal wetlands (100%), while 68% of tidal wetlands in Washington are expected to be submerged. Coastal development and steep topography prevent horizontal migration of most wetlands, causing the net contraction of this crucial habitat in the event of sea level rise.

Compounding the extensive loss of vital wetland habitat, rising ocean temperatures, temperature stratification, ocean acidity, hypoxia, algal toxins, and impacts to other oceanographic processes would alter the composition and abundance of a vast array of marine species. This would include dramatic changes in the abundance and composition of both predators and prey of Pacific salmon, with concomitant changes in 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. Furthermore, climate change is likely to affect the very base of marine trophic structures by reducing the availability of biologically essential omega-3 fatty acids produced by phytoplankton (Thompson et al. 1992; Renaud et al. 2002; Guschina and Harwood 2006). Loss of these lipids may induce cascading trophic effects to marine ecosystems, 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 add complexity to predictions of climate change impacts in marine ecosystems.

Perhaps the most dramatic change in physical ocean conditions would occur through ocean acidification and deoxygenation. It is unclear how sensitive salmon and steelhead might be to the direct effects of ocean acidification, due to their ability to tolerate a wide pH range in freshwater; however, impacts of ocean acidification and hypoxia on sensitive species (e.g., plankton, crabs, rockfish, groundfish) will likely affect salmon indirectly through trophic interactions as predators and prey. Similarly, increased frequency and duration of harmful algal blooms may affect salmon directly via the toxins certain algae species produce (e.g., saxitoxin and domoic acid), as well as indirectly by affecting salmonid predators and prey. The full effects of these ecosystem dynamics are complex and not known.

Within the historical range of climate variability, less suitable conditions for salmonids (e.g., warmer temperatures and lower stream flows) have been associated with detectable declines in many of the listed salmon and steelhead ESUs and DPSs, respectively, highlighting how sensitive they are to climate effects (Lindley et al. 2009; Ward et al. 2015; Williams et al. 2019; Ford et al. 2022). In some cases, the combined, and potentially additive effects, of poorer climate conditions and intense anthropogenic impacts are what initially caused the population declines that led to these population groups to being listed under the ESA (Crozier et al. 2019).

Direct Effects on Salmon and Steelhead: In freshwater, year-round increases in stream temperature and changes in the stream flow regime would affect physiological, behavioral, and demographic processes in salmon and steelhead, as well as the species on which they consume or otherwise depend, with which they compete, and for which they are prey. For example, as stream temperatures increase, many native salmonids face increased competition with, and/or predation from warm-water tolerant invasive species (Sanderson et al. 2009; Rubinson and Olden 2022).

Changing freshwater temperatures are also likely to affect the incubation and emergence timing of salmonid eggs, and in locations where the greatest warming occurs, may reduce egg survival, (Crozier et al. 2021). Changes in temperature and flow regimes may alter the amount of habitat and food available to rearing juveniles, which could, in turn, restrict the distribution of juveniles. As a result, the productivity of a stream/watershed may be reduced overall. Climate-induced changes in freshwater flows and increased temperatures would also affect salmon and steelhead adults during migrating and holding. These changes could alter migration timing and travel duration, and increase thermal stress accumulation for ESUs or DPSs with early-returning (i.e. spring- and summer-run) phenotypes, which have longer freshwater holding times (FitzGerald et al. 2020; Crozier et al. 2021). Rising river temperatures increase the energetic cost of migration and the risk of pre-spawning mortality of adults with long freshwater migrations, although populations of some ESA-listed salmon and steelhead may be able to utilize 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, their physical condition, and carryover effects from the freshwater life stages (Holsman et al. 2012, Burke et al. 2013). It is generally accepted that the probability of marine survival in salmonids is size-dependent, with larger and faster growing fish more likely to survive (Gosselin et al. 2021). Furthermore, early arrival timing in the marine environment is generally considered advantageous for certain populations, such as those that migrate through the Columbia River. However, the optimal day of arrival varies across years, and depends on seasonal variations in the pattern of productivity in the California Current, which affects prey availably and the risk of predation for salmon (Chasco et al. 2021). Siegel and Crozier (2019) point out the concern that for some salmon populations, climate change may drive mismatches between the timing of juvenile arrival and prey availability in the marine environment; however, phenological diversity may 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 salmon migrated over a period of more than 50 days, and populations from higher elevation and further inland streams arrived in the estuary later. As a result of the different arrival times, different populations encountered distinct prey fields. Carr-Harris et al. (2018) recommend 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). Combined with simplified habitats and reduced genetic diversity, a more synchronized climate may, in turn, be leading to more synchrony in the productivity of populations across the entire range of salmon (Braun et al. 2016). For example, salmon productivity (recruits per spawner) has also become more synchronized across Chinook salmon populations from Oregon to the Yukon (Dorner et al. 2018, Kilduff et al. 2014). Chinook salmon have also become smaller and younger at maturation across their range (Ohlberger et al. 2018). Other Pacific salmon species (Stachura el al. 2014) and Atlantic salmon (*Salmo salar*; Olmos et al. 2020) have also 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 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). For instance, changes in winter precipitation patterns would likely affect the incubation and/or rearing stages of most salmonid populations. Changes in the intensity of cool season precipitation, snow accumulation, and runoff could also influence migration cues for fall-, winter-, and spring-run adults. Egg survival rates may be reduced by more intense stream flows in spring, caused by the earlier and more rapid onset of snowmelt due to warming temperatures. These more intense flows could bury redds, or wash them away along with the rest of the streambed substrate (McNeil 1964; Tschaplinski and Hartman 1983; Karl et al. 2009). As described above, this is already impacting the action area (Beamer and Pess 1999).

At the population level, the ability of organisms to genetically adapt to climate change depends on how much genetic variation currently exists within those populations, as well as the interactions among selected traits, and whether those traits are genetically linked (genotype versus phenotype). While genetic diversity may help populations respond to climate change, the remaining genetic diversity of many salmonid 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. The degree of genetic losses in this comparison appeared to show regional variation, with greater losses for Chinook salmon from the mid-Columbia than those from the Snake River Basin. Modified habitats and flow regimes may also create unnatural selection pressures that reduce the diversity of functional behaviors (Sturrock et al. 2020).

Thus, managing to conserve and augment existing genetic diversity may be increasingly important with more extreme environmental change, although the low levels of remaining diversity present challenges to this effort (Anderson et al. 2015). Salmon historically maintained relatively consistent returns across variation in annual weather through the "portfolio effect," in which different populations are sensitive to different climate drivers (Schindler et al. 2015). Applying this concept to climate change, Anderson et al. (2015) emphasized the additional need for a range or "portfolio" of populations with different physiological tolerances. Loss of diversity in the portfolio increases volatility in fisheries, as well as ecological systems. This was demonstrated in Fraser River and Sacramento River stock complexes, where reductions in habitat and salmonid life history portfolios induced by climate change and other anthropogenic factors resulted in declines in productivity of the respective stocks (Healey 2011; Munsch et al. 2022).

Critical Habitat within the Action Area

Critical habitat has been designated for PS Chinook salmon along the entire length of the Lake Washington Ship Canal, Lake Union, Portage Bay, all of Lake Washington, about 1,000 yards upstream into in the Sammamish River, and well upstream into the Cedar River Watershed. The critical habitat in Portage Bay provides the Freshwater Migration PBF for PS Chinook salmon (NMFS 2024).

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). Thus, in accordance with this definition, the action area for the present action was determined to be a product of: 1) the footprint of the combined project sites; and 2) the farthest extend of expected direct or indirect effects stemming from project activities at those sites.

The project sites are located on adjacent properties along the south shore of Lake Union, WA. Both Chandler's Cover Marina and HC Henry Pier have structures located on privately owned land, as well as parcels owned by the city of Seattle. The size of the land parcels on which project activities would occur were used to determine the general footprint of each project site. Parcel size was determined using the King County iMap tool (King county 2024; https://gismaps.kingcounty.gov/iMap/). The total footprint of the HC Henry Pier site is 175,829

ft^2 [~4.04 acres (ac)], and the total footprint of the Chandler's Cover Marina site is 222,048 ft^2 (~5.1 ac), giving a combined total of 397,877 ft^2 (~9.13 ac; value differs from sum of individual acreage values given due to rounding). This should be considered an approximate value and not an exact calculation of project footprint size; the land parcel sizes given in the King County iMap tool are not exact. Furthermore, some of the parcels contain upland areas, such as parking lots, which may not be directly involved in project activities.

The farthest-reaching effects of the action are expected to be to water quality from the leaching of polycyclic aromatic hydrocarbons (PAHs) from the cutting and removal of creosote treated piles during the stubbing process. Project activities may also disturb sediments previously contaminated with PAHs. While it is not possible to determine the exact distance PAHs may travel due to project activities, it is expected that they be transported up to 300' away from the project site once introduced/reintroduced into the water column. This is based on the findings of on the finding of previous NMFS consultations for similar actions (e.g., NMFS 2021).

Thus, the action area includes footprint of the combined project sites, which is roughly 397,877 ft^2 (~9.13 ac), plus any area of the Lake within 300' of that footprint (approximately 945,987 ft^2, 21.7 ac total area).

2.4. Environmental Baseline

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

The project site is located in Seattle, Washington, on the southern shoreline of Lake Union. Lake Union covers an area of approximately 581 ac and has an average depth of approximately 32'. Although the action area includes the marine waters of Puget Sound, all detectable effects of the action would be limited to Lake Union within 300' of the footprint of the combined project sites (Sections 2.5 & 2.12). Therefore, this section focuses on habitat conditions in Lake Union and the Lake Washington Ship Canal, and does not discuss Puget Sound habitat conditions.

The geography and ecosystems in Lake Union and its (now) connected waterbodies have been dramatically altered by human activity. Historically, a small stream flowed from Lake Union to Shilshole Bay, with no surface water connection between Lake Union and Lake Washington. The waters of Lake Washington flowed south to the Duwamish River via the now absent Black River. Lake Union is believed to have historically formed a separate drainage basin (Kerwin 2001). A narrow canal used as a log chute was excavated in the 1880s, connecting Lake Union and Lake Washington. Intense dredging and excavation continued, with the objective providing a navigable passage between Lake Washington and the marine waters of Shilshole Bay. The resulting canal, the Ship Canal, was completed in 1916, and resulted in a connection between Lake Washington, Lake Union, and Puget Sound where none had existed previously. As part of the project, the Ballard Locks were constructed west of Salmon Bay to maintain navigable water levels in the canal and lakes. This permanently converted Salmon Bay from an estuary to freshwater.

The Ship Canal is 8.6 miles long, approximately 150 – 260’ wide in the cuts, widening at Portage Bay, Lake Union, and Salmon Bay. Waterflow through the ship Canal is highly controlled by the Locks, and is typically very slow. The Canal supports high levels of commercial and recreational vessel traffic. The shoreline along the banks of Lake Union and the Ship Canal has been heavily modified, with very little natural shoreline remaining. Instead of slopes that gently rise to the surface, as would typically occur along unmodified banks of natural streams, the bank slope along most of the Ship Canal is vertical. In cross-section, the Ship Canal closely resembles an elongated box culvert along most of its length, and about 96% of the Canal’s banks are armored (City of Seattle 2008). The depths along the edges are typically between 10’ and 20’, and the average depth in the navigational channel is about 30’.

The vast majority of the Ship Canal and Lake Union shoreline is lined by shipyards, industrial properties, large marinas, and residential piers. Unbroken urban development extends north and south immediately landward of both shorelines of the Canal. With the exception of scattered fragments along the southern shoreline of Portage Bay, portions of Gas Works Park, and small enclaves along the south shore of Lake Union, very little natural shoreline or riparian vegetation exists along the canal and lake banks. Less than 5% of the shoreline along the Ship Canal and Lake Union shoreline has natural vegetation, with most of the shoreline having been armored or modified with dock or pier construction (in Kerwin et al. 2001). Relatively little shallow water habitat remains along the shoreline for salmonid juvenile rearing and holding.

Water quality Lake Union and the other waterbodies of the Ship Canal is influenced by the inflow of freshwater from Lake Washington from the east, a saltwater wedge that intrudes through the Ballard Locks from the west, by point and non-point discharges all along the waterway, and by elevated water temperatures (Kerwin 2001). Industrial, commercial, and residential development has impacted water quality in the Lake Union since before construction of the Ship Canal was completed. Lumber and plywood mills, machine shops, metal foundries, fuel and oil facilities, concrete and asphalt companies, power plants, shipyards, marinas, commercial docks, and houseboats were quickly developed along the shoreline of the Ship Canal and its connected water bodies. Virtually all of the early industrial, commercial, and residential facilities discharged untreated wastes directly into the lakes and Ship Canal, some of which persisted into the 1940s and beyond. As a result, there are multiple contaminated sites along the Canal, and most of the north shore of Lake Union, from Gasworks Park to Salmon Bay, has been contaminated (Kerwin 2001). Stormwater drainage has, and continues to add to pollutant loading. Most of the direct discharge of raw sewage was stopped and the gas plant ceased operation during the 1960s, but high levels of pollution persist: “Chemical concentrations of the Lake Union – Salmon Bay sediments are as high as any found in Washington State,” (Kerwin 2001).

When the Ballard Locks are opened for eastbound shipping traffic, saltwater is able to enter the Lake Washington Ship Canal. The extent of saltwater incursion into the Canal is influenced by outflow at the Locks and the intensity of shipping traffic. In summer months when shipping traffics is greatest, the expulsion of saltwater from the Canal system cannot keep pace with the inflow of saltwater, and a saltwater "wedge" enters Lake Union, and may even extend past the Lake during low-flow periods (Kerwin 2001). Due to this saltwater incursion, there is a layer of saline water along the bottom of Lake Union in the summer months (July – September in Kerwin et al. 2001).

Elevated water temperatures have also been a persistent issue in Lake Union and the canal system. Since 1979, water temperatures in the Canal have increased an average of 1° Celsius (C) per decade (City of Seattle 2010). Even in cool years, temperatures reach 20 to 22° C during the summer and early fall, sometimes as early as mid-June, and the number of days that temperatures are in that range is increasing (in Kerwin 2001; City of Seattle 2010). These elevated temperatures exist throughout the canal system, and have been found to impede salmon migration. Fresh et al. (1999) observed that the return migration of adult Chinook salmon through Ballard Locks was delayed until water temperatures dropped below 22° C. When temperatures, are high enough, 23 – 25° C, conditions can be lethal to salmon and steelhead (Coutant 1970).

Furthermore, as described in Kerwin (2001) elevated water temperatures combined with the wedge of high-density saltwater from the locks often creates anoxic conditions early in the summer that may last into October. As bacteria consume organics in the sediment, they remove dissolved oxygen (DO) from the water through metabolic processes. DO concentrations range from 9.5 to 12.6 milligrams per liter (mg/L) during the winter and spring, but can decrease to as low as 1 mg/L during the summer months. The presence of a denser saline layer of water along the bottom of the Lake and canal system leads to stratification of the water column, and prevents mixing of the upper and lower layers. As a result, oxygenated upper layers in the water column are prevented from mixing with the lower anoxic layers, and the water column below 10 meters is rendered inaccessible to salmonids due to the anoxic conditions. The anoxic conditions in Lake Union are reflected in the composition of its benthic invertebrate community, which during the summer months is characteristic of those found in eutrophic and oligotrophic lakes (in Kerwin 2001).

As described above, waters of Lake Union and the canal system, including the project site, are identified on the current WDOE 303(d) list of threatened and impaired water bodies (Category 5) for lead and elevated temperature (WDOE 2024). Sediment in the area immediately adjacent to the project site has been listed as polluted (Category 4B) for arsenic, cadmium, chromium, copper, lead, mercury, various types of PAHs, PCBs, silver, and zinc. The State identifies no specific sediment contamination at the project site, but some level of sediment contamination is likely to exist.

In addition to causing a loss of suitable habitat for salmonids, the artificial shorelines and widespread presence of overwater structures along the length of the canal system and most of Lake Union provide habitat conditions that favor fish species which prey on juvenile salmonids, such as non-native large- and smallmouth bass and native northern pikeminnow (Celedonia et al.

2008a, 2008b; Tabor et al. 2004, 2010). Tabor et al. (2004) estimated that about 3,400 smallmouth bass and 2,500 largemouth bass large enough to consume salmon smolt were in the Ship Canal. They also estimated that smallmouth bass consumed about 48,000 salmon smolts annually, while largemouth bass consumed about 4,200 smolts. Of the smolts consumed, over half were Chinook salmon. Predation appeared to be highest near Portage Bay in June, when smolts made up approximately 50% of the diet for smallmouth bass, and about 45% for northern pikeminnow. Returning adult salmon and steelhead are often exposed to excessive predation by pinniped marine mammals (seals and sea lions) that feed on the fish that accumulate downstream of the fish ladder at Ballard Locks.

