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

Refer to NMFS No:
WCRO-2019-03112

November 25, 2019

Michelle Walker
Chief Regulatory Branch
Seattle District, U.S. Army Corps of Engineers
P.O. Box 3755
Seattle, Washington 98124-3755

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Lehigh Hanson Seattle Terminal Berth Maintenance Dredging project, King County, Washington (6th Field HUC 171100130305).

Dear Ms. Walker:

Thank you for your email on May 24, 2019, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the U.S. Army Corps of Engineers' (COE) proposed issuance of a permit to the Lehigh Hanson Seattle Terminal Berth Maintenance Dredging project. In this opinion, NMFS concludes that the proposed action is not likely to jeopardize the continued existence of Puget Sound (PS) Chinook and PS steelhead. The project is also not likely to result in the destruction or adverse modification of critical habitat designated for PS Chinook or PS steelhead.

As required by section 7 of the Endangered Species Act, the National Marine Fisheries Service provided an incidental take statement with the biological opinion. The incidental take statement describes reasonable and prudent measures the National Marine Fisheries Service considers necessary or appropriate to minimize incidental take associated with this action. The take statement sets forth nondiscretionary terms and conditions. Incidental take from actions that meet the term and condition will be exempt from the Endangered Species Act take prohibition.

NMFS also reviewed the likely effects of the proposed action on essential fish habitat (EFH), pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855(b)), and concluded that the action would adversely affect the EFH of Pacific Coast salmon and Pacific Coast Groundfish. Therefore, we have included the results of that review in Section 3 of this document.

Please contact Lisa Abernathy of the Oregon/Washington Coastal Area Office at (206) 526-4742, or by email at Lisa.Abernathy@noaa.gov if you have any questions concerning this Section 7 consultation, or if you require additional information.

Sincerely,

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

cc: Rory Lee, U.S. Army Corps of Engineers

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

Lehigh Hanson Seattle Terminal Berth Maintenance Dredging Project, King County, Washington

NMFS Consultation Number: WCRO-2019-03112

Action Agency: U.S. Army Corps of Engineers

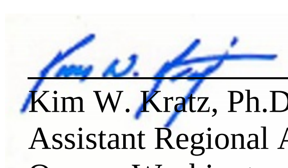
Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely to Destroy or Adversely Modify Critical Habitat?
Puget Sound (PS) Chinook *(Oncorhynchus tshawytscha)*	Threatened	Yes	No	Yes	No
PS steelhead (*Oncorhynchus mykiss*)	Threatened	Yes	No	Yes	No

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

Consultation Conducted By: National Marine Fisheries Service
West Coast Region

Issued By:



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

Date: November 25, 2019

TABLE OF CONTENTS

1. INTRODUCTION

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

1.1 Background

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

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

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

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

1.2 Consultation History

This biological opinion is based on the information provided in the May 24, 2019, biological evaluation (BE) and supporting documents. The U.S. Army Corps of Engineers (COE) requested informal consultation on May 24, 2019. On July 1, 2019, NMFS initiated formal consultation. A complete record of this consultation is on file at the Oregon Washington Coastal Office located in Lacey, Washington.

The COE concluded that the proposed action is likely to adversely affect (LAA) Puget Sound (PS) Chinook (*Oncorhynchus tshawytscha*) and PS steelhead (*Oncorhynchus mykiss*) and their critical habitats. NMFS concurs with the COE's determination.

NMFS also reviewed the likely effects of the proposed action on EFH, and concluded that the action would adversely affect the EFH of Pacific Coast salmon and Pacific Coast Groundfish.

1.3 Proposed Federal Action

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

The Corps of Engineers is proposing to issue a permit under Section 404 of the Clean Water Act to Lehigh Hanson for a Seattle Terminal Berth Maintenance Dredging project at their aggregate, cement, and ready-mix facility located on the Lower Duwamish Waterway (LDW) at 5225 East Marginal Way South, Seattle, Washington 98134. The Project is proposed to provide safe navigation for vessel ingress and egress at the Lehigh Hanson berth area by removing approximately 1,800 cubic yards (cy) of sediment and incidental material through maintenance dredging. The conceptual maintenance dredge design will target a depth of -19 feet mean lower low water (MLLW) with a 2-foot overdredge allowance (to -21 feet MLLW). This is within the previously authorized berth depth of -20 feet MLLW. Lehigh Hanson is also proposing to place clean sand over the dredged area to a minimum thickness of 1 foot (totaling up to 700 cy). The maintenance dredging activities will remove approximately 1,800 cy of sediment comprised of sediment naturally accumulated from the LDW, outside of the property, and incidental material that has accumulated in the waterway since maintenance dredging was completed at the berth in 2004. After maintenance dredging is complete, the contractor will conduct a post-dredge survey to confirm berth elevations.

Construction Methods

The dredging specifications for the Project will be performance-based, such that the contractor will select the specific equipment and dredging methodology best suited to Project performance requirements. It is anticipated sediment will be mechanically dredged to the required dredge elevations by a crane or excavator-operated clamshell bucket mounted on a barge. Gravity dewatering of the dredged sediment will occur on a flat deck, sealed barge equipped with sideboards and scuppers within the vicinity of the Project limits. The scuppers will be covered by a filter media to provide solids separation and meet water quality requirements. Excess water from the dredge material will be conveyed to the scuppers and filtered to retain suspended sediment while allowing the filtered water to drain back into the LDW.

The dewatered material will then be transferred to an upland transfer station where it will be subsequently transported by truck or rail to an appropriate upload disposal facility. To contain sediment that could be spilled during this transfer process, a spill-prevention apron will be installed that sufficiently prevents material from re-entering the water. Contractor staging will occur on barges and in existing developed upland areas.

After maintenance dredging, the 1-foot clean sand layer will be placed with the same or similar equipment used for dredging. The sand will be placed uniformly in a manner that minimizes turbidity.

Water Quality Monitoring Plan
The area of mixing established for marine waters is a 150-foot radius (i.e., point of compliance) surrounding the in-water activity. At the point of compliance, turbidity shall not exceed 5 Nephelometric Turbidity Units (NTUs) more than background turbidity when the background turbidity is 50 NTUs or less, or there shall not be more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTUs. Turbidity measurements will be collected in real time and will not be averaged over time or depth.

The background station will be located 1,000 feet up-current from active in-water work in an area unaffected by the active work. The background station may be to the south or the north of the activity area, depending on tidal flows. Figure 1 shows the background station located to the south during ebb tide and to the north during flood tide. Measurements collected at the background station will be used as baseline data for determining the appropriate exceedance criteria and for comparison purposes.

The monitoring distances for water quality measurements are on 100- and 150-foot radii from the activity site. One station will be measured on each radius, located down-current of the work site (Figure 1). Actual monitoring locations will be based on the location of active in-water work, the tidal cycle, and observations of the current.

The early warning station will be located on a point along the radius 100 feet down-current from maintenance dredging, unless safety concerns require that additional offset from the work is necessary. Measurements at the early warning station will serve as an interim indicator of water quality closer to the site work activity. Elevated measurements indicate the potential for a subsequent exceedance at the compliance station, and this early warning would allow modification of the operation of the activity to potentially avoid exceedances.