The projected effects of climate change are discussed above; however, climate change has already affected the environmental baseline of aquatic habitats across the Pacific Northwest region. Global surface temperatures in the last decade (2010s) were estimated to be 1.09° C higher than the 1850-1900 baseline period (IPCC WGI 2021). Temperature increases were greater over land, ~1.6 °C, compared to oceans ~0.88 °C. The vast majority of this warming has been attributed to anthropogenic releases of greenhouse gases (IPCC WGI 2021). These findings are supported by global weather data; globally, 2014 through 2018 were the five warmest years on record, both on land and in the ocean (NOAA NCEI 2022). Increased air temperatures have been identified as the primary factor associated with increased water temperatures in the Lake Washington Ship Canal system (in Kerwin 2001). Thus, it seems likely that global climate change has already had an effect on water temperatures in Lake Union and the rest of the system, and that these effects will continue into the foreseeable future.

Lake Union and the rest of the canal system has been heavily modified and highly degraded from over a century of anthropogenic impacts. As the numbers presented in Section 2.2 show, this has had dire consequences for the native Chinook salmon and steelhead populations in the Lake Washington Subbasin. Chinook salmon populations have dropped precipitously compared to their historical abundance and remain at very low numbers, and steelhead have been functionally extirpated.

2.5. Effects of the Action

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

Under the proposed action, USACE would authorize the applicant to perform repairs to two adjacent boating dock complexes, Chandler’s Cove Marina and HC Henry Pier on the south shore of Lake Union, WA.

Repairs at Chandlers Cove Marina would include:

- Stubbing of 57 piles
- Replacement of 2,143 ft^2 of solid wooden decking with grated fiberglass decking
- Replacement of two (2) floating finger docks
- Replacement/repair of an unspecified number of dock stingers and other structural components

Repairs at HC Henry Pier would include:

- Stubbing of 35 piles
- Replacement of hardware on 49 fender piles
- Replacement of 3,615 ft^2 of solid wooden decking with grated fiberglass decking
- Replacement of three (2) finger docks
- Replacement/repair of an unspecified number of dock stingers and other structural components on one (1) dock (G-dock)

The proposed repairs would cause direct effects to ESA-listed fish that are present at the site while work is being performed, as well as habitat resources for ESA-listed fish, through exposure to: 1) construction-related noise; 2) construction-related water and forage contamination; 3) construction-related turbidity; and 4) construction-related propeller wash. The proposed action would also cause indirect effects to ESA-listed fish and habitat resources through construction-related forage contamination. Additionally, USACE's authorization of the repairs would cause prolonged effects by extending the operational life of the applicant's marina/dock facilities by several decades beyond that of the existing structures. Over that time, the structure's presence and normal operations would cause indirect effects to ESA-fish and habitat resources through: 1) structure-related noise; 2) structure-related chemical contamination of water and forage; 3) structure-related turbidity; 4) structure-related propeller wash and vessel use; and 5) structure-related shade and lighting effects.

The work window for both projects would be from October 1 to April 15. This avoids the normal migration season for returning adult PS Chinook salmon, but work performed between December 31 and April 15 overlaps with the early part of emigration season for juvenile Chinook salmon, which begin to enter Lake Washington in January. Thus, while adult PS Chinook salmon are extremely unlikely to present while the repairs are ongoing, low numbers of juveniles could be present. The work window also overlaps slightly with the normal migration seasons for both juvenile and adult PS steelhead. However, as described in Section 2.2, PS steelhead have become very rare in the Lake Washington Subbasin. Thus, it is expected that it would be very unlikely that any PS steelhead would be within the action area while the proposed repairs are being performed.

While it is extremely unlikely that adult PS Chinook salmon or any life stage of PS steelhead would be exposed to the direct effects of the proposed action, juvenile Chinook salmon may be exposed to the direct effects of construction. Furthermore, juveniles of both species that pass through the action area during their annual out-migration seasons are likely to be exposed to the action's indirect effects from the prolonged existence of the marina/dock structures and continuation of their associated operations. The PBFs of PS Chinook salmon critical habitat would also be exposed to the action's direct and indirect effects.

2.5.1 Effects on ESA-Listed Species

Direct Effects

Direct effects of the action are those that would be caused by the proposed repairs/construction and supporting activities. The direct effects of the action include: 1) construction-related noise; 2) construction-related chemical contamination of water and forage; 3) construction-related turbidity; and 4) construction-related propeller wash.

Construction-related Noise

General Description of Sound Metrics and Effects on Fish: The effects of noise exposure on fish vary, and depend on: 1) the hearing characteristics of the fish, which depends on the fish species; 2), the sound frequency, intensity, and duration of the sound exposure; and 3) the context under which the exposure occurs. At low levels, effects may include the onset of behavioral disturbances such as acoustic masking (Codarin et al. 2009), startle responses and altered swimming (Neo et al. 2014), abandonment or avoidance of the area of acoustic effect (Mueller 1980; Picciulin et al. 2010; Sebastianutto et al. 2011; Xie et al. 2008), and/or increased vulnerability to predators (Simpson et al. 2016). As the intensity and/or duration of sound exposure increases, the severity of effects may increase to include temporary hearing damage (a.k.a. temporary threshold shift or TTS; Scholik and Yan 2002) and physical stress (Graham and Cooke 2008). At even higher noise levels, exposure may lead to physical injury that can range from permanent hearing damage (a.k.a. permanent threshold shift or PTS), damage to internal organs, or mortality if the sound exposure is severe enough (Popper et al. 2019; Caltrans 2020). The best available information regarding the auditory capabilities of fish suggest that their hearing capabilities are limited to frequencies below 1,500 Hz, with peak sensitivity between about 200 and 300 Hz (Hastings and Popper 2005; Picciulin et al. 2010; Scholik and Yan 2002; Xie et al. 2008;).

Sounds themselves can be divided into two broad categories, impulsive and non-impulsive sounds. As described in *National Marine Fisheries Service: Summary of Endangered Species Act Acoustic Thresholds (Marine Mammals, Fishes, and Sea Turtles)* (NMFS 2023), impulsive sounds are, "typically transient, brief (less than one second), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay," and, "can occur in repetition or as a single event." Non-impulsive sounds, "can be continuous or intermittent… can be broadband, narrowband or tonal, and brief or prolonged," and, "do not have the high peak sound pressure with rapid rise time typical of impulsive sounds." In the present case, project activities are expected to result in non-impulsive sounds only.

A soundwave is comprised of a series of individual high- and low-pressure fluctuations above and below the background hydrostatic pressure, that is, what the hydrostatic pressure at a particular site would be in the absence of the sound. As described in Popper et al. (2019), "sounds are most commonly measured and expressed as the pressure fluctuations in the medium above and below the local hydrostatic pressure. The sound pressure is the contribution to total pressure caused by the action of sound." There are several different metrics that may be used to describe the energy of soundwave, but for the purposes of the present opinion, decibels (DB) are used as the basic unit of measurement.

Decibels (or other basic measurement units) may be used to express different aspects of a soundwave. This is necessary because different aspects of a soundwave, i.e., different quantifications of sound energy, are used to measure different ways in which sound affects fish. In the present opinion, two measurements are used. The first is the instantaneous peak level of a sound impulse (dB_{peak}), which is used to determine the risk of immediate onset of death or injury to fish. Going back to the description of a soundwave, dB_{peak} is the largest instantaneous value of the maximum high or low pressure (peak) during a sound impulse above or below the background hydrostatic pressure (zero). Popper et al. (2019) describe dB_{peak} as, "the zero-to-peak sound pressure level is the largest absolute value of the instantaneous maximum over-pressure or under-pressure observed during the pulse."

The other measurement used in this opinion is the sound exposure level (SEL; dB_{SEL}), which is a measurement of the total energy of a sound impulse. As described in Popper et al. (2019), "SEL is the integral over time of the squared sound pressure." Using dB_{SEL}, the cumulative energy from multiple sound impulses (SEL_{cum}) can be estimated based upon the energy from the individual impulses (SEL_{ss}). Cumulative sound energy is used to measure the total amount of acoustic energy delivered to fish or other organisms over a series of sound impulses. Popper et al. (2019) state, "SEL_{cum} is the total noise energy to which the animal is exposed over a defined time period." The principle of cumulative SEL is based on the "equal energy hypothesis," which predicts that the effects of cumulative energy on fish are identical, regardless of how the given level of cumulative energy is reached (Buehler et al. 2024).

Sound waves emanate from their source in a circular pattern, although the actual pattern of spreading by site conditions such as rocks, submerged structures, and bottom topography. The distance the sound waves travel is affected by water temperature and salinity (which affect density), and/or benthic contours and composition, in addition to the intensity of the sound itself. The distance within which fish and other organisms will be affected by acoustic exposure can be thought of as a radius originating from the sound source and extending outward – described as the radius of effect. NMFS uses different sound thresholds to estimate the effects of acoustic exposure to fish, which have different radii of effect for a given sound source. The sound thresholds and how their radii of effect are calculated are described directly below.

Sound Thresholds and Calculations Used for NMFS Analysis: NMFS presently uses two metrics/thresholds to estimate the onset of injury to fish exposed to high intensity impulsive sounds (FHWG 2008; Stadler and Woodbury 2009; NMFS 2023). These thresholds and their associated calculations are as follows:

1. **206dB_{peak}** – The threshold of immediate onset of death or injury to fish, regardless of fish size or sound duration is 206 dB_{peak}. For the radius of effect to be determined, two steps must often be completed. First, the anticipated dB_{peak} of a particular sound source/activity is often based on reference measurements. Because many reference sound measurements

are taken at a certain distance away from the source of the sound itself, it is necessary to back calculate what the sound levels at a source are likely to be (sound levels at 1m are treated as “source” sound levels). This is accomplished using the practical spreading loss equation:

$$RL = SL - F \times \text{Log}(R)$$

Where:

RL = the received sound level, that is, the given reference sound measurement
SL = the source sound level (the sound level at a distance of 1m)
F = the attenuation factor, also referred to as the spreading loss coefficient. The attenuation factor is a measure of how quickly sound attenuates (drops) with distance. The attenuation factor is highly dependent on site-specific conditions, but typically ranges between 10 and 20. Where a site-specific attenuation factor is unavailable (which is typically the case), NMFS uses a default value of 15.
R = the range at which the reference measurement (RL) was taken

To solve for the source level of sound (SL). The equation is rearranged to:

$$SL = RL + F \times \text{Log}(R)$$

Once the source level of sound has been determined, if SL < 206 dB_{peak}, no further calculation is required, as the maximum sound impulse does not reach the threshold of immediate onset death or injury to fish. However, if SL > 206 dB_{peak}, it is necessary to calculate the distance required for the sound impulse to drop below the 206 dB_{peak} threshold. This is done using the practical spreading loss equation shown above, but instead of solving for SL, the equation is used to find R, the distance required for the source sound level, SL, to drop to the reference sound level, RL, which in this case the known value of 206 $\text{dB}_{\text{peak.}}$ To accomplish this, the formula is rearranged to:

$$R = 10^{((SL - RL) / 15)}$$

Where:

RL = the received sound level, which in this case is the threshold of immediate onset of death or injury for fish, 206 dB_{peak}
SL = the source sound level, previously calculated as described above
F = the attenuation factor; F = 15 when the site-specific value is unavailable
R = the range at which the source sound level (SL) drops to the received sound level (RL), which is 206 dB_{peak} in this application

Thus, the formula can be written as:

$$R = 10^{((SL - 206) / F)}$$

2. **183 dB $\mathrm{SEL}_{\mathrm{cum}}$** and **187 dB $\mathrm{SEL}_{\mathrm{cum}}$** – As described above, the cumulative energy from multiple sound impulses ($\mathrm{SEL}_{\mathrm{cum}}$) is a measure of the total amount of energy delivered to a fish, or other organisms, and is a product of both the sound level form individual sound impulses ($\mathrm{SEL}_{\mathrm{ss}}$) as well as the total number of impulses. The threshold of injury from accumulated sound to fish less than two grams (<2g) is 183 dB $\mathrm{SEL}_{\mathrm{cum}}$. The threshold of injury from accumulated sound for fish 2 grams or greater (≥2g) is 187 dB $\mathrm{SEL}_{\mathrm{cum}}$.

   As described above, the principle of cumulative SEL is based on the "equal energy hypothesis." Under NMFS guidelines, this is believed to apply only when the energy from individual sound impulses ($\mathrm{SEL}_{\mathrm{ss}}$) is greater than 150 dB. That is, any individual sound impulse with a $\mathrm{SEL}_{\mathrm{ss}}$ <150 dB does not count towards $\mathrm{SEL}_{\mathrm{cum}}$. Any sound level below 150 dB $\mathrm{SEL}_{\mathrm{ss}}$ is considered "effective quiet." Effective quiet establishes a definitive limit on the distance from a sound source at which injury to fish may occur. If the range to effective quiet is less than the range at which $\mathrm{SEL}_{\mathrm{cum}}$ reaches 183 dB and 187 dB, for fish <2g and ≥2g, respectively, then the range to effective quiet is used to determine the maximum distance (radius if effect) of injury from accumulated sound energy. Conversely, if the range at which $\mathrm{SEL}_{\mathrm{cum}}$ reaches 187 dB and/or 183 dB is less than the range to effective quiet, then that range will be used as the maximum radius of effect. That is, in a given situation whichever distance is lesser – the range to effective quiet versus the range to 183 dB and/or 187 dB $\mathrm{SEL}_{\mathrm{cum}}$ – is considered to be the maximum radius of effect for injury to fish from accumulated sound energy.

   The threshold of injury from accumulated sound is calculated in four steps. First, if a reference sound measurement is being used to determine $\mathrm{SEL}_{\mathrm{ss}}$, as with $\mathrm{dB}_{\mathrm{peak}}$, $\mathrm{SEL}_{\mathrm{ss}}$ at the source of the sound must be back calculated from the reference $\mathrm{SEL}_{\mathrm{ss}}$ measurement (unless the reference measurement was taken at the source, in which case this step can be skipped). This is done using the same practical spreading loss equation as above, except $\mathrm{SEL}_{\mathrm{ss}}$ is substituted for $\mathrm{dB}_{\mathrm{peak}}$:

$$\mathrm{SL} = \mathrm{RL} + \mathrm{F} \times \mathrm{Log}(\mathrm{R})$$

   Where:

   RL = the received $\mathrm{SEL}_{\mathrm{ss}}$ measurement, that is, the given reference $\mathrm{SEL}_{\mathrm{ss}}$ measurement
   SL = the $\mathrm{SEL}_{\mathrm{ss}}$ at the source of the sound
   F = the attenuation factor, which will be the same as that used for $\mathrm{dB}_{\mathrm{peak}}$; F = 15 when the site-specific attenuation factor value is unavailable
   R = the range at which the reference $\mathrm{SEL}_{\mathrm{ss}}$ measurement (RL) was taken

   Second, once $\mathrm{SEL}_{\mathrm{ss}}$ at the source of the sound has been determined, it is necessary to calculate $\mathrm{SEL}_{\mathrm{cum}}$ at the source. As described above, $\mathrm{SEL}_{\mathrm{cum}}$ is a product of both the sound level from individual sound impulses ($\mathrm{SEL}_{\mathrm{ss}}$), as well as the total number of impulses. This requires an estimate of the number of total sound impulses, labeled as "SI," which stands for "sound impulses." $\mathrm{SEL}_{\mathrm{cum}}$ is derived from $\mathrm{SEL}_{\mathrm{ss}}$ with the equation:

$$\mathrm{SEL}_{\mathrm{cum}} = \mathrm{SEL}_{\mathrm{ss}} + 10 \times \mathrm{Log}(\mathrm{SI})$$

Where:

SI = the maximum number of sound impulses expected in a single day (It should be noted that "SI" is not used in the literature, and is only used in the present opinion as an efficient way to denote individual sound impulses in the formula.)

Third, once SEL_{cum} has been calculated, it is necessary to calculate the distance required for the sound to drop below 183 and 187 dB. This is done using the same practical spreading formula as rearranged to calculate the distance required for sound to drop below 206 dB_{peak}, except the corresponding SEL_{cum} values are plugged in for SL and RL:

$$R = 10^{((SL - RL) / F)}$$

Where:

SL = the source SEL_{cum}, previously calculated as described above
RL = the received sound level, which in this case is the threshold of injury to fish from accumulated sound: 183dB for fish <2g, and 187 for fish ≥2g
F = the attenuation factor, which will be the same as for dB_{peak}; F = 15 when a site-specific attenuation factor is unavailable
R = the range at which the source sound level (SL) drops to the received sound level (RL), which in this application is 183 and 187dB

Since the RL values are known – 183 and 187 dB – two separate distances will be calculated for each sound level with formulas written as:

$$R = 10^{((SL - 183) / 15)} \text{ and } R = 10^{((SL - 187) / 15)}$$

Fourth, the final step is to calculate the distance to effective quiet (150dB SEL_{ss}) so that it can be compared with the distances to 183 and 187 dB SEL_{cum} to determine which distance(s) is/are shorter. The distance to effective quiet is calculated using the same formula as directly above, excepted the SEL_{ss} value is plugged in for SL and the effective quiet threshold, 150 dB SEL_{ss}, is plugged in for RL:

$$R = 10^{((SL - 150) / 15)}$$

Once the distance to effective quiet has been calculated, it can be compared to the distances to 183dB SEL_{cum} and 187dB SEL_{cum}, and the shorter distance from each comparison can be used as the maximum radius of injury from accumulated sound for fish <2g and ≥2g, respectively.

The discussion in Stadler and Woodbury (2009) indicates that these thresholds likely overestimate the potential effects of exposure to impulsive sounds. Further, Stadler and Woodbury's assessment, as well as the guidelines in NMFS (2023) do not consider non-impulsive sound, which is believed to be less injurious to fish than impulsive sound. Therefore, application of the impulsive sound criteria to non-impulsive sounds is also likely to overestimate the potential effects to fish; however, these criteria represent the best available information/methods of assessing effects to fish from non-impulsive sounds. Therefore, this opinion applies these criteria to the non-impulsive sounds expected to result from the proposed action to determine the potential effects that fish may experience due to exposure to project-related sounds.

Construction-related Noise Effects: The construction-related activities that are expected to cause the highest intensity in-water sound levels are: 1) operation of a pneumatic underwater chainsaw, which will be used for pile stubbing; and 2) operation of a tugboat for positioning the crane barge.

The sounds generated by an underwater chainsaw are non-impulsive. Section 7.0, Construction Noise Impact Assessment of the Washington Department of Transportation (WSDOT) *Biological Assessment Preparation Manual* (WSDOT 2020) lists an underwater chainsaw as having a dB_{peak} of 159, a SEL_{ss} of 140 dB, and a SEL_{cum} of 152 dB (after running for a given amount of time). These values are well below the 206dB_{peak} threshold of immediate onset of death or injury to fish as below the 150 dB_{ss} that would result in injury from accumulated sound. Project-related underwater chainsaw operations are therefore not expected to result in injury to PS Chinook salmon or PS steelhead.

As with the underwater chainsaw, the sounds generated by boat engines are non-impulsive. Numerous sources describe sound levels for ocean-going ships, tugboats, and recreational vessels (Richardson et al. 1995; Blackwell and Greene 2006; Picciulin et al. 2010; McKenna et al. 2012; Reine et al. 2014). The best available information about the source sound levels from tugboats and other vessels close to the size to those that would operate at the marina/docks is synthesized in the acoustic assessment done for a similar project (Table 11; NMFS 2018). The data presented in the acoustic assessment show that the source level sound of a tugboat is 185 dB_{peak} and 170 dB_{SEL}. The peak sound level is below the threshold of immediate onset of death or injury to fish, and therefore it is not necessary (or possible) to calculate the radius of effect; there is no radius of effect because the 206 dB_{peak} threshold is not exceeded at any distance, including at the sound source. However, because 170 dB_{SEL} is above effective quiet, a radius of effect would be present for injury from accumulated acoustic energy.

Table 11. Estimates of in-water sounds levels generated by different vessel types/sizes; values taken from NMFS 2018; vessel size given in feet (ft), engine size described in horsepower (HP), vessel power output described in knots (kts) and engine rotations per minute (RPM)

Vessel Type/Size (ft)	Engine	Speed / RPM	dB_{peak}	dB_{SEL}	dB_{RMS}
Fiberglass hull, 16’	Outboard, 40 HP	15 kts, “maximum”	172	162	162
Rigid-hulled inflatable boat (RHIB), 18’	Outboard, 4-cycle, 80 HP	“Full speed”	166	156	156
Fiberglass hull, 21’	Outboard, 2-cycle, 250 HP	“Full speed”	165	155	155
Aluminum hull, 23’	Dual outboards, 4-cycle, 100 HP	4,000 RPM, “~3/4 speed”	175	165	165
“Cabin-cruiser”, 28’	Inboard diesel, 163 HP	“Maximum”	163	153	153
Oceangoing Tugboat	Inboard diesel	Unspecified, while towing loaded barge	185	170	170
Tourist ferry, 85’	Inboard diesel	6 kts, “maximum”	187	177	177

As described above, the calculation of SEL_{cum} requires an estimate of the number of individual sound impulses. This makes the calculation better suited for activities that generate impulsive sound, such as pile driving, where it is possible to estimate a defined number of individual sound impulses that will be generated in a given amount of time. Conversely, this calculation is not well suited to non-impulsive sounds, which have a different profile (peak/rise) than impulsive sounds, and which may vary substantially in duration. Therefore, to calculate the radius of effects, the practical spreading loss equation was used to calculate the distance at which the SEL the source of the sound, 170 dB_{SEL}, drops below effective quiet, 150 dB_{SEL}:

$$R = 10^{((SL - RL) / F)}$$

Where:

SL = the source SEL_{ss}, given in NMFS 2018 = 170 dB_{SEL}
RL = effective quiet = 150 dB SEL_{ss}
F = the attenuation factor =15 (site-specific value not available)
R = the range at which the source sound level (SL) drops to effective quiet (RL)

Therefore:

$$R = 10^{((170 - 150) / 15)} = 21.54\text{m} = \sim 22\text{m}$$

Based on the calculation shown above, the radius around the tugboat within which fish may be susceptible to injury from accumulated sound is approximately 22m. This gives a total area of approximately 1520.5 square meters (m^2). The actual area will vary highly, depending on a wide range factors, including site-specific acoustic conditions and the actual size and condition of the tugboat and its powerplant; however, as a general estimate, this is the best approximation available.

It is extremely unlikely that adult PS Chinook salmon would be would be exposed to this effect, as it is unlikely that any would be in the action area while construction activities are taking place. Adult Chinook salmon use Lake Union as a thoroughfare on their migration from the ocean, and usually pass through the Lake within day, on their way to spawning habitat much farther upstream. Migration takes place from May through July, peaking in August. The October 1 – April 15 work window avoids overlap between construction activities and adult Chinook salmon migration.

Juvenile Chinook salmon rearing has been documented in Lake Washington (Tabor et al. 2006). Lake Union is directly connected to Lake Union by the Shipping Canal and therefore, due to this connection, the possibility exists that some juvenile Chinook salmon rearing occurs in Lake Union as well. Some juvenile PS Chinook salmon may therefore be exposed to construction-related noise from operation of the barge tug, and could be adversely affected; however, the number of adversely affected juveniles is expected to be extremely small, if any. This is because:

1. The small area of effect – the radius within which fish could experience injury is 22m.

2. For juvenile Chinook salmon to be adversely affected: 1) individuals must remain within the radius of effect long enough to incur physical injuries, without moving outside it, and/or without the tugboat moving beyond the distance at which injuries may occur; and 2) the tugboat engine must be running long enough, and at a high enough intensity, to generate sufficient sound levels for injuries from accumulated acoustic energy to occur.
3. The abundance of juvenile Chinook salmon within the action area during the in-water work period is expected to be exceedingly low, or absent altogether. As described above, conditions in Lake Union are severely degraded, and utilization by Chinook salmon juveniles as rearing habitat is expected to be very low.

If juvenile Chinook salmon are present within the action area, some behavioral disturbance may occur from noise associated with operation of the barge tug; however, any behavioral effects would be temporary, with a highly limited in duration, and are highly unlikely to affect the survival or fitness of juvenile Chinook salmon.

Steelhead occurrence in Lake Union overlaps with the in-water work window, during both adult spawning migration (January – May) and juvenile outmigration (April – May), and the possibility cannot be ruled out completely that juvenile steelhead could rear in Lake Union year-round. However, the presence of steelhead within the action area, regardless of life history phase, remains largely hypothetical, as both native steelhead populations Lake Washington Subbasin have been functionally extirpated. For this reason, in addition to the reasons listed above for Chinook salmon, steelhead are not expected to be exposed to construction-related noise from operation of the barge tug.

Construction-related Chemical Contamination of Water and Forage

This discussion addresses the effects on PS Chinook salmon and PS steelhead from the introduction of harmful chemicals into the water column, lakebed substrate, and food web from construction-related activities. The introduction of fine sediment, i.e., turbidity, into the water column and bed substrate is another form of water and forage contamination; however, this is addressed in a separate subsection below. That is, the present subsection is intended to address the effects of harmful chemicals, whereas the subsection on turbidity addresses the deleterious effects of fine sediment itself. Similarly, this subsection discusses the spread of harmful contaminants via propeller wash, whereas the direct negative effects of propeller wash itself are addressed in a separate subsection.

Fish may absorb certain contaminants directly through their gills, or indirectly through dietary exposure (Karrow et al. 1999; Lee and Dobbs 1972; McCain et al. 1990; Meador et al. 2006; Neff 1982; Varanasi et al. 1993). An example of the latter, are PAHs, commonly found in many fuels, lubricants, and other fluids commonly used in motorized vehicles and construction equipment, and in creosote, a compound commonly used to treat timber piles. Amphipods and copepods uptake PAHs and other harmful compounds from contaminated sediments (Landrum and Scavia 1983; Landrum et al. 1984; Neff 1982), and pass them to juvenile Chinook salmon and other small fish through the food web. Varanasi et al. (1993) found high levels of PAHs in the stomach contents of juvenile Chinook salmon in the contaminated Duwamish Waterway. They reported reduced growth, suppressed immune competence, and increased mortality in juvenile Chinook salmon, likely caused by dietary exposure to PAHs. Meador et al. (2006) demonstrated that dietary exposure to PAHs caused “toxicant-induced starvation,” evident by reduced growth and lipid stores in juvenile Chinook salmon. The authors surmised that these impacts could severely impact the odds of survival in affected Chinook salmon juveniles.

Contaminants may also affect Chinook salmon and steelhead indirectly by diminishing the number, size, and species diversity of prey. The growth of juvenile salmonids is heavily dependent on the availability of prey in freshwater systems (Mundie 1974). A study by Mason (1976) demonstrated a strong relationship between food abundance and the growth rate and biomass of juvenile salmonids in streams. In turn, juvenile growth is a critical indicator of the likelihood of salmonid survival in both freshwater and marine environments (Higgs 1995). This is because smaller individuals are vulnerable to size-selective predation during their first year in the ocean, and because slower growing individuals may be more susceptible to starvation and exhaustion (Parker 1971; Healey 1982; Holtby et al. 1990; Sogard 1997). When juvenile fish encounter areas of diminished prey, they would experience increased energetic costs (Heerhartz and Toft 2015), and the increased competition for limited resources, which may cause increased interspecific mortality (Auer et al. 2020; Biro and Stamps 2010).

In the proposed action, construction-related chemical contamination of water and forage could come from: 1) contamination from pile stubbing and propeller wash; 2) the use of ACZA-treated timber; and 3) leakage of contaminants from saws, the barge tug, or other construction equipment.

Contamination from Pile Stubbing and Propeller Wash: The proposed action includes the stubbing of 39 Piles at HC Henry Pier and 57 Piles at Chandler’s Cover Marina as part of the proposed repairs. As described in Section 1.3, pile stubbing would involve cutting the damaged/degraded section of a pile with an underwater chainsaw, while leaving the bottom section of the pile imbedded in the lakebed substrate. The damaged pile section is then lifted out of the water and placed onto a barge for offsite disposal, and a new section of pile is spliced onto the remaining pile stub left in the lakebed.

In their response to follow-up inquiry regarding the presence of creosote at the work sites (USACE 2024a, 2024b), the applicant stated that there was “none known in the work areas;” however, during a site visit conducted by a NMFS staff biologist, all timber piles that were observed were found to be heavily treated with creosote. This was confirmed by staff from WA-DNR and described in the reports for site inspection reports carried out in 2019 and 2020 by Echelon Engineering (WA-DNR 2024; Echelon Engineering 2019, 2020).

Creosote is comprised of 65 to 85% of PAHs in addition to other potentially harmful chemicals, such as certain phenolic compounds and nitrogen-, sulfur-, or oxygenated heterocyclics (EPRI 1995, Brooks 1997 [also see Smith 2003]). PAHs and other creosote-derived chemicals may have a wide range of deleterious effects on fish, including carcinogenesis, disruption of the immune system, disrupted hormone regulation, teratogenic effects, hematological alterations, reduced growth and physical development, among other toxicological effects (Krahn et al. 1986; Meyers et al. 1990; Tuvikene 1995; Karrow et al. 1999; Johnson 2000; Rice et al. 2000; Meador et al. 2006; Bravo et al. 2011). Vines et al. (2000) examined Pacific herring embryos exposed to creosote-treated wood and found abnormalities in 100% of those that managed to survive to hatching. In another example, Rice et al. (2000) found reduced growth in English sole (*Pleuronectes vetulus*) that were fed a diet of polychaete worms contaminated with PAHs, compared to individuals fed uncontaminated polychaetes. Riguad et al. (2020), found that exposure to PAHs altered levels of certain proteins involved in cardiac function in early-stage juvenile rainbow trout.

During the stubbing process, it is likely that PAHs and other harmful compounds will be leached into the water column from wood splinters and particles generated when creosote-treated piles are cut with a chainsaw, as well as from any exposed tops of the freshly cut pile stubs that remain in the lakebed. Fragments of old creosote-treated piles have been found to readily release PAHs into the water column (Parametrix 2011). While the leaching rate decreased for certain PAHs within 96 hours after the piles were cut, it remained constant or even increased after almost 2 weeks for others. The freshly exposed surfaces on the fragments of old creosote-treated timber were observed to behave similarly to the surfaces of newly treated piles in releasing large amounts of PAHs into the surrounding water.

In the proposed action, the freshly exposed tops of any stubbed creosote-treated piles are likely to continue to release PAHs and other chemicals into the water column after being cut. In accordance with WA-DNR regulations. after pile stubs are spliced with a new section, the piles will be wrapped and sealed from 1’ below the mudline to above the waterline. This will remove contact between the exposed top of the preexisting, creosote-treated pile stub, this preventing further release of PAHs and other creosote-derived chemicals into the water column.

Pile cutting will also generate splinters and particles of creosote-treated wood. These wood fragments will continue leaching chemicals until either: a) they are removed from the water; or b) leaching proceeds to completion, i.e., all of the chemicals leech out of the wood and into the water. As described in Section 1.3, a floating boom will be placed around the project area while work is being performed, and will be cleared of floating debris before it is removed. While this will likely remove some of the contaminated wood fragments, it will only be effective in capturing fragments that float to the surface after being cut, and which remain floating until they can be collected. Fragments that are saturated and remain on the bottom, or that sink before they can be collected, will not be captured using this measure. Additionally, it is unlikely that it will be possible to remove all of the floating wood fragments, as some are likely to be quite small, and will be missed during the collection process. Nor will this measure prevent floating wood fragments from releasing chemicals between the time they are cut and when they are collected.

A full-length sediment curtain will also be installed around the project area while in-water work is being performed. While this may help limit the drift distance of contaminated non-buoyant wood fragments (and contaminated sediment, see below), it will not remove them from contact with the water. Contaminated fragments that sink to the bottom will continue to release PAHs and other chemicals into the water column where they fall. Where contaminated wood is left in direct contact with water, it is likely to continue leaching chemicals for an extended period after construction activities have ceased, possibly years or even decades. Vines et al. (2000) found that creosote-treated piles continued to release chemicals 40 years after being installed.

PAHs and other harmful creosote-derived chemicals are also likely be introduced into the environment by the resuspension of contaminated sediment during the pile stubbing process. Creosote leaches from treated piles into the surrounding sediment in which they are imbedded. A study by Smith (2008) found high concentrations of PAHs in the bed substrate around the bases of creosote-treated posts at an oyster farm. During pile stubbing, the lakebed substrate around the piles will be disturbed by trampling and when the base of a pile must be excavated to expose a suitable section for splicing. Disturbance of the lakebed would likely resuspend creosote-contaminated sediment that was previously contained beneath the bed surface. Some contaminated sediment stuck to removed pile sections would also likely fall of and become suspended in the water column as the sections are hoisted onto the barge by the crane. While the work barge will be fitted with filtration material to prevent sediment runoff from the pile sections from washing back into the Lake after they are removed, contaminated sediment will be introduced and resuspended in the water column while pile sections are raised from the bottom and hoisted onto the barge.

Additionally, while no specific sediment contamination has been identified at either of the project sites, sediment in the area immediately west of HC Henry Pier has been listed as polluted for arsenic, cadmium, chromium, copper, lead, mercury, various types of PAHs, PCBs, silver, and zinc (WDOE 2024). Therefore, the presence of legacy contamination at the project sites from sources other than the pre-existing creosote-treated piles must be considered. If such legacy contamination were to exist at either of the project sites, its composition would likely mirror that of the adjacent area to the west, and would include various heavy metals, PAHs, and PCBs.

Propeller wash from the barge tug could expose and mobilize sediment contaminated by the pre-existing creosote-treated piles, as well as other legacy contamination, reintroducing it into the water column and the aquatic food web. The intensity and duration of the resulting turbidity plumes are uncertain, and would depend on a combination of the tugboat’s thrust, the water depth, and the substrate composition. Fine material, such as silt and clay, remains mobilized longer than coarse material such as sand and gravel. A longer time in suspension allows fine sediment to travel greater distances. The shallower the water, the greater the amount of thrust energy is able to impinge on the bottom substrate. Therefore, the higher the thrust, the finer the substrate, and/or the shallower the water depth, the greater the amount of mobilized sediment and potential distance of spread of contaminated sediment.

The exact extent of turbidly plumes from tugboat operations for the proposed action are unknown, but it is expected that project-related tugboat travel would be infrequent, and would likely total in the low number of hours for the entire project duration. The tugboat would be used to reposition the crane barge as required, but would presumably not be in operation otherwise. Therefore, the resulting propeller wash turbidity plumes would be low in number and episodic.