The compliance station will be located at a point along the 150-foot radius down-current from dredging activities. Measurements from the compliance station will be used to determine if water quality conditions meet water quality standards for the Project.

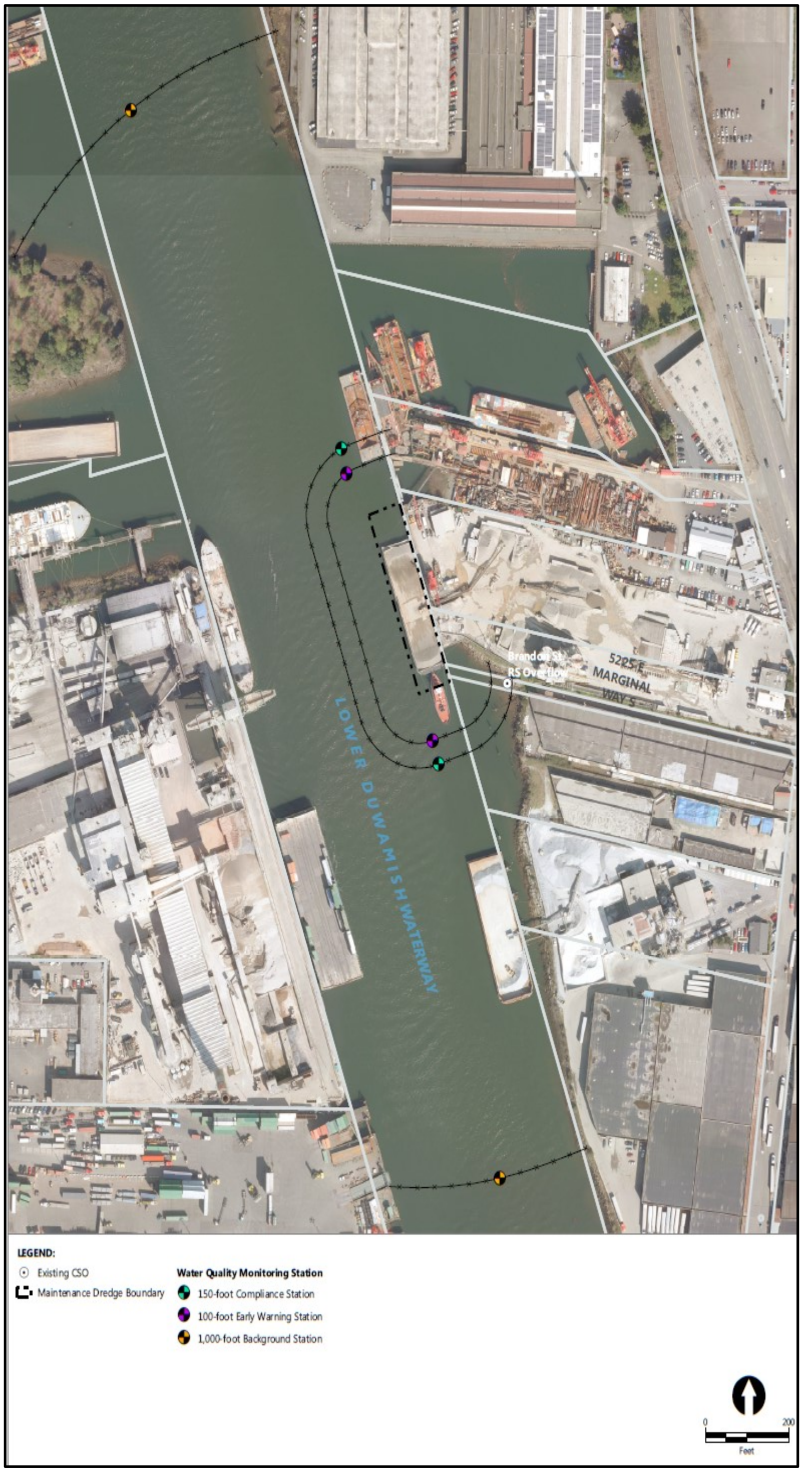


Figure 1: Water Quality Monitoring Locations

Monitoring Depth
Water depth will be determined using a lead line at the monitoring location and will be recorded on a Water Quality Monitoring Form. At each station, water quality parameters will be measured at 3 feet below the water surface, the mid-point of the water column, and 3 feet above the sediment bed. If the water column is 10 feet or less, no mid-point sample will be collected.

Field Monitoring Frequency and Schedule
Maintenance dredging activities are anticipated to take up to 20 working days (4 weeks) to complete and will be performed during the in-water work window, or approved extension. Monitoring frequency will be coordinated to ensure that in-situ water quality monitoring is occurring for at least half of the time that active maintenance dredging activities are occurring. Any changes to the monitoring plan, based on contractor schedule, field conditions, or progress, shall be submitted to Ecology for review and approval.

Two frequencies of in-situ water quality monitoring are anticipated: intensive and routine monitoring. Intensive monitoring will include 3 full days of monitoring, with water quality measurements being collected at least twice per day. Intensive monitoring will begin at the onset of the first potentially turbidity-generating activity. If no changes in turbidity (considering background station measurements and waterway vessel activity) are noted during the first 3 days, or if the contractor is successfully able to modify operations and/or implement additional best management practices (BMPs) to mitigate the elevated turbidity conditions, then water quality monitoring activities will switch to routine monitoring. Routine monitoring will occur every other day that the potentially turbidity-generating activity occurs, through completion of the Project. Routine monitoring activities will similarly include twice-daily water quality measurements at minimum. A change in activities (i.e., new dredge bucket or other change in equipment) will also restart the intensive monitoring cycle (3 day, twice-daily).

Daily Monitoring Routine
The first round of monitoring will be conducted approximately 1-hour after the start of maintenance dredging. An additional round will be conducted prior to sunset. Background stations will be measured prior to early warning and compliance stations, for each round of water quality monitoring. Additional samples at background stations may be collected if field conditions change (e.g., extreme weather shifts) or if lateral inputs are suspected to be causing increased turbidity. Monitoring data collected in the field will be recorded on the Water Quality Monitoring Form.

Visual Monitoring
Visual monitoring (e.g., identification of visible turbidity plume) will be performed by the water quality monitor at each monitoring station and while moving between monitoring stations throughout the work day. Visual monitoring will also be conducted throughout the life of the project by the contractor and/or other construction oversight staff or consultants. If at any point during construction turbidity is identified as a potential problem (i.e., turbidity plumes extending beyond the early warning or compliance stations), the construction area will be examined to determine if the increased turbidity is resulting from construction activities or external sources. If the elevated turbidity is determined to be from construction activities, the contractor will stop work and in-situ water quality measurements will be collected by the water quality monitor.

Contingency measures will be implemented as described in Section 3 until the turbidity plume is dissipated. If the event occurs when the water quality monitor(s) is not present, contingency measures will be implemented as described in Section 3 until the turbidity plume is dissipated and routine monitoring will be required to start the following day. Any turbidity events identified as a potential problem during visual monitoring will be recorded in the Water Quality Monitoring Form.