Romberg (2005) discusses the spread of contaminated sediments that were mobilized by the removal of creosote-treated piles from the Seattle Ferry Terminal, which included digging into the bottom substrate with a clamshell bucket to remove broken piles. Soon after the work, high PAH levels were detected up to 800’ away, on the surface of a clean sand cap that had been installed less than a year earlier. Contaminant concentrations decreased with time and with distance from the pile removal site; however, PAH concentrations remained above pre-contamination levels 10 years later.

There is a considerably large difference in the scale of disturbance between the proposed pile stubbing the operation described by Romberg (2005), and sediment mobilization from the proposed action would be of a much lesser intensity and magnitude. As described above, the project area will be contained within a full-length sediment curtain while in-water work is being performed, as a well as a floating boom to capture debris that comes to the surface. This will help contain the majority of contaminated sediment and wood fragments within the immediate project area. Most of the mobilized sediment, and therefore the highest concentrations of contaminants, would settle onto the top layer of the substrate within tens of feet around the pile stubbing sites. However, it is predicted that propeller wash from the barge tug or other vessels in the vicinity could possibly spread sediments as far as 300’ around the project site. This distance is based on the findings of a previous consultation for a similar action (NMFS 2021).

As described above, fish may absorb harmful chemicals directly, such as through their gill membranes, or indirectly through the ingestion of contaminated prey and other materials. Juvenile rainbow trout have been shown to uptake PAHs directly from contaminated suspended sediment (Masterbeit 2011) This suggests that Juvenile PS Chinook salmon and juvenile PS steelhead that are present within the affected area may be exposed to PAHs from contaminated sediment suspended in the water column. Juvenile Chinook salmon and steelhead in the affected area would also be exposed to PAHs and other chemicals leaching directly into the water from creosote-treated pile stubs and wood fragments.

While some level of direct exposure may occur, the primary means of exposure of salmonids to PAHs and other creosote-derived chemicals is expected to be indirect, through the food web. Contaminated sediments that settle to the bottom would remain biologically available to juvenile PS Chinook salmon and juvenile PS steelhead for years after project completion. During this time, a portion of those contaminants are likely to be taken up by invertebrate prey organisms within the affected area. Many species of invertebrates have been shown to bioaccumulate PAHs (Meador et al. 1995; Van Hattum and Montanes 1999; Meador 2003; Bleeker and Verbrugen 2009; Parametrix 2011; Girardin et al. 2020), meaning that PAHs concentrations in their tissue may be much higher than background concentrations. Macroinvertebrates comprise the majority of the diet of salmonid fry and parr (Higgs 1995). Thus, there is a high likelihood that any juvenile PS Chinook salmon and PS steelhead feeding in the affected area would ingest invertebrates contaminated with PAHs and other creosote-derived chemicals, possibly at high concentrations due to bioaccumulation.

Any juvenile salmonids exposed to contaminated forage could experience a range of deleterious effects from consuming PAHs and other harmful chemicals. As described above, Meador (2006) noted reduced growth and lipid stores in juvenile Chinook salmon from dietary exposure to PAHs. Another example, Bravo et al. (2011) found juvenile rainbow trout exhibited decreased immune response after dietary PAH exposure.

Not only would juveniles rearing in the project area be affected, out-migrating juveniles would likely be affected as well. The normal behaviors of juvenile Chinook salmon during the freshwater out-migration life history phase include a strong tendency toward shoreline obligation, meaning they are biologically compelled to follow and remain close to streambanks and shorelines. Therefore, some out-migrants are likely to pass through and forage within the affected area each year. Stein et al. (1995) found higher concentrations of PAHs in the gut contents of out-migrating juvenile Chinook salmon in urban estuaries compared to juveniles in less developed estuaries. Lundin et al. (2021) found high concentrations of PAHs and other chemicals in the tissue of out-migrating juvenile Chinook salmon in Portland Harbor, a similarly industrialized waterway as the Lake Washington Ship Canal. Reduced growth rates were associated with higher concentrations of PAHs and other contaminants in the tissue of juveniles. The normal behaviors of out-migrating juvenile steelhead are much less tied to shoreline habitats; however, over the years-long presence of construction-related contaminants at the site, some out-migrating juvenile steelhead could hypothetically pass through and forage within the affected area.

The number of juveniles of either species that will be affected by construction-related water and forage contamination is expected to be very low, and well below the threshold of population-level effects. The reasons for this are largely the same as those mentioned above in the discussion of construction-related noise, and include:

1. The limited scale of the proposed action/action area – The maximum extent of construction-related water and forage contamination is not expected to extend beyond 300’ around the project site, with the highest concentrations of contaminants limited to a much smaller area. PDCs including the use of a floating debris boom and full-length sediment curtain will reduce the extent and level of contamination, and construction-related contamination is expected to be limited, even at the highest concentrations. Furthermore, it is likely the proposed action will have a mid- to long-term beneficial effect on water and forage quality due to the removal of damaged sections of creosote-treated piles and the installation or wraps around the remaining pile stubs, which will remove contact between the creosote-treated timber and the water.

2. Low numbers of PS Chinook salmon and PS steelhead are likely to be in the action area. Conditions in Lake Union are severely degraded and utilization by Chinook salmon juveniles as rearing habitat is expected to be very low or absent altogether. Utilization by juvenile steelhead is likely to be even lower due to the functional extirpation of both native populations from the Lake Washington Subbasin.

   While some out-migrating PS Chinook salmon juveniles are likely to consume forage contaminated by construction-related activities, the number of affected individuals will likely be very low. Furthermore, exposure of outmigrants to contaminated forage is likely to be highly transient as they make their way toward Puget Sound. Exposure of out-migrating PS steelhead to contaminated forage will be even lower than that of PS Chinook salmon. This is due both: a) the extremely low number of native steelhead that remain in the Subbasin; and b) the differing out-migration behavior of steelhead compared to Chinook salmon. Whereas Chinook salmon remain close to streambanks and shorelines during out-migration, out-migrating steelhead are much less associated with shoreline habitats during out-migration, meaning there is a lower likelihood they will encounter contaminated forage from the proposed action.

No adverse effects are expected to adult PS Chinook salmon or PS steelhead from construction-related water or forage contamination. Adults of both species use the Lake Washington Ship Canal as a migration corridor and usually pass through Lake Union in less than one day (Kerwin 2001). Exposure to construction-related contamination is unlikely, and if exposure were to occur, it would be highly limited in intensity and duration. PS Chinook salmon and PS steelhead spawning and holding occurs well upstream of Lake Union. Thus, no holding adults, incubating eggs, or newly hatched alevin or fry will be exposed to construction-related contamination.

Use of ACZA-treated Timber: Under the proposed action, ACZA-treated timber may be used to construct new framing and other support structures. ACZA contains heavy metals, including copper and zinc, which have shown to have deleterious effects on salmonids (Brooks 2004; Hecht et al. 2007). All components utilizing AZCA-treated timber will be installed above the waterline; no ACZA-treated material will be installed where it is in contact with water. Additionally, cutting of AZCA-treated any wood or other chemicals must be completely contained to prevent and dust or debris from entering the water, or must performed in an upland location. These protection measures are expected to avoid adverse effects to PS Chinook salmon or PS steelhead during any life history stage. Some runoff of ACZA from treated wood is expected to occur during storm events; however, this is addressed in the discussion of structure-related water and forage contamination below.

Contamination from Equipment Leakage: In addition to the mobilization of contaminated sediments and/or the release of PAHs from creosote-treated timber piles during stubbing, contaminants may enter the water through spills and discharges from construction equipment. Apart from the barge-mounted crane and barge tug, additional sources of contamination would likely be limited to leakage from handheld tools. The possibility exists that auxiliary vessels (e.g., small to mid-size motorized boats) will used in the project, although such usage was not mentioned in either of the BEs.

Many of the fuels, lubricants, and other fluids commonly used in motorized vehicles and construction equipment are petroleum-based hydrocarbons that contain PAHs. The effects of PAHs on salmonids and potential pathways of exposure are addressed above in the discussion of contamination from pile stubbing and propeller wash, and are therefore not repeated here. Other contaminants may include heavy metals, PCBs, phlalates, and other organic compounds. Depending on the pollutant, its concentration, and/or the duration of exposure, exposed fish may experience effects that can range from avoidance of an affected area, to reduced growth, altered immune function, and mortality (Beitinger and Freeman 1983; Brette et al. 2014; Feist et al. 2011; Gobel et al. 2007; Incardona et al. 2004, 2005, and 2006; Mcintyre et al. 2012; Meador et al. 2006; Sandahl et al. 2007; Spromberg et al. 2015).

The limited use of heavy equipment in the proposed action, and the small scale of the work site, will reduce the amount of potential leakage/spillage of fuel, lubricants, and/or other chemicals. Spill containment and removal materials will also be kept onsite while work is being performed in the event that any spills or leaks do occur. Some leakage/spillage may still occur, and may result in limited water and forage contamination. As described in the discussion of contamination from pile stubbing and propeller wash, this would adversely affect any juvenile PS Chinook salmon or PS steelhead rearing in the action area, and any juvenile Chinook salmon or steelhead out-migrants feeding as they pass through the action area on their way to Puget Sound. However, for the same reasons listed above, the number of juveniles of either species that would be adversely affected by leakage/spillage-related contamination is expected to be minimal, and well below the threshold at which effects would be detectable at a population-level. No detectable effects to adult PS Chinook salmon and PS steelhead are expected, and Chinook salmon and steelhead holding and spawning takes place well upstream of the action area.

Construction-related Turbidity

Whereas the discussion of construction-related chemical contamination of water and forage addressed the deleterious effects of harmful chemical contaminants carried in sediment, the present subsection addresses the deleterious effects of the turbidity itself.

General Description of Turbidity Metrics and Effects on Fish: The intensity of turbidity is typically measured in Nephelometric Turbidity Units (NTUs) that describe the opacity caused by suspended sediments, or by the concentration of total suspended solids (TSS) measured in milligrams per liter (mg/L). A strong positive correlation exists between NTU values and TSS concentrations. Depending on the particle sizes, NTU values roughly equal the same number of mg/L for TSS (i.e. 10 NTU = ~ 10 mg/L TSS, and 1,000 NTU = ~ 1,000 mg/L TSS; Campbell Scientific Inc. 2008; Ellison et al. 2010). Therefore, the two units of measure are easily compared.

Water quality is considered adversely affected by suspended sediments when turbidity is increased by 20 NTU for a period of 4 hours or more (Berg and Northcote 1985; Robertson et al. 2006). The effects of turbidity on fish are somewhat species and size dependent. In general, severity typically increases with sediment concentration and duration of exposure, and decreases with the increasing fish size. Bjornn and Reiser (1991) report that adult and larger juvenile salmonids appear to be minimally affected by the high concentrations of suspended sediments that may be mobilized during storm and snowmelt runoff episodes. However, empirical data from numerous studies report the onset of minor physiological stress in juvenile and adult salmon after one hour of continuous exposure to suspended sediment concentration levels between about 1,100 and 3,000 mg/L, or after three hours of exposure to 400 mg/L, and after seven hours of exposure to concentration levels as low as 55 mg/L (Newcombe and Jensen 1996). The authors reported that serious non-lethal effects such as major physiological stress and reduced growth were reported after seven hours of continuous exposure to 400 mg/L and 24 hours of continuous exposures to concentration levels as low as about 150 mg/L.

Elevated levels of turbidity may also affect salmonids indirectly through a reduction in prey species, impeding feeding success and growth of juveniles (Gregory and Northcote 1993; Vogel and Beauchamp 1999; Bash et al. 2001; Suttle et al. 2004). Macroinvertebrates comprise the majority of the diet of salmonid fry and parr (Higgs 1995). The preferred freshwater forage species for rearing juvenile salmon are small aquatic invertebrates, such as mayflies, caddisflies, and stoneflies. These aquatic insects live in the well-oxygenated interstitial spaces among the rocks and gravel in bottom substrate. Fine sediment has the potential to fill and clog these interstitial spaces. As interstitial spaces are lost due to sedimentation, the invertebrate composition and density in the affected area typically transitions away from the preferred forage species of salmonids to non-preferred, less available (more difficult to prey upon) species, such as aquatic worms and other borrowing invertebrates.

Salmonid growth is heavily dependent on the availability of prey in freshwater systems (Mundie 1974). A study by Mason (1976) demonstrated a strong relationship between food abundance and the growth rate and biomass of juvenile salmonids in streams. In turn, juvenile growth has been shown to be critical to salmonid survival in both freshwater and marine environments (Higgs 1995). This is because smaller individuals are vulnerable to size-selective predation during their first year in the ocean, and because slower growing individuals may be more susceptible to starvation and exhaustion (Parker 1971; Healey 1982; Holtby et al. 1990; Sogard 1997). Reduced forage availability is likely to increase competition, and may reduce growth and the likelihood of survival for some individuals that rear in the impacted areas. As a result, gravel embeddedness may significantly reduce an affected area's carrying capacity for juvenile salmonids.

Mobilization of anaerobic sediments can also decrease dissolved oxygen levels (Hicks et al., 1991; Morton 1976). The impact on dissolved oxygen is a function of the oxygen demand of the mobilized sediments, the amount of material suspended in the water, the duration of sediment suspension, and water temperature (Lunz and LaSalle 1986; Lunz et al. 1988). Reduced dissolved oxygen can affect salmonid swimming performance (Bjornn and Reiser 1991), as well as cause avoidance of water with low dissolved oxygen levels (Hicks 1999).

Construction-related Turbidity Magnitude and Effects: Pile stubbing and propeller wash from the barge tug would mobilize bottom sediments. This is expected to cause episodic, localized, and short-lived turbidity plumes with relatively low TSS concentrations.

During pile stubbing, sediment around the base of the piles would be disturbed by trampling and when the base of pile must be excavated to expose a suitable section for splicing. A full-length sediment curtain will be installed around the project area while work is being performed, which will help contain turbidity generated by pile stubbing within the immediate work area. The use of hand digging instead of water jets to excavate around the base of piles will also help minimize the amount of sediment disturbed from the lakebed.

As described above, the intensity and duration of the turbidity plumes generated by the barge tug would depend on a combination of the tugboat's thrust, water depth, and the substrate composition. A previous study described the turbidly caused by large tugboats operating in Navy harbors (ESTCP 2016). After approximately 13 minutes, the plume extended about 550 yards [~503 meters (m)] and had a TSS concentration of about 80 mg/L. The TSS concentration fell to 30 mg/L within 1 hour, and to 15 mg/L within 3 hours. At its highest concentration, the plume was below the concentrations required to elicit physiological responses reported by Newcombe and Jensen (1996).

The exact extent of turbidly plumes from tugboat operations associated with the proposed action are unknown, but it is extremely unlikely that it would rise to the levels described above. Project-related tugboat movement is expected be relatively infrequent, and would likely last a low number of hours while work barges are repositioned, and the resulting propeller wash turbidity plumes are expected to likewise be low in number and episodic. While the exact intensity and duration of the resulting turbidity plumes is uncertain, based on the information above, and on numerous consultations for similar projects in the region, sediment mobilization from tugboat propeller wash would likely consist of relatively low-concentration plumes that could extend up to approximately 300’ from the site, and last a low number of hours hour after the disturbance ends.

Construction-related turbidity from either pile stubbing, or from operation of the barge tug is not expected to be of sufficient intensity to have a detectable effect on the quality or quantity of benthic forage habitat within the action area. This is especially true given the current highly degraded conditions in the action area, in which the benthos is dominated by invasive Eurasian milfoil and green algae. Sections of the bottom not covered by milfoil or green algae are comprised of fine sediment, large cobble, and assorted refuse items.

Because no detectable effects to forage habitat are expected, and because the in-water work window avoids the timing of adult Chinook salmon spawning migration and juvenile out-migration, neither adult or juvenile PS Chinook salmon are likely to be affected by construction-related turbidity. Rearing juvenile Chinook salmon in the action area may experience temporary behavioral disturbances, but turbidity is not expected to reach a concentration that would result in physical injury, or last for a duration sufficient to cause mid- or long-term displacement of juveniles. Furthermore, the number of juvenile Chinook salmon rearing in the action area is likely to be very low, if any are present at all.

The in-water work window overlaps with the first month of adult PS steelhead spawning migration and the final month of juvenile out-migration, and thus it is possible that migrating adult and juvenile steelhead could be exposed to construction-related turbidity. However, this contingency is more academic than practical. Both native populations of PS steelhead have been functionally extirpated and persist in very small numbers. In the remote chance that any of the few returning PS steelhead were to encounter a construction-related turbidity plume, they would easily be able to avoid it. The avoidance behavior would not impede their travel to their holding and spawning habitat upstream, or otherwise reduce their fitness or chances of survival. Out-migrating juvenile PS steelhead would also be unlikely to encounter any construction-related turbidity, due to their small numbers, the minimal overlap between their out-migration timing and the in-water work window, and because steelhead smolts do not exhibit a strong tendency toward the shoreline as do Chinook salmon smolts, meaning that they would be unlikely to enter the action area. If out-migrating juvenile steelhead were to encounter a construction-related turbidity plume, it would likely result in temporary avoidance behavior and possibly interrupt or redirect foraging. This would not be expected to impede their out-migration to any detectable degree, or reduce their fitness or chances of survival.

As with Chinook salmon, any juvenile PS steelhead rearing in the action area may experience temporary behavioral disturbances, but turbidity is not expected to reach such a concentration that would result in physical injury, or last for a duration sufficient to cause mid- or long-term displacement. The number of juvenile PS steelhead that use the action is likely to be extremely small or absent altogether.

In summary, small numbers of rearing juvenile PS Chinook salmon, rearing juvenile PS steelhead, and migrating adult and juvenile PS steelhead may experience minor and temporary behavioral disturbances from construction-related turbidity. However, any effects from exposure to construction-related turbidity would fall far below the threshold at which they would be detectable at a population level, nor would such exposure be expected to reduce the fitness or survival, or significantly impede the migration of affected individuals.

Construction-related Propeller Wash

Whereas the discussions above on construction-related chemical contamination and construction-related turbidity addressed deleterious effects from the spread of chemical contaminants and turbidity by propeller wash, respectively, the present subsection is intended to address the direct effects of propeller wash itself.

Work-related tugboat operations would cause propeller wash within the action area. Exposure to construction-related propeller wash would adversely affect juvenile PS Chinook salmon and PS steelhead that happened to be close by while such operations were ongoing. It is extremely unlikely that adult PS Chinook salmon or PS steelhead would be would be exposed to this stressor.

Spinning boat propellers kill fish and small aquatic organisms (Killgore et al. 2011; VIMS 2011). Spinning propellers also generate fast-moving turbulent water (propeller wash) that can displace and disorient small fish, and can dislodge benthic aquatic organisms and submerged aquatic vegetation (SAV) via propeller scour, particularly in shallow water and/or when a propeller is being operated at high power.

During construction, operation of the barge tug and possibly smaller auxiliary vessels would cause propeller wash within the action area. Juvenile PS Chinook salmon and PS steelhead within the area would be too small to effectively swim against the propeller wash. Individuals that are struck or are nearly missed by the propeller would be injured or killed by the exposure. At greater distances, propeller wash may displace and disorient fish. Depending on the direction and strength of the thrust plume, displacement could increase energetic costs, reduce feeding success, and may increase vulnerability to predators for individuals that tumble stunned and/or disoriented in the wash.

The number of juvenile PS Chinook salmon and PS steelhead that may be impacted by this stressor is unquantifiable with any degree of certainty; however, it is expected to be extremely low due to the relatively short duration and episodic timing of the work, the timing of the in-water work window, and the low numbers of fish within the affected area. The numbers of juvenile PS Chinook salmon and PS steelhead that may be exposed to construction-related propeller wash would represent such a small subset of their respective cohorts that their loss would cause no detectable population-level effects.

Construction-related propeller scour may also reduce SAV and diminish the density and diversity of the benthic community at the project site. However, the disturbances would be brief, the affected areas would likely consist of a tiny portion of the SAV- and invertebrate-supporting substrate in the immediate area, and the disturbed SAV and invertebrates would likely recover very quickly after work is complete. Furthermore, the SAV within the action area is dominated by invasive Eurasian milfoil and green algae, which are of questionable value. Therefore, the effects of propeller scour would be too small to cause any detectable effects on the fitness and normal behaviors of juvenile PS Chinook salmon and juvenile PS steelhead in the action area.

Indirect Effects

Authorization of the repairs by USACE would extend the operational life of the applicant's marina/dock facilities by several decades beyond that of the existing structures. Indirect effects are those that would result from structures' continued presence and operations. Thus, whereas the direct effects associated with the proposed action would be mostly limited to the Oct. 1 – Apr. 15 work window and would occur over a single season (with the exception of chemical contamination), indirect effects would occur year-round, year after year. The indirect effects of the proposed action would include: 1) structure-related noise; 2) structure-related chemical contamination of water and forage; 3) structure-related turbidity; 4) structure-related propeller wash; and 5) structure-related shade and lighting effects.

Structure-related Noise

A general discussion of the effects of noise on fish, and the noise level thresholds at which those effects occur, is given in the direct effects subsection above, and is therefore not repeated here.

The highest intensity noise that would result from extending the operational life of the dock and marina structures would come boat traffic. The BE for HC Henry Pier states that approximately 29 to 30 vessels are moored at the Pier at any given time, ranging in size from 40 to 70'. The BE for Chandler's Cove Marina states that there are typically approximately 15 to 16 vessels moored at the Marina at any given time, ranging in size from 40 to 70'. Using the measuring tool on Google Earth (Google Earth 2024) showed vessels in excess of 70' at both sites, including one vessel measuring over 90' at HC Henry Pier. During the site visit, a 105' commercial touring/cruise ship was observed moored along the east side of the main pier at Chandler's Cove. The website of the company operating the cruise vessel lists the address for Chandler's Cove Marina as the vessel's location, suggesting long-term moorage and operation of the vessel from the Marina. Based on these observations, it should thus be expected that vessels >70' regularly operate from both HC Henry Pier and Chandler's Cove Marina.

The same acoustic assessment date that were used to estimate the source level of sound from the barge tugboat (NMFS 2018) were used to estimate the source level of sound for ~90 – 100' cruise vessels and recreational yachts. The closest vessel to this type and size listed in the acoustic assessment data is an 87' ferry vessel, which is listed as having a source sound level of 187 dB_{peak} and 177 dB_{SEL}. It was determined that this would be an adequate surrogate or the largest vessels operating from HC Henry Pier and Chandler's Cove Marina, despite the minor size difference. This was based on the findings of two other studies: Reine et al. (2014) present source level sound data for several ocean-going container ships ranging in size from ~853 to 984’ (260 – 300m). The highest source sound level Reine et al. report is 188.9 dB for a 984’ container ship displacing 46.3 kilotons (kt). They also report the source sound for a ~308’ (94m) ferry with a maximum recorded sound level of 181.3 dB. The other study, McKenna et al. 2012, reports source sound levels for multiple container ships, tankers, and other types of cargo ship. The highest source sound level they report is 188.1 dB for a ~978’ (298m) container ship displacing 53.8 kt. Thus, given the minimal difference in source sounds levels between the 87’ ferry listed in NMFS 2018 and vessels many times larger reported in Reine et al. 2014 and Makenna et al. 2012, it was determined that any differences in source sound levels of the largest vessels likely to operate from HC Henry Pier and Chandler’s Cover Marina, which would only be 5 – 20’ larger than the 87’ ferry reported in NMFS 2018, would be undetectable and discountable.

The radius of effects to Chinook salmon and steelhead from dock/marina vessel traffic was calculated following the methods described above for the barge tug. Because the expected maximum noise level from cruise vessel/yacht operation does not exceed 206 $\mathrm{dB_{peak}}$, the threshold of immediate onset of death or injury to fish would not be exceeded, and therefore it is not necessary to calculate the radius of effect (radius of effect = 0). The threshold of injury from accumulated acoustic energy (150 dB $\mathrm{SEL_{ss}}$) would be exceeded, and therefore a radius of effect was calculated using the spreading loss equation as described above:

$$R = 10^{((177 - 150)/15)} = 63.1\text{m} = \sim 64\text{m (rounded up as a precaution)}$$

Thus, the maximum radius of effect of injury from accumulated acoustic energy of the largest vessels that would be expected to operate from Chandler’s Cover Marina and HC Henry Pier would be approximately 64m. There will also be many smaller vessels, that produce smaller radii of effect of injury from accumulated acoustic energy, operating from the facilities as well. The range and intensity of noise-related effects will also vary, depending on a range of factors, such as site-specific conditions, the actual noise levels produced by specific vessels, and the duration and intensity/power level at which the engines of those vessels are operated.

Injuries from accumulated acoustic energy will likely be limited as: 1) fish must: remain within the radius of effect long enough to incur physical injuries without moving outside if it, and/or without the vessel moving beyond the distance at which injuries may occur; and 2) the vessel engine must be running long enough, and at a high enough intensity, for injuries from accumulated acoustic energy to occur. However, unlike the barge tugboat, which will only be operated for a limited duration during certain months in a single year, vessel traffic operating the dock/marina facilities would occur year-round, year after year. As a result, a greater number of both PS Chinook salmon and PS steelhead are likely to be affected over the course of decades of structure-related vessel traffic than by operation of the barge tugboat over a single season.

It is likely that some migrating adult PS Chinook salmon and well as rearing and out-migrating juveniles would be exposed and adversely affected by harmful noise levels over the course of decades of structure-related vessel traffic. Noise from structure-related vessel traffic would likely illicit an avoidance behavior response in migrating Chinook adults, but would not be of sufficient intensity or duration to result in bodily injury from accumulated acoustic energy. Adult Chinook salmon rapidly pass through Lake Union during their return migration, usually remaining in the Lake for less than a day, and would easily be able to avoid harmful noise levels produced by the vessels. Between the swimming adult Chinook salmon and moving vessel, it is expected that the window of exposure would be too narrow to result in bodily injury.

Juveniles are not as strong swimmers as adults, and therefore it is more likely that some juveniles would be exposed to harmful noise levels long enough to incur noise-related injuries. This could be particularly true when vessels are left idling at a dock, although it is also possible that the engine would not produce sound levels intense enough to cause bodily injury when simply idling. Rearing juvenile Chinook salmon or out-migrating juveniles passing through the area might become disoriented or otherwise not be able to escape the radius of effect in time to avoid incurring bodily injuries. Such injuries could reduce the fitness and/or chances of survival of affected juveniles, or if severe enough cause direct mortality. It is expected that exposure to structure-related sound from vessel traffic of sufficient intensity and/or duration to cause bodily injury would be a relatively uncommon occurrence; however, avoidance behavior and other behavioral disturbances to juvenile Chinook salmon are expected to be more frequent. Such disturbances would interrupt foraging, out-migration, and predator avoidance, and cause additional stress. If severe/persistent enough, such behavioral disturbances would reduce the fitness and chances of survival of affected individuals. It is likely that any juvenile Chinook salmon rearing in the action area would be at a higher risk of this, as they would be subjected to the habitual noise of vessel traffic. Conversely, there is also evidence that fish can acclimate to prolonged exposure to certain sounds (Popper et al. 2019).

It is not expected that sufficient numbers of adult or juvenile Chinook salmon would be adversely affected by noise from structure-related vessel traffic to result in detectable population-level effects. While vessel traffic would persist year-round, year after year, the noise the vessels produce would be either relegated to the relatively small action area, or would be disbursed, due to the travel of the vessels, across the relatively large area of Lake Union and its connected waterbodies. Exposure to harmful noise levels from structure-related vessel traffic would likely be fairly infrequent, of limited duration, and seldom result in bodily injury.

The effects of noise from structure-related vessel traffic on PS steelhead would be the same as those described for PS Chinook salmon, with migrating adults as well as rearing and out-migrating juvenile steelhead being affected; however, the number of steelhead that would be adversely affected is expected to be smaller than that of Chinook salmon. This is because: a) there are considerably fewer PS steelhead remaining in the Lake Washington Subbasin than PS Chinook salmon; and b) out-migrating juvenile steelhead do not exhibit the same tendency toward shoreline obligation as do Chinook salmon out-migrants, and are therefore less likely to pass through the action area on their way to Puget Sound. Likewise, for the reasons highlighted above, noise from structure-related vessel traffic is not expected to result in detectable effects to PS steelhead.

Structure-related Chemical Contamination of Water and Forage

Structure-related chemical contamination would come from three sources: 1) fuels, lubricants, coatings, and other pollutants from vessels utilizing the dock/marina facilities; 2) copper from

ACZA-treated timber used in the structures' construction; and 3) contaminated sediment exposed and/or spread by vessel propellers.

Vessel-derived Contamination: Chandler's Cover Marina and HC Henry Pier have a combined moorage space for up to approximately 90 vessels or more (based on a slip count from design plans), including large vessels over 100'. Vessels mooring at Chandler's Cover Marina and HC Henry Pier would discharge a wide range of pollutants into Lake Union from antifouling hull paints and other preservative coatings, petroleum-based fuels and lubricants, engine coolant, and assorted trash and refuse. While discharges would be fairly infrequent and the majority of discharges minor, some pollution would be inevitable. The vessels moored at the facilities would likely be a continuous, year-round source of pollutants over the decades of continued operational life of the marina and dock structures; however, the pollution discharge would likely be episodic, low-intensity, and highly localized.

The primary pollutants discharged from the vessels would be in the form of copper from antifouling paint used to coat hulls, and from petroleum-based fuels and lubricants, which contain harmful PAHs and other chemicals. The harmful effects of PAHs to salmonids are discussed above in the direct effects subsection, and are therefore not repeated here.

Exposure to dissolved copper at concentrations between 0.3 to 3.2 µg/L above background levels has been shown to cause avoidance of an area, to reduce salmonid olfaction, and increase juvenile salmon's vulnerability to predators due to behavior modification (Giattina et al. 1982; Hecht et al. 2007; McIntyre et al. 2012; Sommers et al. 2016; Tierney et al. 2010). Copper-based anti-fouling paints leach copper into the water at fairly constant levels, and can be a significant source of dissolved copper in harbors and marinas with high boat occupancy and restricted water flows (Schiff et al. 2004). This is most notable under conditions of high boat occupancy in enclosed moorages where water flows are restricted. WDOE (2017) reports that dissolved copper concentrations from anti-fouling paints can be above 5 µg/L in protected moorages, but below 0.5 µg/L in open moorages with high flushing rates. The dissolved copper concentrations that would be attributable to copper-based anti-fouling paints from structure-related vessel traffic are uncertain, but may exceed the threshold for the onset of adverse effects in salmonids. The combined vessel occupancy of Chandler's Cove Marina and HC Henry Pier could be as many as 90 or more, of which an unknown and variable subset would be likely to have anti-fouling hull paint. Additionally, the water flushing rates along the lake shoreline are relatively low.

Based on this information, it is expected that dissolved copper concentrations from structure-related vessel moorage may periodically exceed 0.3 µg/L above background levels in the action area. Over the decades of the extended operational lives of the facilities, some juvenile PS Chinook salmon and PS juvenile steelhead are likely to be exposed to dissolved copper at levels high enough to measurably alter their normal behaviors and increase their risk of predation.

Most of the discharged petroleum-based fuels and lubricants would float on the water surface. While some would evaporate relatively quickly (Werme et al. 2010) or be dispersed by currents, some would collect, at least temporarily, in protected areas within the marina and docks around mooring floats and other structures. Therefore, over the decades-long life extension of the facilities, some juvenile PS Chinook salmon and juvenile PS steelhead are likely to be directly exposed to structure-related petroleum-based pollutants from vessel discharges at concentrations capable of causing some combination of behavioral disturbances, reduced growth, increased susceptibility to infection, and increased mortality. Migrating adult Chinook salmon and steelhead would be unlikely to be exposed, or would have minimal exposure, as they rapidly pass through Lake Union.

Vessel-derived contaminants that settle to the bottom would accumulate in the action area and be biologically available to salmonids for years (Romberg 2005). As described above in the direct effects subsection, amphipods, copepods, and other invertebrates uptake, and may bioaccumulate contaminants from sediment. These contaminants may be passed to salmonids through dietary exposure when they eat contaminated invertebrates, causing reduced growth, suppressed immune competence, and increased mortality. Migrating PS Chinook salmon and PS steelhead pass through Lake Union rapidly and are unlikely to consume contaminated forage; however, it is likely that over the decades of continued operation of Chandler's Cove Marina and HC Henry Pier, rearing and out-migrating juvenile Chinook salmon and steelhead will encounter and consume forage contaminated by discharge from vessels moored at the facilities. As a result, some individuals of are likely to experience reduced growth, increased susceptibility to infection, and increased mortality among other effects. However, due to the expected small scale and infrequent occurrence, structure-related pollutant discharges from vessels are not expected to result in detectable population-level effects in either PS Chinook salmon or PS steelhead.

ACZA-treated Timber: The proposed repairs to Chandler's Cover Marina and HC Henry Pier would include rebuilding/refurbishing a combined total of 5,758 ft^2 of pier and dock structures (measured as amount of decking, area of structural components will be smaller). All new framing structure material above the waterline would be ACZA-treated timber.

Wet ACZA-treated wood leaches some of the metals that are components of the ACZA preservative. Of these metals, dissolved copper is of the greatest concern to fish due to its higher leaching rate compared to arsenic and zinc (Poston 2001). Copper leaching from ACZA-treated wood is highest when the treated wood is immersed in freshwater, and decreases precipitously to low levels during the first few weeks after installation. The deleterious effects of copper on salmonids are described above.