Monitoring Location Determination and Documentation
A range finder will be used to determine station locations at target monitoring distances in relation to dredging activities. Once the vessel is on station, the vessel operator will maintain the position while monitoring occurs. GPS coordinates and the monitoring station name will be recorded on the Water Quality Monitoring Form. In each round of monitoring, the background station will be monitored first, followed by the early warning station and then the compliance station.

Turbidity Measurements
Monitoring will be performed using a calibrated multi-probe meter (e.g., Hydrolab, YSI probe, or similar) and/or a Hach turbidity meter. The depth at each station will be measured, and turbidity measurements will be collected at three depths at each of the three monitoring stations.

Quality Assurance/Quality Control
All field staff will be experienced in water quality monitoring. Staff will be trained in standardized field monitoring and data collection procedures, requirements, data management protocol, and quality assurance/quality control.

Instruments and equipment will be inspected before each monitoring event. Any field equipment that is faulty or not functioning properly will not be used for monitoring or sample collection. Each day and prior to use, a calibration check will be performed on the water quality meter using certified calibration standards. If water quality meter results are not consistent with standards, manufacturer's guidelines will be used to recalibrate the instrument. Standard instrument operating procedures will be used for all field instruments.

Contingency Measures
If turbidity is elevated above the criterion at the 100-foot early warning station, the water quality monitor will notify the contractor to begin assessing BMPs and sample the 150-foot compliance station. If turbidity is elevated above the criterion at the 150-foot compliance station, the following sequence of responses will be initiated:

1. If comparison indicates that turbidity is potentially due to maintenance dredging activities, then the water quality monitor will notify the contractor and Lehigh Hanson representative of the situation. The contractor will be required to stop work at this point to further assess what changes to BMPs should be made.

2. Field measurements will be retaken within 15 minutes after the initial measurements at the compliance station and compared against re-checked background measurements.

Stormwater outfalls located in the vicinity of the project area will also be checked to confirm they are not exacerbating turbidity conditions.

3. If the elevated turbidity condition is confirmed and attributed to construction activities (and not ambient background conditions), the contractor will be directed to immediately modify operations and/or implement additional BMPs to mitigate the elevated turbidity condition.

4. The water quality monitor will retake field measurements at the compliance station and compare them against background measurements at least 1-hour after the contractor has implemented the additional BMPs and/or operational modifications.

5. Upon retaking field measurements in Step 1, the water quality monitor will notify Lehigh Hanson who will notify Ecology of the elevated turbidity condition, and describe the actions taken to mitigate the condition and the results of the follow-up measurements.

Project Timing
The Project is expected to be completed in approximately 20 working days (4 weeks). In-water work will be performed consistent with allowable in-water work windows established by regulatory agencies to minimize potential disturbance of sensitive fish and wildlife species. Within the LDW, these work windows are expected to occur between October 1 and February 15 of each year the permit is valid.

Best Management Practices
BMPs have been incorporated into the Project design in order to avoid or minimize environmental effects and the exposure of sensitive species to potential effects from maintenance dredging. The following BMPs will be implemented to avoid or minimize environmental impacts during the Project.

- Work will be completed during regulatory approved work windows, anticipated to be October 1 to February 15 of each year that the permit is valid.

- Turbidity and other water quality parameters will be monitored to ensure that construction activities are in compliance with Washington State Surface Water Quality Standards per Washington Administrative Code 173-201A.

- Appropriate BMPs will be employed to minimize sediment loss and turbidity generation during dredging. BMPs may include, but are not limited to, the following:
    - Eliminating multiple bites while the bucket is on the bottom
    - No stockpiling of dredged material on the sea bed
    - No marine bed leveling

- The barge will be managed such that the dredged sediment load does not exceed the capacity of the barge. The load will be placed in the barge to maintain an even keel and avoid listing.

- The dredging contractor will inspect fuel hoses, oil or fuel transfer valves, and fittings on a regular basis for drips or leaks in order to prevent spills into the surface water.

- The contractor shall be responsible for the preparation of a Spill Prevention, Control and Countermeasure Plan to be used for the duration of the Project to safeguard against an unintentional release of fuel, lubricants, or hydraulic fluid from construction equipment.

- The clean sand layer placed after maintenance dredging will be conducted in a controlled manner to minimize turbidity.

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

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

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 CFR402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

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

The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. The 2016 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 2019 regulations define effects of the action using the term “consequences” (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition 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 habitat using an exposure-response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species, or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

2.2 Rangewide Status of the Species and Critical Habitat

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

One factor affecting the status of ESA-listed species considered in this opinion, and aquatic habitat at large, is climate change. Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species, and the conservation value of designated critical habitats, in the Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. The largest hydrologic responses are expected to occur in basins with significant snow accumulation, where warming decreases snow pack, increases winter flows, and advances the timing of spring melt (Mote et al., 2016; Mote et al., 2014). Rain-dominated watersheds and those with significant contributions from groundwater may be less sensitive to predicted changes in climate (Mote et al., 2014; Tague et al., 2013).

During the last century, average regional air temperatures in the Pacific Northwest increased by 1-1.4 degrees Fahrenheit as an annual average, and up to 2 degrees Fahrenheit in some seasons (based on average linear increase per decade; (Abatzoglou et al., 2014; Kunkel et al., 2013)). Recent temperatures in all but two years since 1998 ranked above the 20th century average (Mote et al., 2013). Warming is likely to continue during the next century as average temperatures are projected to increase another 3 to 10 degrees Fahrenheit, with the largest increases predicted to occur in the summer (Abatzoglou et al., 2014).

Decreases in summer precipitation of as much as 30 percent by the end of the century are consistently predicted across climate models (Abatzoglou et al., 2014). Precipitation is more likely to occur during October through March and less during summer months. More winter precipitation will be rain than snow (ISAB, 2007) (Mote et al., 2013; Mote et al., 2014). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB, 2007; Mote et al., 2014). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al., 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al., 2014).

The combined effects of increasing air temperatures and decreasing spring through fall flows are expected to cause increasing stream temperatures; in 2015 this resulted in 3.5-5.3 degree Celsius increases in Columbia Basin streams and a peak temperature of 26 degrees Celsius in the Willamette (NWFSC, 2015). Overall, about one-third of the current cold-water salmonid habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (Mantua et al., 2009).

Higher temperatures will reduce the quality of available salmonid habitat for most freshwater life stages (ISAB, 2007). Reduced flows will make it more difficult for migrating fish to pass physical and thermal obstructions, limiting their access to available habitat (Isaak et al., 2012; Mantua and Hamlet, 2010). Temperature increases shift timing of key life cycle events for salmonids and species forming the base of their aquatic foodwebs (Crozier et al., 2008; Tillmann and Siemann, 2011; Winder and Schindler, 2004). Higher stream temperatures will also cause decreases in dissolved oxygen and may also cause earlier onset of stratification and reduced mixing between layers in lakes and reservoirs, which can also result in reduced oxygen (Meyer et al., 1999; Raymondi et al., 2013; Winder and Schindler, 2004). Higher temperatures are likely to cause several species to become more susceptible to parasites, disease, and higher predation rates (Crozier et al., 2008; Raymondi et al., 2013; Wainwright and Weitkamp, 2013).

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

In addition to changes in freshwater conditions, predicted changes for coastal waters in the Pacific Northwest as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al., 2014). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by 1.0-3.7 degrees Celsius by the end of the century (IPCC, 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Reeder et al., 2013; Tillmann and Siemann, 2011).

Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. A 38 percent to 109 percent increase in acidity is projected by the end of this century in all but the most stringent CO2 mitigation scenarios, and is essentially irreversible over a time scale of centuries (IPCC, 2014). Regional factors appear to be amplifying acidification in Northwest ocean waters, which is occurring earlier and more acutely than in other regions and is already impacting important local marine species (Barton et al., 2012; Feely et al., 2012). Acidification also affects sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al., 2012; Sunda and Cai, 2012).

Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10-32 inches by 2081-2100 (IPCC, 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Reeder et al., 2013; Tillmann and Siemann, 2011). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al., 2007). Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances, and therefore these species are predicted to fare poorly in warming ocean conditions (Scheuerell and Williams, 2005; Zabel et al., 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (NWFSC, 2015). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these habitats, have the potential to impact a wide range of listed aquatic species (Reeder et al., 2013; Tillmann and Siemann, 2011).

The adaptive ability of these threatened and endangered species is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. Without these natural sources of resilience, systematic changes in local and regional climatic conditions due to anthropogenic global climate change will likely reduce long-term viability and sustainability of populations in many of these ESUs (NWFSC, 2015). New stressors generated by climate change, or existing stressors with effects that have been amplified by climate change, may also have synergistic impacts on species and ecosystems (Doney et al., 2012). These conditions will possibly intensify the climate change stressors inhibiting recovery of ESA-listed species in the future.

2.2.1 Status of the Critical Habitat

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

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

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

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

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Puget Sound Chinook salmon	9/02/05 70 FR 52630	Critical habitat for Puget Sound Chinook salmon includes 1,683 miles of streams, 41 square mile of lakes, and 2,182 miles of nearshore marine habitat in Puget Sounds. The Puget Sound Chinook salmon evolutionarily significant unit (ESU) has 61 freshwater and 19 marine areas within its range. Of the freshwater watersheds, 41 are rated high conservation value, 12 low conservation value, and eight received a medium rating. Of the marine areas, all 19 are ranked with high conservation value.
Puget Sound Steelhead	2/24/16 81 FR 9251	Critical habitat for PS steelhead includes 2,031 stream miles (3,269 km). Nearshore and offshore marine waters were not designated for this species. There are 66 watersheds within the range of this DPS. Nine watersheds received a low conservation value rating, 16 received a medium rating, and 41 received a high rating to the DPS.

2.2.2 Status of the Species

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

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

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Puget Sound Chinook salmon	Threatened 6/28/05	Shared Strategy for Puget Sound 2007 NMFS 2006	NWFSC 2015	This ESU comprises 22 populations distributed over five geographic areas. Most populations within the ESU have declined in abundance over the past 7 to 10 years, with widespread negative trends in natural-origin spawner abundance, and hatchery-origin spawners present in high fractions in most populations outside of the Skagit watershed. Escapement levels for all populations remain well below the TRT planning ranges for recovery, and most populations are consistently below the spawner-recruit levels identified by the TRT as consistent with recovery.	• Degraded floodplain and in-river channel structure • Degraded estuarine conditions and loss of estuarine habitat • Degraded riparian areas and loss of in-river large woody debris • Excessive fine-grained sediment in spawning gravel • Degraded water quality and temperature • Degraded nearshore conditions • Impaired passage for migrating fish • Severely altered flow regime
Puget Sound Steelhead	Threatened 5/11/07	In development	NWFSC 2015	This DPS comprises 32 populations. The DPS is currently at very low viability, with most of the 32 populations and all three population groups at low viability. Information considered during the most recent status review indicates that the biological risks faced by the Puget Sound Steelhead DPS have not substantively changed since the listing in 2007, or since the 2011 status review. Furthermore, the Puget Sound Steelhead TRT recently concluded that the DPS was at very low viability, as were all three of its constituent MPGs, and many of its 32 populations. In the near term, the outlook for environmental conditions affecting Puget Sound steelhead is not optimistic. While harvest and hatchery production of steelhead in Puget Sound are currently at low levels and are not likely to increase substantially in the foreseeable future, some recent environmental trends not favorable to Puget Sound steelhead survival and production are expected to continue.	• Continued destruction and modification of habitat • Widespread declines in adult abundance despite significant reductions in harvest • Threats to diversity posed by use of two hatchery steelhead stocks • Declining diversity in the DPS, including the uncertain but weak status of summer-run fish • A reduction in spatial structure • Reduced habitat quality • Urbanization • Dikes, hardening of banks with riprap, and channelization

2.3 Action Area

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

The dredge footprint is approximately 375 feet long by 80 feet wide, or 0.7 acre. However, the action area for the project also includes the geographic area likely to be affected by the maintenance dredging activities. Potential impacts from maintenance dredging includes both underwater noise, turbidity, entrainment, and changes to prey distribution and abundance.

Noise generated from dredging is not anticipated to exceed typical background noise in the project area, the proposed dredging will occur in and near an active marine transportation zone and industrial facilities. As a result, the farthest-reaching effect from the proposed project activities is likely to be turbidity. We therefore draw the action area based on the area in which we expect turbidity to exceed background levels. In Washington, water quality standards (Washington Administrative Code [WAC] 173-201A) specify a mixing zone where visible turbidity must not extend more than 150 feet from the bucket location. Because consultations must be on otherwise lawful actions, we therefore set the action area to extend 150 feet waterward from the maintenance dredging footprint (Figure 2). This covers approximately 3.5 acres.

The action area is utilized by Puget Sound Chinook salmon and by Puget Sound steelhead and is designated critical habitat for both. Based on life history/behavior patterns that show juvenile Chinook to be dependent on estuarine and nearshore habitat to a much greater degree than juvenile steelhead. The action area is also EFH for Pacific Coast Salmon and Pacific Coast Groundfish.