All AZCA-treated timber would be installed above the waterline. While this would reduce the amount of copper that is leached from the timber, it would episodically release small amounts of copper when exposed to waves and stormwater. The dissolved copper concentrations that would be attributable to action-related installation of ACZA-treated timber is uncertain. Detectable concentrations from ACZA-treated timber are expected to be very low, episodic, brief, and limited to the areas immediately adjacent to the structures themselves, as the treated timber would not be permanently immersed. However, any dissolved copper from ACZA-treated timber would be additive to that from antifouling paint on the hulls of vessels moored at the dock/marina facilities (described above). The combined copper pollution from antifouling paint and ACZA-treated timber is expected to periodically reach concentration levels high enough (0.3 µg/L) that it would measurably alter the normal behaviors and increase the predation risk to juvenile PS Chinook salmon and PS steelhead within the action area; however, as described above, it is not expected to result in detectable population-level effects in either species due to the limited size of size of the action area and the low numbers of Chinook salmon and steelhead that are likely to be exposed.

Creosote-treated Timber: Both HC Henry Pier and Chandler's Cove Marina contain legacy components that are treated with creosote, including piles and structural features such as beams (Echelon Engineering 2019, 2020; WA-DNR 2024). While some of these structures will be replaced or otherwise mitigated by the proposed repairs, others will remain in place. While no new creosote-treated components will be installed, by extending the service life of the structures, the repairs will extend the duration during which the existing creosote-treated components will continue to leach chemicals into the waters of Lake Union.

As described above, creosote contains high concentrations of PAHs and other harmful chemicals, which have a wide range of deleterious effects to salmonids. These chemicals are known to leach out of creosote-treated wood when it comes in contact with water (Parametrix 2011). By extending the service life of the marina/dock structures, existing creosote-treated timber piles that are left in place would continue to leach chemicals into the water column. During storm events, chemicals from creosote-treated components above the waterline would be washed into the lake. The creosote-treated components have been in place for decades and thus are likely discharging/leaching chemicals at significantly lower concentrations than in the months and years following when they were first installed. However, despite the time that has passed, they are likely still discharging/leaching some amounts of PAHs and other chemicals into the water column, and will likely continue to do so over the decades-long life extension of the structures.

PAHs from legacy creosote-treated components of the marina/dock structures will add to construction- and vessel-derived PAHs. As described above, these PAHs are likely to enter the food web and eventually be taken up by juvenile PS Chinook salmon and PS steelhead that are rearing in the action area or that forage as they pass through during their outmigration to Puget Sound. As a result, a subset of the exposed fish is likely to experience deleterious effects such as reduced growth and fitness and increased likelihood of mortality. However, as with construction- and vessel-related pollution, PAHs derived from existing marina/dock components are not expected to extend beyond 300' from the project sites. Therefore, for the reasons discussed above – small scale of the affected area and limited number of fish exposed – the PAHs from these components are not expected to have detectable population level effects on PS Chinook salmon or PS steelhead juveniles. Furthermore, as also discussed above, migrating adult Chinook salmon and steelhead rapidly pass through Lake Union and are unlikely to be exposed to contaminated forage from structure-derived PAHs or other chemicals and any exposure to PAHs suspended in the water column as they pass through the action area would minimal and discountable.

Contamination from Propeller Wash: As described in the direct effects subsection, while no specific sediment contamination has been identified at either of the project sites, sediment in the area immediately west of HC Henry Pier has been listed as polluted from a range of different contaminants (WDOE 2024). The possibility must therefore be considered that propeller wash from vessels operating from the facilities could mobilize sediment contaminated by legacy sources of pollution. Propeller wash could also further mobilize creosote-contaminated sediment exposed during pile stubbing, or structure-related sediment contamination (as described directly above).

As described above, the intensity and duration of the turbidity plumes generated by vessel traffic would depend on a combination of the vessels' thrust, the water depth, and the substrate composition. While the exact intensity and duration of the resulting individual turbidity plumes is uncertain, based on numerous consultations for similar projects in the region, sediment mobilization from propeller wash would likely consist of relatively low-concentration plumes that could extend up to approximately 300' from the site, and last up to a low number of hours hour after the disturbance ends. Vessel traffic would occur year-round, but is expected to peak during summer months when recreational activities on Lake Union are at their highest. Vessel traffic would occur over the decades of extended operational life of the facilities.

It is likely that turbidity plumes generated by structure-related vessel traffic will mobilize and spread contaminated sediment, and that the contaminants within the sediment will enter the food web via invertebrate uptake. Some of the contaminated invertebrates will likely be consumed by juvenile PS Chinook salmon and PS steelhead, and that some of these juveniles will experience behavioral disturbances, reduced growth, increased susceptibility to infection, and increased mortality as a result. While this exposure would continue for decades due to the prolonged operational life of the marina and dock structures, it is not expected to reach a scale at which population-level effects would be detectable. Migrating adult PS Chinook salmon and PS steelhead rapidly pass through Lake Union and are not expected to be exposed to contaminated forage.

Structure-related Turbidity

Structure-related turbidity is expected to come from turbidity plumes generated by the propeller wash of vessel traffic operating from the marina/dock facilities. A general discussion of turbidity and its effects on salmonids is given in the direct effects subsection above, and is therefore not repeated here.

The intensity and duration of the turbidity plumes generated by vessel traffic would depend on a combination of vessel thrust, water depth, and substrate composition. Unlike construction-related turbidity, which would be primarily or wholly generated by a single vessel within a specific period of time in a single year, turbidity generated by vessels operating from the marina/dock facilities would persist year-round, year after year over the decades-long operational life extension of the structures. As a result, a wider range of life history stages, and greater total numbers of PS Chinook salmon and PS steelhead would be exposed to structure-related turbidity. Because of the year-round occurrence of vessel traffic, it is expected that some migrating adults as well as rearing and out-migrating juveniles of both species would be exposed to structure-related turbidity plumes. The turbidity plumes generated by vessels operating from the facilities are not expected to extend beyond 300', and turbidity is not expected to reach concentrations at which fish would experience bodily harm. Some loss or degradation of benthic foraging habitat is likely to occur; however, baseline conditions of benthic habit within the action area are highly degraded, and it is unlikely that structure-related turbidity would either: 1) significantly degrade the habitat further; or 2) prevent its recovery to a more functional state.

Structure-related turbidity is expected to elicit a behavioral avoidance response when/where PS Chinook salmon and PS steelhead encounter turbidity plumes. Adults would easily be able to avoid the turbidity plumes, whereas juveniles might not be able to swim rapidly enough to get away. Structure-related turbidity may thus interrupt the out-migration of PS Chinook salmon and PS steelhead juveniles, as well as interrupt the feeding behavior of juveniles rearing in the action area or out-migrants foraging as they pass through. However, due to the limited scale of the action area, the limited duration and intensity of the turbidity, and the small numbers of PS Chinook salmon and PS steelhead likely to be affected, structure-related turbidity is not expected to cause detectable population-level effects to either species.

Structure-related Propeller Wash

Whereas the discussion above addressed the deleterious effects of turbidity generated by propeller wash, the direct effects of propeller wash on PS Chinook salmon and PS steelhead is addressed here.

Authorization of the repairs to Chandler's Cove Marina and HC Henry Pier by USACE would extend the operational life of the facility structures by several decades, over which time vessel traffic would operate from the facilities year-round, year after year. Each time a vessel is operated, it would generate propeller wash. The intensity and size of the area affected by propeller wash would depend on a vessel's size, that is, the size and power of the engine and propeller(s); the power level at which the engine was run; and the vessel's path of travel, the water depth where it was operated, and the duration it was run in the marina/dock area.

Spinning boat propellers kill fish and small aquatic organisms, and the fast-moving turbulent water they generate can displace and disorient small fish and dislodge benthic aquatic organisms SAV, particularly in shallow water and/or when a propeller is being operated at high power. While adults would likely be able to avoid thrust plumes generated by vessel propellers, juvenile PS Chinook salmon and PS steelhead within the affected area would be too small to effectively swim against the propeller wash. Individuals that are struck or nearly missed by the propeller would be injured or killed by the exposure. At greater distances, propeller wash may displace and disorient fish. Depending on the direction and strength of the thrust plume, displacement could increase energetic costs, reduce feeding success, and may increase vulnerability to predators for individuals that tumble stunned and/or disoriented in the wash.

The number of juvenile PS Chinook salmon and PS steelhead that may be impacted by this stressor is unquantifiable, but is expected that some rearing and out-migrating juvenile PS Chinook salmon and PS steelhead would be affected over the course of decades of vessel operation from the marina/dock structures. However, it is not expected that sufficient numbers of either species would be affected to cause detectable population-level effects due to the small scale of the sites. Adult Chinook salmon and steelhead are not expected to be adversely affected, as they would be able to avoid propeller-generated thrust plumes, and any extra distance they may need to travel for to avoid the plume is expected to be minimal and would not affect their fitness or migration.

Construction-related propeller scour may also reduce SAV and diminish the density and diversity of the benthic community at the project site. However, the disturbance is not expected to have a significant effect on the SAV or benthic invertebrate communities within the action area. The SAV within the action area is dominated by invasive Eurasian milfoil and green algae, and benthic invertebrate composition is compromised due to the annual pycnocline that exists in Lake Union during warmer summer months. Thus, the effects of propeller scour are expected be too small to cause any detectable effects to benthic habitat against the backdrop of the current, highly degraded baseline conditions, nor are the effects expected to be significant enough to prevent or measurably hinder the recovery of benthic habitat within the action area due to the persistent and ongoing effects of other disturbances not related to the proposed action.

Structure-related Shade and Lighting Effects

Structure-related shade and lighting effects may come from; 1) shade cast by the dock and pier structures, as well as by vessels mooring at those structures; and 2) artificial lighting sources associated with the continued existence and operation of the marina/dock structures. Effects from structure-related shade and lighting would persist year-round, over the decades-long extension of the operational life of those structures made possible by the proposed repairs.

Structure-related Shade: The proposed repairs to Chandler's Cover Marina and HC Henry Pier will include replacement of a total of 5,758 ft^2 of existing wooden decking with grated fiberglass decking, which will allow the passage of 43% of sunlight. Although this will represent a reduction in shade compared to that of the existing structures, the repaired structures and the vessels moored to them would maintain reduced light conditions within the current footprint for the decades-long life extension of the facilities. Structure-related shade would reduce aquatic productivity within the action area, alter juvenile salmonid migratory behaviors, and increase juvenile salmonids' exposure and vulnerability to predators. As described above, some subset of each year's cohort of out-migrating juvenile PS Chinook salmon and PS steelhead would likely pass through the action area each year.

Shade limits primary productivity and can reduce the diversity of the aquatic communities beneath over-water structures (Nightingale and Simenstad 2001; Simenstad et al. 1999). Juvenile salmon feed on planktonic organisms such as amphipods, copepods, and euphausiids, as well as the larvae of many benthic species (NMFS 2006). Because large portions of the repaired structures and moored vessels would cast shadows over water and substrate that would otherwise be supportive of SAV and planktonic and benthic invertebrates, the shade would continue to reduce the quantity and diversity of natural cover and prey organisms for juvenile salmonids.

If situated alone along a stretch of undisturbed shoreline, the structures' impacts on aquatic productivity might not be expected to measurably affect the fitness of migrating juvenile salmonids. However, because the applicant's structures are situated among many other long-standing bankside over-water structures that line the shores of Lake Union, their shadows, in combination with the shadows of the adjacent structures, act to maintain long stretches of migratory habitat with inadequate shelter and forage resources for juvenile salmonids. Therefore, juvenile PS Chinook salmon and juvenile PS steelhead within the action area are likely to experience some degree of reduced fitness due to reduced availability of cover and prey that would be attributable to the applicant's marinas.

The shade of over-water structures also negatively affects juvenile salmonid migration. Numerous studies demonstrate that juvenile salmonids in both freshwater and marine habitats are more likely to avoid shadows cast by overwater structures rather than pass through the shaded area (Celedonia et al. 2008a, 2008b; Kemp et al. 2005; Moore et al. 2013; Munsch et al. 2014; Nightingale and Simenstad 2001; Ono et al. 2010; Southard et al. 2006; Tabor et al. 2006). Swimming around overwater structures increases the migratory distance, which has been positively correlated with increased mortality in juvenile Chinook salmon (Anderson et al. 2005).

Additionally, shade is a habitat characteristic preferred by freshwater predatory species, such as smallmouth bass and northern pikeminnow, both of which are known to prey heavily on juvenile salmonids (Celedonia et al. 2008a; Tabor et al. 2010). Migrating juvenile salmonids may be forced into deeper water in order to avoid shaded areas; however, deep water is also favored by freshwater predatory species and would increase the risk of predation to migrating juvenile salmonids (Willette 2001). Shade-related altered migratory behaviors would mostly affect juvenile PS Chinook salmon, as the juvenile PS steelhead that pass through the Lake Washington Shipping Canal are relatively large and shoreline independent, as are the adults of both species

Although shade coverage will be reduced compared to the existing conditions, the continued presence of the pier and marina structures is likely to continue to alter the migratory behavior for at least some of the juvenile Chinook salmon that pass through the action area, and inhibit them from migrating along the shoreline. Shade cast by the structures and vessels moored to them would delay passage beneath them, and/or induce some individuals to swim around the structures, effectively forcing them into open and relatively deep waters where they would be more vulnerable. While out-migrating juvenile PS steelhead are not as closely associated with the shoreline as Chinook salmon, the passage of some out-migrants is likely to be affected by structure-related shade as well. The forced off-bank migration of fish would increase migration distance and time, energetic costs (Heerhartz and Toft 2015), exposure to predation. It is also possible that rearing and out-migrating PS Chinook salmon and PS steelhead juveniles would experience reduced forage due to a loss of productivity as a result of structure-related shade. Reduced forage could, in turn, result in reduced fitness and increase mortality of affected juveniles. However, due to the relatively small scale of the proposed action, the structure-related shade is not expected to result in detectable population-level effects to either PS Chinook salmon or PS steelhead juveniles. Adult PS Chinook salmon and PS steelhead pass through Lake Union rapidly during migration and are not susceptible to predation from small mouth bass and northern pike minnow due to their larger size. Therefore, adult Chinook salmon and steelhead are not expected to be affected by structure-related shade.

Artificial Illumination: For the proposed action, it was asserted that there would be, "no artificial lighting associated with the proposed work," (USACE 2024a; 2024b). However, the vessels that use the marina/structures would have lighting systems that would cause nighttime artificial illumination of lake waters. Nighttime artificial illumination of the water's surface attracts fish (positive phototaxis) in marine and freshwater environments, and often shifts nocturnal behaviors toward more diurnal behaviors, and may affect light-mediated behaviors such as migration timing (Becker et al. 2013; Celedonia and Tabor 2015; Ina et al. 2017; Tabor and Piaskowski 2002; Tabor et al. 2017). Tabor and Piaskowski (2002) report that juvenile Chinook salmon in lacustrine environments typically feed and migrate during the day, and are inactive at night, residing at the bottom in shallow waters. They tend to move off the bottom and become increasingly active at dawn when light levels reach 0.8 to 2.1 lumens per square meter. Tabor et al. (2017) found that sub-yearling Chinook, coho, and sockeye salmon exhibit strong nocturnal phototaxic behavior when exposed to levels of 5.0 to 50.0 lumens per square meter, with phototaxis positively correlated with light intensity. Celedonia and Tabor (2015) found that juvenile Chinook salmon in the Lake Washington Ship Canal were attracted to artificially lit areas at 0.5 to 2.5 lumens per square meter. They also reported that attraction to artificial lights may delay the onset of morning migration by up to 25 minutes for some juvenile Chinook salmon in the Canal.

Vessels moored at the facilities are likely to be episodically illuminated at night, and are likely to illuminate the water surface at levels above 0.5 lumens. However, those incidences would likely be most frequent during the summer boating season after juvenile salmon have departed the Lake, and would be limited to relatively brief periods (minutes to low numbers of hours), and would be unlikely to cause anything more than short-lived minor phototaxis. Therefore, it is not expected that artificial illumination from the vessels moored at the marina/pier structures would cause any measurable effects on the fitness of exposed individuals, or cause any meaningful change in their normal behaviors.

2.5.2 Effects on Critical Habitat

This assessment considers the intensity of expected effects in terms of the change they would cause in affected Primary Biological Features (PBFs) and the severity of each effect, considered in terms of the time required to recover from the effect. Ephemeral effects are those that are likely to last for hours or days; short-term effects would likely last for weeks; and long-term effects are likely to last for months, years, or decades.