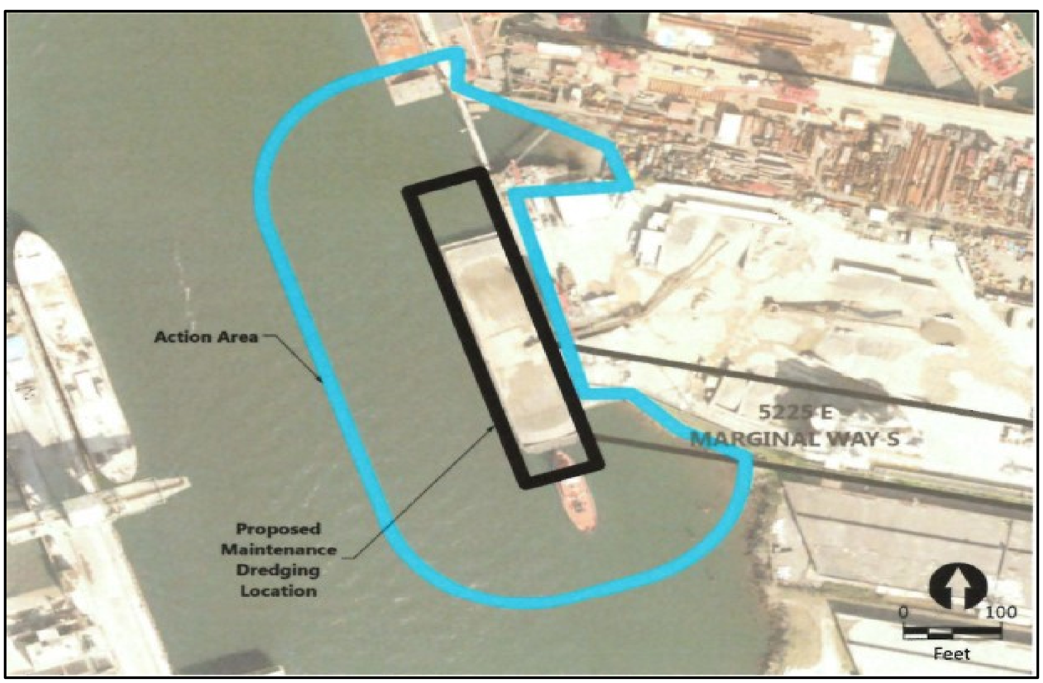


Figure 2: Action area

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

The LDW is the downstream portion of the Duwamish River and is located along a major shipping route for bulk and containerized cargo. This portion of the Duwamish River is estuarine, where freshwater from the river mixes with the salt water of the Puget Sound Estuary. Habitat conditions for listed salmonids in the action area are degraded. In the early 1900s, the waterway was filled to create uplands that were subsequently developed for industrial and commercial operations, including the dredging and straightening of the original watercourse (Ecology 2011). The site lacks natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels.

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

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

Genstar Sand and Gravel Company and Tilbury Cement (historical predecessors to Lehigh Hanson) historically operated a cement distribution terminal at the property, which is consistent with its current use. Current operations at the Seattle Terminal include the manufacturing and distribution of ready-mix concrete, concrete blocks, cement, sand, and gravel through Cadman (Ecology 2011). Cement, sand, and gravel are regularly received by barge. Dry cement is piped ashore, stored in silos, and conveyed to the ready-mix plant via an underground pipe network or to bulk tanker trucks for off-site transport. Sand and gravel are transported via a conveyor system from the barges to stockpiles at the property.

To facilitate the ingress and egress of barges at the facility, the existing berth area requires periodic dredging to maintain operational elevations. The Seattle Terminal property is currently owned by King County and leased to Manson Construction, who in turn leases the berth area to Cadman, a Lehigh Hanson affiliated company. The berth area was last dredged in 2004 to a depth of -20 feet MLLW under Lehigh Hanson ownership (DMMO 2004). Approximately 9,000 cy of material were removed during this event.

2.5 Effects of the Action

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

All effects associated with the proposed action are temporary. The assessment below considers the intensity of expected effects in terms of the change they would cause on habitat features 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.

Temporary effects include disturbance of bottom sediments, which will cause water quality impacts, and disturbance of benthic communities (forage).

Water Quality
Water quality is an essential element of both the rearing and migration PBFs, and is likely to be affected during dredging and capping. Dredging operations are to be completed using mechanical (clamshell) dredging methods of approximately 1,800 cubic yards of subtidal material. Additionally, 1-foot clean sand layer will be placed uniformly in a manner that minimizes turbidity. Effects to water quality due to dredging and capping can include increased

suspended sediments leading to increased turbidity, decreased dissolved oxygen (DO), or resuspended toxins.

Turbidity: Temporary and localized increases in turbidity are expected in the immediate vicinity of the clamshell but water quality monitoring at the point of compliance (i.e., 150 feet from activity) is intended to ensure that effects are localized in order to minimize potential effects.

Dissolved oxygen: Suspension of anoxic sediment compounds during dredging can result in reduced DO in the water column as the sediments oxidize. Sub-lethal effects of DO levels below saturation can include metabolic, feeding, growth, behavioral, and productivity effects. Behavior responses can include avoidance and migration disruption (NMFS 2005).

Based on a review of six studies on the effects of dredging on DO levels, LaSalle (1988) concluded that, considering the relatively low levels of suspended material generated by dredging operations and counterbalancing factors such as flushing, DO depletion around dredging activities is minimal. In addition, when DO depletion is observed near dredging activities, it usually occurs in the lower water column, whereas juvenile salmon are more closely associated with the upper water column. A number of other studies reviewed by LaSalle (1988) showed little or no measurable reduction in DO around dredging operations. Simenstad (1988) concluded that because high sediment biological oxygen demand is not common, significant depletion of DO is usually not a factor in dredging operations. A model created by LaSalle (1988) demonstrated that, even in a situation where the upper limit of expected suspended sediment is reached during dredging operations, DO depletion of no more than 0.1 mg/L would occur at depth. Any reduction in DO beyond background should be limited in extent and temporary in nature. Additionally, the short duration of the project (i.e. on month) further reduces the potential for effects of low DO due to turbidity and suspended sediment.

Resuspended toxins: During dredging ad capping, PAHs, and other contaminants will be re-suspended in the water column during and immediately following the activity. However, the probability of exposure of individuals to water quality effects is generally low, given that the work windows would mostly preclude the presence of juveniles, and BMPs will be implemented to minimize the mobilization of sediments (e.g., clamshell dredge, sediment reduction devices on barge scuppers). Short-term and intermittent exposure to reduced water quality could result in minor reductions in foraging success, gill damage and/or sublethal toxicity within 150 feet of dredging activities.

Over the long term, removal of this sediment is expected to provide a net beneficial effect, by improving water quality for ESA listed species and their prey by decreasing dioxin/furan concentrations in the water column. Removal of dioxins/furans from the environment is especially important for SRKW, which, as long-lived apex predators, accumulate persistent toxins, which are passed across trophic levels and concentrated at the top of the food chain.

Benthic Communities and Forage Species Disturbance

Sessile, benthic, and epibenthic organisms within the sediments of the dredge prism that cannot move fast enough to avoid the capture of sediment by the clamshell bucket are entrained and experience high mortalities. Several studies have demonstrated that benthic organisms rapidly recolonize habitats disturbed by dredging (McCabe et al. 1996; Quian et al. 2003; Richardson et al. 1977; Van Dolah et al. 1984). However, the speed of recovery by benthic communities is affected by several factors, including the intensity of the disturbance, with greater disturbance increasing the time to recovery (Dernie et al., 2003). The infaunal community in the river would experience disruption during dredging and for a short time after, expected to recover toward baseline levels within several months, but full recruitment of prey complexity and abundance may take up to 3 years, at most. Suspended sediment tolerance generally decreases with increasing temperature or decreasing dissolved oxygen, and the combination of summer temperature and low dissolved oxygen is particularly adverse to benthic prey communities. Where DO is low, effects can persist for many weeks (WES 1978).

2.5.1 Effects on Critical Habitat

As mentioned in Section 2.2.1, critical habitat for PS chinook and PS steelhead occur within the action area. The NMFS reviews effects on critical habitat affected by a proposed action by examining how the PBFs of critical habitat will be altered, and the duration of such changes.

Chinook Critical Habitat:

The NMFS reviews the effects on critical habitat affected by the proposed action by examining changes of the project to the condition and trends of physical and biological features identified as essential to the conservation of the listed species. Critical habitat includes the stream channels within the proposed stream reaches, and includes a lateral extent as defined by the ordinary high-water line (33 CFR 319.11). In areas where ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain and is reached at a discharge which generally has a recurrence interval of 1 to 2 years on the annual flood series. Critical habitat in lake areas is defined by the perimeter of the water body as displayed on standard 1:24,000 scale topographic maps or the elevation of ordinary high water, whichever is greater. In estuarine and nearshore marine areas critical habitat is proposed to include areas contiguous with the shoreline from the line of extreme high water out to a depth no greater than 30 meters relative to mean lower low water.

It should be noted that the lowermost 4.6 miles of the Duwamish River are located within an estuary where saltwater from the sound and freshwater from the river mix. Water levels and salinity here fluctuate with the tide and amount of water in the river.

The salmonid PBFs present in the action area are presented below, with the affected features in bold:

> 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 invertebrate**s and fishes, supporting growth and maturation.

The project will cause temporary effects to physical and biological features of critical habitat for PS Chinook and PS steelhead salmon. Those effects are:

1. Water Quality/Turbidity and Dissolved Oxygen (DO) - Dredging and capping activities will degrade water quality in the berth and a 150 foot area surrounding the berth by elevating suspended sediments for up to 20 working days (4 weeks) within the in-water work window, and which will return to baseline levels within hours after work ceases. Conditions for juvenile maturation will be disrupted by the water quality degradation. Maintenance dredging would cause no measurable changes in water temperature and salinity, but mobilized contaminants and suspended sediments into the water column, can reduce DO. Both turbidity and DO are expected to return to baseline within hours (turbidity) to days (DO) after work ceases. Based on these factors, the impairment of this PBF will not reduce the conservation value of the habitat for salmon.

2. Water Quality/Pollutants – Increased levels of PAHs, polychlorinated biphenyls (PCBs), and other contaminants re-suspended in the water column will co-occur with the dredging and capping, a following briefly after the commencement of activity. This aspect of water quality degradation could temporarily impair the value of critical habitat for growth and maturation of juvenile salmon by exposing them to pollutants with both immediate and latent health effects, and could incrementally impair forage/prey communities that are exposed to the contaminants, delaying the speed that these communities re-establish after being physically disrupted by dredging.

3. Forage and Prey/Reduced prey abundance from dredging. Removing sediment will simultaneously remove the benthic communities that live within those sediments, reducing prey availability in the footprint of the dredge. Among prey fishes, short-term and intermittent exposure to reduced water quality could result in minor reductions in forage species via gill damage of forage fishes. Suspended sediment will eventually settle in the area adjacent to the dredge prism, which can disrupt benthic prey species and if the sediments are contaminated, then sublethal toxicity of benthic prey species could occur within 150 feet of dredging activities. The limited duration of the in water dredging (20 working days (4 weeks) within the in-water work window), and low intensity of these effects, and the prompt return to baseline levels (expected to be several months), indicate that the prey reduction are not detrimental over the long term to conservation values to the critical habitat in the action area.

Critical Habitat Summary. The LDW in the vicinity of the project includes degraded critical habitat with water quality conditions that somewhat support salmonid transitions between fresh and saltwater. The project is located in a heavily industrialized portion of the LDW that includes steep slopes, riprap armoring, and creosoted piling; poor riparian and marsh vegetation conditions; and lack of complex shoreline habitat. Fish presence is expected to be transitory as conditions don't support robust forage or shelter opportunities.

The proposed action temporarily degrades water quality (4 weeks) and prey communities (reduction lasting several months) caused during the dredge in the habitat, The proposed action will not cause any loss of critical habitat in the action area, as all diminished features are affected in a limited footprint, and will return to baseline level within hours (water quality) or months at most (prey communities).

2.5.2 Effects on Species

Effects of the proposed action on species are based, in part, on exposure of species to the effects to features of habitat, as described above. Adult PS Chinook and PS steelhead, and juvenile PS Chinook, will be exposed to the modified prey base, and temporary diminishment of water quality from elevated suspended sediment and contaminants described above. Entrainment during the operation of the dredge equipment might also occur. No permanent pathways of fish exposure to effects are expected as a result of the proposed dredging or disposal.

2.5.2.1 Species Presence and Exposure

Each of the following species uses the action area with variable presence. In order to determine effects on species, we must evaluate when species will be present and the nature (duration and intensity) of their exposure to those effects of the action in their habitat, which were described above. It should be noted; an effect exists even if only one individual or habitat segment may be affected (Fish and Wildlife Service and the National Marine Fisheries Service 1998). Work is expected to take up to 20 working days (4 weeks), and is allowed to occur at any time within the October 1 to February 15 work window. Life history behaviors influence which life stages could be present during that work window.

Chinook salmon:
Chinook salmon presence is documented within the LDW, and juveniles and adults migrate in the action area (WDFW 2018). Chinook salmon in the action area would primarily be of Green River (Duwamish) stock, although fish from other stocks do use the same area (Nelson et al. 2004).

For these reasons, it is expected that adult and juvenile Chinook salmon may be present in the action area as follows: adults are expected to occur in the deep water areas in the vicinity of the action area during the summer and fall during their upstream spawning migration, and juveniles may occur in the shallow nearshore during typical outmigration periods between February and July. Thus adults may be exposed in the autumn portion of the work window, and juveniles in the winter portion of the work window.

Steelhead
Steelhead that would be present in the action area are winter or summer run steelhead from the Green River (Duwamish) stock (WDFW 2018). Run timing for adult Green River winter steelhead is generally from December through mid-March, with spawning generally from early March through mid-June. Run timing for Green River summer steelhead is generally from August through December with spawning generally from mid-January through mid-March. Juvenile steelhead would be expected to outmigrate between mid-March and early June, and would not be anticipated in the nearshore of the action area in large numbers because the majority of steelhead smolts migrate directly to the open ocean and do not rear extensively in the estuarine or coastal environments (Burgner et al. 1992).

For these reasons, it is expected that adult steelhead may be present in the action area as follows: adults are expected to occur in the deep water areas in the vicinity of the mouth of the LDW during the summer, fall, and winter of their upstream spawning migration, overlapping the fall and winter portion of the work window. The general steelhead life history and available research suggest that steelhead use of the action area is lowest in the winter. Juvenile outmigtation starts in March so we do not expect them to be present when work occurs.

2.5.2.2 Species Response to Temporary Effects

Modified Benthic Prey
Prey communities will be reduced in the action area and are expected to recolonize the dredge and cap footprint within several months following the completion of the in-water work. Salmonids present in the action area would experience reduced forage opportunity for the several weeks of the in-water work, and the period of benthic community recovery.

Adult Chinook salmon in their return migration cease eating as they enter fresh water, so the reduced prey availability in this estuarine area is unlikely to adversely affect them. Adult steelhead are iteroparous, and will continue to consume prey as returning adults, but as larger fish, they are likely to seek out much larger prey than the benthic assemblies would provide, meaning the reduced benthic prey availability is also unlikely to be significant to adult steelhead.