PS Chinook Salmon Critical Habitat

The action area contains designated critical habitat for PS Chinook salmon. Designated critical habitat for PS steelhead is not present within the action area. The proposed action, including full application of the planned conservation measures and BMPs, is likely to adversely affect designated critical habitat for PS Chinook salmon. The expected effects to critical habitat are below by PBF:

1. Freshwater spawning sites – There are no freshwater spawning sites within the action area.

2. Freshwater rearing sites – Juvenile Chinook salmon rearing in Lake Union is thought to be highly limited and not much information is available. It is highly questionable whether any juvenile Chinook salmon rearing habitat is present within the action area; however, if rearing habitat is present, the proposed action would affect freshwater rearing site attributes as follows:

    a. Floodplain connectivity – The proposed action would cause no effect on this attribute.
    b. Water quantity – The proposed project action would cause no effect on this attribute.
    c. Water quality – The proposed action would cause minor short-, medium-, and long-term effects on this attribute. In the short- and medium-term, water quality would be degraded by the release/mobilization of creosote-derived contaminants during pile stubbing, and from the generation of turbidity and mobilization of turbidity-bound contaminants from operation of the barge tug. In the medium- and long-term, water quality would be degraded by the release of pollutants from vessels moored at marina and pier facilities, copper runoff from ACZA-treated timber used in the construction of structural components of the overwater structures, leaching and runoff of contaminants from remaining legacy creosote-treated piles and structural components, and turbidity generated by vessel traffic. The proposed action is not expected to detectably affect water temperature within the action area.
    d. Forage – The proposed action would cause minor short-, medium-, and long-term effects on this attribute. In the short- and medium-term, forage quality would be degraded by the release/mobilization of creosote-derived contaminants during pile stubbing, and from the generation of turbidity and mobilization turbidity-bound contaminants trough operation of the barge tug. In the medium- and long-term, forage quality would be degraded by the release of pollutants from vessels moored at the marina and pier facilities, copper runoff from ACZA-treated timber used in the construction of structural components of the overwater structures, leaching and runoff of contaminants from remaining legacy creosote-treated piles and structural components, turbidity generated by vessel traffic, and a loss of productivity due to the prolonged operational life of the overwater structures.
    e. Natural cover – The proposed action would cause minor long-term adverse effects on this attribute. Extending the operational life of the facilities' overwater structures and floats would perpetuate conditions that act to limit the growth of SAV and provide habitat for predatory species that consume juvenile salmonids. However, the replacement of solid plank decking to grated decking would act to increase light penetration under the repaired structures and would be an improvement over current conditions.

3. <u>Freshwater migration corridors free of obstruction and excessive predation</u> – The action area is used as a migration corridor by both returning adult PS Chinook salmon, and by out-migrating juveniles. The proposed action would affect migration corridor attributes as follows:
    a. Obstruction and excessive predation – The proposed action would cause minor long-term adverse effects on this attribute. The altered light and in-water noise levels stemming from the continued presence and associated operations of the facilities' overwater structures and the moored vessels would act to obstruct or otherwise hinder the out-migration of juvenile Chinook salmon by creating shaded areas. The shaded areas would act as impediments to passage and would expose out-migrating juveniles to increased predation. However, the replacement

of solid plank decking to grated decking would act to increase light penetration under the repaired structures and would be an improvement over present conditions.

b. Water quantity – The proposed project would cause no effect on this attribute.
c. Water quality – The proposed action would cause minor short-, medium-, and long-term effects on this attribute. In the short- and medium-term, water quality would be degraded by the release/mobilization of creosote-derived contaminants during pile stubbing, and from the generation of turbidity and turbidity-bound contaminants from operation of the barge tug. In the medium- and long-term, water quality would be degraded by the release of pollutants from vessels moored at marina and pier facilities, copper runoff from ACZA-treated timber used in the construction of structural components of the overwater structures, leaching and runoff of contaminants from remaining legacy creosote-treated piles and structural components, and turbidity generated by vessel traffic. The proposed action is not expected to detectably affect water temperature within the action area.
d. Natural cover – The proposed action would cause minor long-term adverse effects on this attribute. Extending the operational life of the facilities' overwater structures and floats would perpetuate conditions that act to limit the growth of SAV and provide habitat for predatory species that consume juvenile salmonids. However, the replacement of solid plank decking to grated decking would act to increase light penetration under the repaired structures and would be an improvement over current conditions.

4. <u>Estuarine areas free of obstruction and excessive predation</u> – There are no estuarine areas in the action area.

5. <u>Nearshore marine areas free of obstruction and excessive predation</u> – There are no nearshore marine areas within the action area.

6. <u>Offshore marine areas</u> – There are no offshore marine areas within the action area.

2.6. Cumulative Effects

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

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

The current conditions of ESA-listed species and designated critical habitat within the action area are described above in sections 2.2 and 2.4. The non-federal activities in and upstream of the action area that have contributed to those conditions include past and on-going bankside development, vessel activities, and upland urbanization, as well as upstream forest management, agriculture, road construction, water development, subsistence and recreational fishing, and restoration activities. Those actions were, and continue to be, driven by a combination of economic conditions that characterized traditional natural resource-based industries, general resource demands associated with settlement of local and regional population centers, and the efforts of conservation groups dedicated to the restoration and use of natural amenities for cultural inspiration and recreational experiences.

NMFS is unaware of any specific future non-federal activities that are reasonably certain to affect the action area; however, NMFS is reasonably certain that future non-federal actions such the activities mentioned above are all likely to continue and increase in the future as the human population continues to grow across the region: Continued habitat loss and degradation of water quality from development and chronic low-level inputs of non-point source pollutants will likely continue into the foreseeable future. Recreational and commercial use of the waters within the action area are also likely to increase as the human population grows. The effects of anthropogenic climate change will also likely become increasingly pronounced throughout many parts of the Pacific Northwest region in the coming decades.

The intensity of these influences depends on many social and economic factors, and therefore is difficult to predict. Further, the adoption of more environmentally acceptable practices and standards may gradually reduce some negative environmental impacts over time. Interest in restoration activities has increased as environmental awareness continues to rise among the public. State, tribal, and local governments have developed plans and initiatives to benefit ESA-listed PS Chinook salmon and PS steelhead within many of the watersheds that flow into the action area. However, the implementation of plans, initiatives, and specific restoration projects are often subject to political, legislative, and fiscal challenges that increase the uncertainty of their success.

2.7. Integration and Synthesis

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

As described in more detail above in Section 2.4, climate change is likely to increasingly affect the abundance and distribution of the ESA-listed species considered in the opinion. It is also likely to increasingly affect the PBFs of designated critical habitat. The exact effects of climate change are both uncertain, and unlikely to be spatially homogeneous. However, climate change is reasonably likely to cause reduced instream flows in some systems, and may impact water quality through elevated instream water temperatures and reduced dissolved oxygen, as well as by causing more frequent and more intense flooding events.

Climate change may also impact coastal waters through elevated surface water temperature, increased and variable acidity, increased storm frequency and magnitude, and sea level rise. The adaptive ability of ESA-listed species is uncertain, but is likely reduced due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. The proposed action will cause direct and indirect effects on the ESA-listed species and critical habitats considered in the opinion well into the foreseeable future. However, the action's effects on water quality, substrate, and the biological environment are expected to be of such a small magnitude that no detectable effects on ESA-listed species or critical habitat due to synergistic interactions with climate change impacts are expected.

2.7.1 ESA-listed Species

PS Chinook salmon and PS steelhead are both listed as threatened under the ESA. The listings are based on declines from historical abundance and productivity, loss of spatial structure and diversity, and an array of limiting factors which have become a baseline habitat condition. Both species will be affected over time by cumulative effects, some positive – as restoration efforts and regulatory revisions advance habitat protections and recovery, and some negative – as climate change and unregulated or difficult to regulate sources of environmental degradation persist or increase. Overall, habitat trends are likely to be a primary determining factor of the degree to which the viability parameters of each species are positive or negative. In this context NMFS considers how the proposed action's impacts on individual fish would affect each listed species at the population and ESU/DPS scales.

PS Chinook salmon

The long-term abundance trend of the PS Chinook salmon ESU is slightly negative. Reduced or eliminated accessibility to historically important habitat, combined with degraded conditions in the habitat that remains due to land use activities, appear to be the greatest threats to the recovery of PS Chinook salmon. To a lesser degree, commercial and recreational fisheries also continue to impact this species.

The PS Chinook salmon most likely to occur in the action area would be from the fall-rum Cedar River and the North Lake Washington/Sammamish River populations, both of which are part of the South Puget Sound MPG. Both populations are considered to be at a high risk of extinction due to low abundance and productivity.

The project site is located along the south bank of Lake Union, which serves as a freshwater migration route for both populations to and from marine waters for juvenile and adult fish, respectively. The environmental baseline within the action area has been degraded by the effects of long-term, near-complete bankside development; extensive alteration of the biotic and abiotic characteristics of Lake Union due to the construction of the Lake Washington Ship Canal; and by nearby, as well as farther down- and upstream industrial development, urbanization, agriculture, forestry, water diversion, and road construction and maintenance.

The timing of the proposed work avoids the normal migration season for returning adult PS Chinook salmon, but work between December 31 and April 30 would overlap with the early part of the out-migration season for juveniles. Additionally, over the next several decades, low numbers of out-migrating juveniles that pass through the project sites would be exposed to low levels of contaminated forage and other altered habitat conditions, that both individually and collectively, would cause some combination of altered behaviors, reduced fitness, and mortality in some of the exposed individuals. Juvenile Chinook salmon rearing in Lake Union is thought to be highly limited, if present at all, and not much information is available; however, the possibility must be considered that an extremely small number of rearing juveniles could be present in the action area at some point. The annual numbers of individuals across all life history stages that would be detectably affected by action-related stressors would be extremely low, and not detectable at the population level.

Based on the best available information, the scale of the direct and indirect effects of the proposed action, when considered in combination with the degraded baseline conditions, cumulative effects, and the impacts of climate change, would be too small to cause detectable effects on any of the population viability characteristics (abundance, productivity, distribution, or genetic diversity) of the affected PS Chinook salmon populations. Therefore, the proposed action would not appreciably reduce the likelihood of survival and recovery of the ESU.

PS Steelhead

The long-term abundance trend of the PS steelhead DPS is negative, especially for natural spawners. Growth rates are currently declining at 3 to 10% annually for all but a few DIPs. The extinction risk for most DIPs is estimated to be moderate to high, and the DPS is currently considered “not viable”. Reduced or eliminated accessibility to historically important habitat, combined with degraded conditions in remaining available habitat due to land use activities, appear to be the greatest threats to the recovery of PS steelhead. Fisheries activities also continue to impact this species.

The PS steelhead most likely to occur in the action area would be fish from the winter-run Cedar River and North Lake Washington/Lake Sammamish DIPs. The abundance trends between 1984 and 2016 were strongly negative for both DIPs, and ten or fewer adult natural-spawners are estimated to return to the DIPs annually; the DIPs can be considered functionally extirpated from the Lake Washington Subbasin.

The project site is located along the south bank of Lake Union, which serves as a freshwater migration route for both DIPs to and from marine waters for juvenile and adult fish, respectively. The environmental baseline within the action area has been degraded by the effects of long-term, near-complete bankside development; extensive alteration of the biotic and abiotic characteristics of Lake Union due to the construction of the Lake Washington Ship Canal; and by nearby, as well as farther down- and upstream industrial development, urbanization, agriculture, forestry, water diversion, and road construction and maintenance.

It is unlikely that any PS steelhead would be directly exposed to the proposed work; however, over the next several decades, low numbers of out-migrating juveniles that pass through the action area may be exposed to low levels of contaminated forage and other altered habitat conditions, that both individually and collectively, would cause some combination of altered behaviors, reduced fitness, and mortality in some of the exposed individuals. The annual numbers of individuals that would be detectably affected by action-related stressors would be extremely low.

Based on the best available information, the scale of the direct and indirect effects of the proposed action, when considered in combination with the degraded baseline conditions, cumulative effects, and the impacts of climate change, would be too small to cause detectable effects on any of the population viability characteristics (abundance, productivity, distribution, or genetic diversity) of the affected PS steelhead DIPs. Therefore, the proposed action would not appreciably reduce the likelihood of survival and recovery of the DPS.

2.7.2 Critical Habitat

Critical habitat was designated for PS Chinook salmon to ensure that specific areas with PBFs that are essential to its conservation are appropriately managed or protected. Critical habitat for PS Chinook salmon will be affected over time by cumulative effects, some positive – as restoration efforts and regulatory revisions advance habitat protections and recovery, and some negative – as climate change and unregulated or difficult to regulate sources of environmental degradation persist or increase. Overall, the effects on PBFs of critical habitat for PS Chinook salmon are likely to reflect the degree to which overall habitat trends are negative or positive. In this context NMFS considers how the impacts of the proposed action on the action area’s PBFs would affect the designated critical habitat’s ability to support the conservation of the PS Chinook salmon ESU as a whole.

Past and ongoing land and water use practices have degraded salmonid critical habitat throughout the Puget Sound Basin. Hydropower and water management activities have reduced or eliminated access to significant portions of historic spawning habitat. Timber harvesting, agriculture, industry, urbanization, and shoreline development have adversely altered floodplain and stream morphology in many watersheds, diminished the availability and quality of estuarine and nearshore marine habitats, and reduced water quality across the region.

Global climate change is expected to increase stream temperatures, alter stream flows, and exacerbate impacts to baseline conditions in freshwater habitats across the region through a variety of mechanisms. Rising sea levels are expected to increase coastal erosion and alter the composition of nearshore habitats, which could further reduce the availability and quality of estuarine habitats. Increased ocean acidification may also reduce the quality of estuarine habitats.

In the future, water and land use on non-federal land is likely to increase, as are the impacts of global climate change. The degree to which those factors will influence salmonid critical habitat is uncertain, as is the degree to which those impacts may be tempered by the adoption of more environmentally acceptable water and land use practices, and by efforts to address the effects of climate change.

The primary PBF of PS Chinook salmon critical habitat in the action area is are freshwater migration corridors free of obstruction and excessive predation. The site attributes of this PBF that would be affected by the action are obstruction and excessive predation, water quality, and natural cover. As described above, the project site is located along a heavily impacted waterway, and all three of these site attributes currently function at reduced levels compared to undisturbed freshwater migratory corridors. The extended life of the facilities' piers and docks, along with the continuation of structure-related vessel operations would cause minor long-term adverse effects on the identified site attributes. On the positive side, the proposed work would also reduce ongoing PAH contamination due to the requirement that all stubbed creosote-treated piles must be wrapped, and would increase light penetration of the overwater structures from the installation of new grated decking.

The possibility exists that some juvenile Chinook rearing may occur within the action area, and therefore it must be considered that the action area provides the freshwater rearing site PBF. The freshwater rearing site PBF attributes that would be affected by the action would include water quality, natural cover, and forage. However, information on Chinook salmon rearing in Lake Union is highly limited, and juvenile Chinook salmon rearing in the action area is largely hypothetical. If any rearing of juvenile Chinook salmon were to occur within the action area, it is expected that such usage would be minimal and uncommon.

Based on the best available information, the scale of the proposed action's effects, when considered in combination with the degraded baseline, cumulative effects, and the impacts of climate change, would be too small to cause any detectable long-term negative changes in the quality or functionality of the freshwater migration corridors or rearing habitat PBF in the action area. Therefore, this critical habitat is expected to maintain its current level of functionality, and the ability for current PBFs to attain recovery to serve the intended conservation role for PS Chinook salmon would not be affected.

2.8. Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of PS Chinook salmon or PS steelhead, nor destroy or adversely modify designated critical habitat for the former. (Critical habitat has not been designated for PS steelhead within the action area.)

2.9. Incidental Take Statement

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

2.9.1. Amount or Extent of Take

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

Harm of PS Chinook salmon from exposure to:

- Construction-related noise,
- Construction-related chemical contamination of forage,
- Construction-related turbidity
- Construction-related propeller wash
- Structure-related noise
- Structure-related chemical contamination of forage
- Structure-related turbidity
- Structure-related propeller wash, and
- Structure-related altered lighting.

Harm of PS steelhead from exposure to:

- Construction-related noise,
- Construction-related chemical contamination of forage,
- Construction-related turbidity
- Construction-related propeller wash
- Structure-related noise
- Structure-related chemical contamination of forage
- Structure-related turbidity
- Structure-related propeller wash, and
- Structure-related altered lighting

NMFS cannot predict with meaningful accuracy the number of PS Chinook salmon and PS steelhead that are reasonably certain to be injured or killed annually by exposure to any of these stressors. The distribution and abundance of fish that occur within an action area are affected by habitat quality, competition, predation, and the interaction of processes that influence genetic, population, and environmental characteristics. These biotic and environmental processes interact in ways that may be random or directional, and operate across far broader temporal and spatial scales than are affected by the proposed action. Thus, the distribution and abundance of fish within the action area cannot be attributed entirely to habitat conditions, nor can NMFS precisely predict the number of fish that are reasonably certain to be injured or killed if their habitat is modified or degraded by the proposed action. Additionally, NMFS knows of no device or practicable technique that would yield reliable counts of individuals that may experience these impacts. In such circumstances, the NMFS uses the causal link established between the activity and the likely extent and duration of changes in habitat conditions to describe the extent of take as a numerical level of habitat disturbance. The most appropriate surrogates for take are action-related parameters that are directly related to the magnitude of the expected take.

For the proposed action, the timing and duration of work is the best available surrogate for the extent of take of juvenile PS Chinook salmon and juvenile PS steelhead from exposure to construction-related noise, turbidity, and propeller wash. This is because the planned work window was selected to reduce the potential for juvenile fish presence at the project sites while construction activities are ongoing, and thus reduce their risk of exposure to construction-related take. Therefore, working outside of the planned work window would increase the number of fish likely to be exposed to these construction-related impacts.

The number of piles to be stubbed is the best available surrogate for the extent of take of juvenile PS Chinook salmon and juvenile PS steelhead from exposure to construction-related forage contamination. This is because stubbing of creosote-treated piles is expected to the primary source of construction-related chemical contamination. Thus, the extent and severity of contamination is expected to be roughly proportional to the number of piles that are stubbed. Furthermore, construction-related chemical contamination is expected to extend beyond the in-water work window, therefore making the timing and duration of work an unsuitable surrogate for construction-related forage contamination.