When juvenile salmonids are entering the nearshore or marine environment, they must have abundant prey to allow their growth, development, maturation, and overall fitness. As dredging dislodges bottom sediments, benthic communities are disrupted where the sediment removal occurs and in the locations where sediment falls out of suspension and layers on top of adjacent benthic areas. Benthic communities will be impacted over approximately 3.5 acres and it can take up to three years to fully re-establish their former abundance and diversity. It should be noted, within the 3.5 acres of impact the area closest to the dredge prism will experience the most impact with lessening impacts when moving further away from the dredging activity. All 3.5 acres is expected to be impacted, but on a gradient. Work will occur across one work window so we can expect three years in which benthic prey is less available to juveniles, incrementally diminishing the growth and fitness of four separate cohorts of individual juvenile outmigrants from the ESA listed salmonid species that pass through the action area. Given the relatively small area from within available prey sources in the river system, and the high level of mobility that juvenile migrants have when they reach the marine environment, that many individual fish will experience reduce food or increased competition to a degree that impairs their growth, fitness, or survival. Even if several fish from each cohort of each population had diminished foraging success, we anticipate that this would be a transitory condition as they migrate to more suitable forage locations. The level of reduced growth, fitness, or survival would be impossible to detect numerically, and the reduced abundance in juvenile cohorts would probably be insufficient to be discerned as an influence on productivity of the populations.

Diminished Water Quality
Exposure to water of degraded quality is likely to adversely affect adult PS chinook and PS steelhead, and juvenile PS chinook. Water quality will be impaired for roughly 20 days across a period of up to 4 months, by suspended sediments and suspended contaminants.

Suspended sediment

The effects of suspended sediment on fish increase in severity with sediment concentration and exposure time and can progressively include behavioral avoidance and/or disorientation, physiological stress (e.g., coughing), gill abrasion, and death—at extremely high concentrations. Newcombe and Jensen (1996) analyzed numerous reports on documented fish responses to suspended sediment in streams and estuaries and identified a scale of ill effects based on sediment concentration and duration of exposure, or dose. Exposure to concentrations of suspended sediments expected during dredging could elicit sub-lethal effects such as a short-term reduction in feeding rate or success, or minor physiological stress such as coughing or increased respiration. In general, fish are more likely to undergo sublethal stress from suspended sediments rather than lethality because of their ability to move away from or out of an area of higher concentration to a lower concentration versus sessile or less mobile species" Kjelland et al 2015.

Several reports summarized dredged material behavior and sediment resuspension due to clamshell dredging and associated open water disposal (Palermo et al. 2009; LaSalle et al. 1991; Havis 1988; McLellan et al. 1989; Herbich and Brahme 1991; Truitt 1988). Laboratory studies have consistently found that the 96- hour median lethal concentration of fine sediments for juvenile salmonids is above 6,000 mg/L (Stober et al. 1981) and 1,097 mg/L for 1 to 3-hour exposure (Newcombe and Jensen 1996). Based on an evaluation of seven clamshell dredge operations in fine silt or clay substrates, LaSalle (1991) determined that the expected concentrations of silty suspended sediment levels was 700 mg/l and 1,100 mg/l at the surface and bottom of the water column, respectively (within approximately 300 feet of the operation). Sediment in the action area consists of silty sands which would settle out of the water column faster than fine silt or clay. Suspended sediment from the proposed dredge operations is expected to not reach levels leading to injure exposed fishes because salmonids are expected to avoid or promptly vacate areas where sediment concentrations are high enough to cause injury. Studies show that salmonids have an ability to detect and distinguish turbidity and other water quality gradients (Quinn, 2005; Simenstad, 1988). Also by the time juvenile salmonids are in the marine environment we expect them to be large that even with exposure, injury will not result as studies have shown that larger juvenile salmonids are more tolerant to suspended sediment than smaller juveniles (Servizi and Martens, 1991; Newcombe and Jensen, 1996). Thus, behavioral responses and perhaps cough or gill irritation are the most likely responses, and lasting injury is unlikely to result. Based on life history behaviors and work window timing, the overlap of adult Chinook with potential in-water work is only 2 months, juvenile Chinook presence is 1 month, but steelhead presence and the work window overlap the whole in-water work window, 4 months. While juvenile salmonids are more vulnerable to suspended sediment than adults, their exposure will be during winter when water temperatures are colder, increasing their level of tolerance (Servizi and Martens, 1991).

Suspended contaminants

Due to the highly industrialized nature of the project area, numerous sites containing hazardous substances exist in and near the project area. Contaminants in sediments and dissolved in-water can have varying levels of toxicity, most often occurring as sub-lethal effects. The LDW was listed as a federal Superfund site in 2001. At least 41 different hazardous chemicals have been found in LDW sediments. Elevated concentrations of mercury, polycyclic aromatic hydrocarbons (PAHs), bis(2-ethylhexyl) phthalate, polychlorinated biphenyls (PCBs), and dioxin/furans (D/Fs) have been measured in sediments associated with portions of this source control area (Ecology 2011). Because concentrations of PAHs, PCBs, and dioxins/furans exceeded screening levels, the potential effects of those contaminants are discussed in more detail below. Some of the effects of these contaminants to salmon species include:

- Sublethal effects to fish include external injury such as damage to the skin, fins, and eyes as well as internal organ problems such as liver tumors from exposure to PAH-contaminated sediments and water. Gill tissues are highly susceptible to damage because they actively pass large volumes of water and are thereby exposed to PAHs present in water (SHNIP 2016). Most non-benthic fish tissue contains relatively low concentrations of PAH, and accumulation is usually short term because these organisms can rapidly metabolize and excrete them (Lawrence and Weber 1984 and West et al. 1984 as cited in Eisler 1987).

- Many studies have reported the nature of PAHs in the aquatic environment and their metabolism in fish. Fish exposure to PAHs has been linked to a wide range of physiological dysfunctions in fish, including neoplasia, endocrine disruption, immunotoxicity, reduced reproductive success, embryonic development, post-larval growth, and transgenerational impacts (Tierney et al. 2014).

- Exposure of fish to PAHs is generally associated with narcosis, resulting in a general depression of biological and physiological activities (Van Brummelen et al. 1998). These effects may be linked to reduced immune function, increased mortality after disease challenge, and reduced growth (Karrow et al. 1999; Varanasi et al. 1989; Arkoosh et al. 1991, 1998).

- Dioxin and dioxin-like PCBs act similarly on salmon and other fish species. Reported effects on juvenile salmon include a wide range of sub-lethal outcome including impaired growth and reproduction, hormonal alterations, enzyme induction, alterations to behavior patterns, and mutagenicity (Meador 2002, SHNIP 2016). Eisler (1986) stated that in general, toxicity increased with increasing exposure, crustaceans and younger developmental stages were the most sensitive groups tested, and lower chlorinated biphenyls were more toxic than higher chlorinated biphenyls.

- Exposure to dioxin can result in developmental or reproductive toxicity in fish, birds, and mammals. Fish larvae are among the most sensitive vertebrates to the toxic effects of dioxins/furans (Peterson et al., 1993); and exhibit similar signs of toxicity as other vertebrates including decreased food intake, wasting syndrome, and delayed mortality. Adult fish are less susceptible to dioxin-induced toxicity compared to earlier life stages, requiring considerably higher body burdens to elicit adverse effects (Lanham et al. 2011; Peterson et al. 1993; Walker and Peterson 1992, Walker et al. 1994).