The location, size, and configuration of the repaired and/or replaced overwater structures are the best available surrogates for the extent of take of juvenile PS Chinook salmon and juvenile PS steelhead from exposure to structure-related noise, water and forage contamination, propeller wash, and altered lighting. The location is appropriate because installation of the overwater structures closer to shore would increase the likelihood of exposing juvenile PS Chinook salmon and to altered lighting, vessel noise, and propeller wash, due to the increased proximity of those structures to preferred juvenile Chinook salmon habitat. Installation of the structures in shallower water would also increase propeller wash impacts on SAV and other benthic resources, which would increase the likelihood that juvenile PS Chinook salmon and juvenile PS steelhead would experience unanticipated take due to reduced availability of shelter and forage resources, and would be more likely to be directly exposed to the propelelr wash itself.

Structure size and configuration are appropriate for altered lighting because this will determine the amount of water and benthic habitat that is shaded by the marina/pier structures, and the distance juveniles would be required to swim around those shaded areas. The amount of shaded area would increase as the size and opacity of the structures increased. The additional travel distance juveniles would need to swim to avoid shaded areas would be influenced by the size of the structures, but could also be influenced by the structure confituration/shape. For instance, a 10’ × 10’ and a 2’ × 50’ structure would both occupy the same square footage of area, but the 2’ × 50’ structure would require a much greater travel distane to circumvent.

Artifical illumination could also increase with structure size and/or be influneced by configuration. Vessels moored at the strutures would produce artificial illumination. The moorage space, and therefore total number of vessels would be influenced by the size and configuration of a structure. Moorage space would, in principle, increase with strucure size, but would also be dependant on configuration as well. Configurations with a larger perimeter, such as docks with many individual fingers/floats, would have more moorage space than, a less complex structure, such as a single pier. The additional moorage space could be used by more vessels, which would in turn produce more artificial light. Under the present proposed action, nightime phototaxis is not expected to occur; however, unexpected/unanalyzed increases illumination levles would increase the risk of the occurrence of phototaxis.

Size and configuration are also appropriate surrogates for structure-related water and forage contamination, noise, and propeller wash because those stressors are all positively linked with the number of vessels that moor at a structure, which is largely a function of the structure's size and perimiter. As described above, as the size and permiter of a mooring structure increases, the number of boats that in can accommodate also increases. As the number of boats increases, so too does boating activity, with concomittant increases in the potential exposure to vessel-derived pollutants, noise, and propeller wash for juvenile PS Chinook salmon and juvenile PS steelhead.

Furthermore, AZCA-treated timber will be used to construct the above-water framing components of the reparied marina/pier structures. Therefore, as structure size increases, so too would the amount of ACZA timber that is used, which increases the amount of copper introduced into the Lake in stormwater runoff and from wave action. Any additional copper from ACZA-treated timber would compound pollutants from vessels moored at the facilities.

In summary, the extent of PS Chinook salmon and PS steelhead take for this action is defined as:

- Approximately 2 – 3 weeks of in- and over-water work each at Chandler's Cove Marina and HC Henry Pier to be completed between October 1 and April 15;
- Stubbing a combined total of 92 piles between both sites;
- Replacement of a combined total of 5,758 ft^2 of existing wooden decking with new grated decking that provides light penetration of 43%;
- Adherence to the post-construction location, dimensions, and configuration of the applicant's overwater structures as described in the proposed action section of this opinion, and as shown as the designed plans used in the analysis herein.

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

Although these take surrogates could be construed as partially coextensive with the proposed action, they nevertheless function as effective reinitiation triggers. If any of these take surrogates exceed the proposal, it could still meaningfully trigger reinitiation because USACE has authority to conduct compliance inspections and to take actions to address non-compliance, including post-construction (33 CFR 326.4).

2.9.2. Effect of the Take

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

2.9.3. Reasonable and Prudent Measures

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

USACE shall require the applicant to:

1. Ensure the implementation of monitoring and reporting to confirm that the take exemption for the proposed action is not exceeded.

2.9.4. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. 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. The following terms and conditions implement reasonable and prudent measure 1:
    a. USACE shall require the applicant to develop and implement plans to collect and report details about the take of listed fish. That plan shall:
        i. Require the applicant and/or their contractor to maintain and submit records to verify that all take indicators are monitored and reported. Minimally, the records should include:
            1. Documentation of the timing and duration of in-water work to ensure that the work is accomplished between October 1 and April 14 at both sites;
            2. Documentation of the dates and counts of pile stubbing, and that all creosote-treated piles were wrapped in accordance with WA-DNR regulations;
            3. Documentation of the lateral extent of any turbidity plumes generated by construction-related activities, and measures taken to maintain them within 300’; and
            4. Documentation of the location, size, and configuration of the repaired and/or replaced overwater structures to confirm that they do not deviate from the locations, dimensions, and configurations described in the provided design plans.
        ii. Require the applicant to establish procedures for the submission of construction records and other materials to the appropriate USACE office, and to submit an electronic post-construction report to NMFS within six months of project

completion. Send the report to: projectreports.wcr@noaa.gov. Be sure to include "Attn: WCRO-2022-02773 & WCRO-2022-02774" in the subject line.

2.10. Conservation Recommendations

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

1. USACE and the applicant should encourage contracted tugboat operator(s) and client vessel operators to use the lowest safe maneuvering speeds and power settings when maneuvering near the marina/pier structures, with the intent to minimize propeller wash effects and mobilization of sediment.
2. USACE should encourage the applicant to limit all in- and overwater work to the period between July 16 and December 31 to reduce the likelihood exposing juvenile Chinook salmon to the direct effects of construction.
3. USACE should encourage the applicant to develop a plan to reduce the environmental impacts at each site. Suggested measures include:
    a. Establish and/or continue to implement a system to prevent and routinely remove litter, wastes, and floating pollutants from the waters within the sites;
    b. Establish and/or continue to implement efforts at the sites to reduce the input of vessel-related pollutants;
    c. Establish or continue to implement a policy to require patrons to operate power boats at low speeds at each site and in adjacent shallow shoreline areas; and
    d. Establish and/or continue to implement a system to instruct patrons about the importance of the nearshore habitats at the sites to migrating juvenile Chinook salmon.

2.11. Reinitiation of Consultation

This concludes formal consultation for Repairs to Chandler's Cove Marina and HC Henry Pier, Lake Union, King County, Washington (NMFS Consultation Numbers: WCRO-2022-02773 & WCRO-2022-02774, respectively).

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

2.12. "Not Likely to Adversely Affect" Determinations

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.

As described in Section 1.2, NMFS has concluded that the proposed action would be not likely to adversely affect southern resident killer whales (SRKW) or their designated critical habitat. Detailed information about the biology, habitat, and conservation status and trends of SRKW can be found in the listing regulations and critical habitat designations published in the Federal Register, as well as in the recovery plans and other sources at: https://www.fisheries.noaa.gov/species-directory/threatened-endangered, and are incorporated here by reference.

The applicable standard to find that a proposed action is not likely to adversely affect listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial. 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. Discountable effects are those extremely unlikely to occur. The effects analysis in this section relies heavily on the descriptions of the proposed action and project site conditions discussed in Sections 1.3 and 2.4, and on the effects analyses presented in Section 2.5.

2.12.1 Effects on Listed Species

SRKW are limited to marine water habitats, and would not be directly exposed to any construction-related effects, but they could possibly be exposed to indirect effects through the trophic web (Hanson et al. 2021). As described in Section 2.1 the PS Chinook populations that would be affected by the proposed action are very small. Further, as described in Section 2.5, the proposed action would annually affect too few individuals to cause detectable population-level effects on the affected Chinook salmon populations. Therefore, any project-related reduction in Chinook salmon availability for SRKW would be undetectable. Similarly, although some juvenile Chinook salmon would be exposed to contaminated prey at the project site, their individual levels of contamination as well as the total numbers of annually exposed individuals would be too low to cause any detectable trophic link between the sediment contaminants and SRKW. Therefore, the action is not likely to adversely affect SRKW.

2.12.2 Effects on Critical Habitat

This assessment considers the intensity of expected effects in terms of the change they would cause in affected PBFs from their baseline conditions, and the severity of each effect, considered in terms of the time required to recover from the effect. Ephemeral effects are those that are likely to last for hours or days, short-term effects would likely to last for weeks, and long-term effects are likely to last for months, years or decades.

SRKW Critical Habitat: Designated critical habitat for SRKW includes marine waters of Puget Sound that are at least 20' deep. The expected effects on SRKW critical habitat from completion of the proposed action, including full application of the conservation measures and BMPs, would be limited to the impacts on the PBFs as described below:

1. Water quality to support growth and development – The proposed action would cause no detectable effects on marine water quality.

2. Prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth – The proposed action would cause long-term undetectable effects on prey availability and quality. Action-related impacts would annually injure extremely low numbers of juvenile Chinook salmon (one of the primary prey items for SRKW; NMFS and WDFW 2018; Hanson et al. 2021), including exposing some individuals to contaminated forage. However, the number of affected juvenile Chinook salmon and the levels of contamination would be too small to cause detectable effects on prey availability for SRKW, nor to create any detectable trophic link between the contaminants and SRKW. Thus, no detectable reduction in prey availability and quality is expected.

3. Passage conditions to allow for migration, resting, and foraging – The proposed dredging would cause no detectable effects on marine passage conditions.

Therefore, the proposed action is not likely to adversely affect SRKW critical habitat.

For the reasons expressed immediately above, NMFS has concluded that the proposed action is not likely to adversely affect ESA-listed SRKW or their designated critical habitat.

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 on the NMFS Habitat App (NMFS 2024; https://maps.fisheries.noaa.gov/portal/apps/webappviewer/index.html?id=e8311ceaa4354de290fb1c456cd86a7f) and EFH assessment provided by the USACE and the descriptions of EFH contained in the fishery management plan for Pacific Coast salmon developed by the Pacific Fishery Management Council and approved by the Secretary of Commerce (PFMC 2014).

EFH Affected by the Proposed Action

The action area is located in Seattle, along the southern shore of Lake Union, which is part of a network of different water bodies termed the Lake Washington Ship Canal. The waters and substrate of the Lake Union and other areas of the Lake Washington Ship Canal are designated as freshwater EFH for various life-history stages of Pacific Coast Salmon, which, within the Lake Washington Subbasin, include Chinook and coho salmon. The waters of Lake Union have also been designated as EFH for Pacific Coast Groundfish based on habitat suitability (PFMC 2023; NMFS 2024); however, the presence of groundfish is unlikely due to the Lake being freshwater during most months of the year, and brackish in summer months, when a saltwater wedge is able to advance through the Ballard Locks and up the Canal due to the high vessel traffic, and therefore frequent opening of the Locks. Furthermore, due to trophic links between PS Chinook salmon and SRKW, the project's action area also overlaps with marine waters that have been designated under the MSA as EFH for Pacific Coast Salmon, Pacific Coast Groundfish, and Coastal Pelagic Species; however, the action would cause no detectable effects on any components of marine EFH. Therefore, the action's effects on EFH would be limited to impacts on freshwater EFH for Pacific Coast Salmon, and would not adversely affect marine EFH for Pacific Coast Salmon, or for Pacific Coast groundfish and coastal pelagic species.

Freshwater EFH for Pacific salmon is identified and described in Appendix A to the *Pacific Coast Salmon Fishery Management Plan* (PFMC 2014), and consists of four major components: 1) spawning and incubation; 2) juvenile rearing; 3) juvenile migration corridors; and 4) adult migration corridors and holding habitat.

Those components of freshwater EFH for Pacific Coast Salmon depend on habitat attributes for spawning, rearing, and migration that include: 1) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); 2) water quantity, depth, and velocity; 3) riparian-stream-marine energy exchanges; 4) channel gradient and stability; 5) prey availability; 6) cover and habitat complexity (e.g., large woody debris, pools, aquatic and terrestrial vegetation, etc.); 7) space; 8) habitat connectivity from headwaters to the ocean (e.g., dispersal corridors); 9) groundwater-stream interactions; and (10) substrate composition.

As part of Pacific Coast Salmon EFH, five Habitat Areas of Particular Concern (HAPCs) have been defined: 1) complex channels and floodplain habitats; 2) thermal refugia; 3) spawning habitat; 4) estuaries; and 5) marine and estuarine submerged aquatic vegetation. HAPCs have also been identified for Pacific Coast Groundfish. The action area provides no known HAPC habitat features for Pacific Coast Salmon or any other species.

Adverse Effects on EFH

The ESA portion of this document (Sections 1 and 2) describes the proposed action and its adverse effects on ESA-listed species and critical habitat, and is relevant to the effects on EFH for Pacific Coast Salmon. Based on the analysis of effects presented in Section 2.5 the proposed action will cause minor short- and long-term adverse effects on EFH for Pacific Coast Salmon as summarized below.

1. Water quality: – The proposed action would cause minor short-, medium-, and long-term adverse and beneficial effects on this attribute. Adverse effects would be caused by: a) chemical contamination associated with stubbing of creosote-treated piles; b) turbidity generated by pile stubbing and by construction-related propeller wash; c) structure-related chemical contamination from vessels moored at the marina/pier structures; d) structure-related chemical contamination from ACZA timber used to construct new structural components of the marina/pier structures; e) structure-related chemical contamination from the continued existence of legacy creosote-treated piles, beams, and other structural components present in the marina and pier structures; and f) structure-related turbidity from vessels moored at the marina/pier structures. Beneficial effects would be due to the requirement that all creosote-treated piles that were stubbed would need to be wrapped from 1' below the mudline to above the highwater mark, thus removing a source of contamination by ending direct contact between the creosote-treated timber piles and the water. Detectable water quality impacts are expected to be limited to the areas within 300' around the project sites and marina/pier structures. The action would cause no measurable changes in water temperature or salinity.

2. Water quantity, depth, and velocity: – No changes to this attribute are expected.

3. Riparian-stream-marine energy exchanges: – No changes to this attribute are expected.

4. Channel gradient and stability: – No changes to this attribute are expected.

5. Prey availability: – The proposed action would cause short-, medium-, and long-term minor adverse effects on this attribute. The replacement of the overwater structures would limit productivity and SAV growth and reduce the density and diversity of the benthic and planktonic communities under those structures, such as amphipods, copepods, and larvae of benthic invertebrate species that are important prey for juvenile salmonids. Additionally, any contaminants that are introduced/mobilized during pile stubbing, combined with continued low-level inputs of structure-related contaminants, would continue to be taken up by some of the available prey organisms. Detectable effects are expected to be limited to the area within about 300' around the marina/pier structures.

6. Cover and habitat complexity: – The proposed action would cause long-term minor adverse effects on this attribute. The replacement of the overwater structures would limit SAV growth under those structures. Furthermore, the overwater structures would provide preferred habitat for certain species which prey upon juvenile salmonids, increasing their risk of predation mortality. Detectable effects would be limited to the combined 59,620 ft^2 area under the overwater structures at the two sites.

7. Water quantity: – No changes to this attribute are expected.

8. Space: – No changes to this attribute are expected.

9. Habitat connectivity from headwaters to the ocean: – No changes to this attribute expected.

10. Groundwater-stream interactions: – No changes to this attribute are expected.

11. Connectivity with terrestrial ecosystems: – No changes to this attribute expected.

12. Substrate composition: – No changes to this attribute are expected.

3.1. EFH Conservation Recommendations

The proposed action includes design features, conservation measures, and BMPs that are expected to reduce and help offset action-related impacts on the quantity and quality of Pacific Coast salmon EFH. Full implementation of the following EFH conservation recommendations would protect up to approximately 21.7 ac of designated EFH for Pacific Coast salmon by avoiding or minimizing the adverse effects described in section 3.2 above.

To reduce adverse impacts on water quality and prey availability, USACE should:

1. Require the applicant to limit all in- and overwater work to the period between July 16 and December 31 to reduce the likelihood exposing juvenile Chinook salmon to the direct effects of construction;
2. Encourage the applicant to require contracted tugboat operator(s) and client vessel operators to use the lowest safe maneuvering speeds and power settings when maneuvering near the marinas, with the intent to minimize propeller wash effects and mobilization of sediments at the sites; and
3. Encourage the applicant to continue or develop a plan to reduce the environmental impacts at their facilities. Suggested measures include:
    a. Continue or establish a system to prevent and routinely remove litter, wastes, and floating pollutants from the waters within the facilities;
    b. Continue or resume efforts at the facilities to reduce the input of vessel-related pollutants;
    c. Continue or establish a policy to require patrons to operate vessels at low speeds at the marina/pier docks and in adjacent shallow shoreline areas; and
    d. Continue or establish a system to instruct patrons about the importance of the nearshore habitats at the sites to migrating juvenile salmon.

NMFS knows of no practical measures that are available to further reduce the action’s expected effects on cover and habitat complexity.

3.2. 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.

3.3. Supplemental Consultation

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 U.S. Army Corps of Engineers. Other interested users could include applicants/licensee. Individual copies of this opinion were provided to the U.S. Army Corps of Engineers. The document will be available at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

4.2 Integrity

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

4.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

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