Resuspension of contaminated sediments are proportional to the amount of dredging and the local levels of contamination. Assuming a three percent sediment resuspension rate (SHNIP 2016), approximately 54 cubic yards of material will be resuspended during the course of dredging. In addition, disturbance of the substrate will increase contaminant concentrations by resuspending particulates, thereby allowing more contaminants to transport into the water column. However, measures to limit suspended sediment, such as the dredging techniques, will reduce disturbance of substrate particles and contaminants (SHNIP 2016). Contaminant concentrations will be increased for up to 20 days during the work window (October 1 to February 15), with potentially harmful acute increases contained within the 150-foot compliance boundary. Which species and life stages have the most exposure will be determined by the actual dates of in-water work, which at this time is unspecified. Ultimately, once the contaminated sediment has been removed, the concentration of contaminated material in the surrounding environment will decrease and the pathway of exposure for fish through contamination of prey will be reduced in perpetuity.

PAHs have been found to reduce fitness and have potential to kill juvenile salmonids through the effect of "toxicant-induced starvation" in which lipid stores and biomass are reduced (Meador et al. 2006). Impacts of PAHs on the reproduction and development of wild Puget Sound salmon have not been well characterized, although some laboratory studies have shown abnormal behavioral effects during early development of coho salmon exposed to PAHs (Ostrander et al. 1988). Dioxin exposure can cause detrimental but sublethal effects, described above, among juvenile salmonids. Dioxin toxicity varies dramatically across fish species with salmonids exhibiting the highest sensitivity. Recent studies have shown negative effects to eggs and fry but little is known about toxicity levels to adult salmonids that might be found in the action area (King-Heiden et al. 2011). The period of potential exposure to these contaminants is during the 20 days of dredging.

Dissolved oxygen
DO is discussed in Section 2.5.1. Habitat and prey resources may be affected through temporary decreases in DO contemporaneous with the increased suspended sediment (Mitchell et al, 1999). "Suspended sediments absorb heat energy thereby raising water temperatures … Turbidity can reduce light transmission through the water and decrease photosynthesis by aquatic plants, consequently affecting dissolved oxygen levels …." (Kjelland et al. 2015, internal citations omitted). Reductions in DO will likely be short lived if they occur at all. Because the window for the dredging operation is between October and February, we anticipate both that water temperatures are likely to remain cold, and inflow from the freshwater environment will be strong, both of which should limit reductions in DO. Fish exposure to decreased DO is therefore not expected to have either an intensity or duration that would be expected to injure fish.

Entrainment

Entrainment is the process where objects are enclosed and transported within some form of vessel or where solid particles are drawn-in and transported by the flow of a fluid. In this context, entrainment refers to the uptake of aquatic organisms by dredge equipment. Mechanical (clamshell) dredges entrain organisms that are captured within the clamshell bucket. The likelihood of entrainment increase with a fish's proximity to the dredge, and the frequency of interactions.

Mechanical (clamshell) dredges commonly entrain slow-moving and sessile benthic epifauna along with burrowing infauna that are removed with the sediments. They also entrain algae and aquatic vegetation. There is little evidence of mechanical dredge entrainment of mobile organisms such as fish. In order to be entrained in a clamshell bucket, an organism, such as a fish, must be directly under the bucket when it drops. The small size of the bucket, compared against the distribution of the organisms across the available habitat make this situation is very unlikely, and that likelihood would decrease after the first few bucket cycles because mobile organisms are most likely to move away from the disturbance. Further, mechanical dredges move very slowly during dredging operations, with the barge typically staying in one location for many minutes to several hours, while the bucket is repeatedly lowered and raised within an area limited to the range of the crane arm. Most fish in the vicinity of the dredge at the start of the operation would likely swim away to avoid the noise and activity. "Carlson et al. (2001) documented the behavioral responses of salmonids to dredging activities in the Columbia River using hydroacoustics. During dredging operations, out-migrating salmon smolt (Oncorhynchus spp., likely fall chinook salmon (O. tshawytscha) and coho salmon (O. kisutch)) behavioral responses ranged d from (1) salmon orienting to the channel margin move inshore when encountering the dredge, (2) most out-migrating salmon passing inshore moved offshore upon encountering the discharge plume, and (3) out-migrating salmon were observed to assume their prior distribution trends within a short time after encountering both the dredging activity and dredge plume" (Kjelland et al. 2015).

Entrainment can also occur during material placement, when the sand/rock fall through the water column, and creates a plume that extends from the bottom of the vessel to the seafloor. Fish that are above the point of discharge or are otherwise not directly below a discharge plume are likely to detect the plume and attempt to evade the descending material as a perceived threat. Based on the available research, fish are likely to initially dive and then initiate horizontal evasion. Fish that are below a discharge plume are likely to initially dive and then initiate horizontal evasion, or to simply move laterally if already on or near the bottom. The determining factor in avoiding entrainment will be whether the fish can swim fast enough to move out of the discharge field once the fish detects the threat. The risk of entrainment would increase with proximity to the center of the plume and/or to the seafloor. Individuals that become entrained, or are unable to escape before contact with the substrate are likely to be buried under the sediments. The likelihood of injury or mortality would again increase with proximity to the center of the discharge field where depth and weight of the sediments would be greatest.

As stated above, the probability of fish entrainment is largely dependent upon the likelihood of fish occurring within the dredge prism, dredge depth, fish densities, the entrainment zone (water column of the clamshell impact), location of dredging within the river, type of equipment operations, time of year, and species life stage. Demersal fish, such as sand lance, sculpins, and pricklebacks are most likely to be entrained as they reside on or in the bottom substrates with life-history strategies of burrowing or hiding in the bottom substrate (Nightingale and Simenstad 2001). Consequently, the risk of entrainment of ESA-listed species by the dredge is extremely low.

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 and 402.17(a)). 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 in the environmental baseline (Section 2.4).

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 versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.4). Because LDW is expected to remain in highly industrialized and utilized for several decades, we do expect climate change conditions to become more pronounced over that time, which we anticipate may disrupt important habitat features and ecosystem functions that are critical in salmon survival and recovery.

NMFS does not expect any new non-Federal activities within the action area because the area is already highly developed with industrial activities and work within the water would fall under federal authorities such as the Clean Water Act. However, at the watershed scale, future upland development activities lacking a federal nexus will continue and are expected to lead to increased impervious surface, surface runoff, and non-point discharges. NMFS expects these activities to continue in perpetuity. These activities will degrade water quality and exert a negative influence on ESA-listed species. Any future federal actions will be subject to section 7(a)(2) consultation under ESA.

2.7 Integration and Synthesis

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

The two species considered in this opinion are listed as threatened with extinction because of declines in abundance, poor productivity, and reduced spatial structure and diminished diversity. Systemic anthropogenic detriments in fresh and marine habitats are limiting the productivity for PS Chinook and PS steelhead salmon.

The environmental baseline in the action area is a mix of commercial fishing and vessel infrastructure as well as commercial development landward of HAT that degrade habitat conditions for listed species in their nearshore marine life stage. Within the action area there are sources of noise and shade (vessels), water quality impairments (nonpoint sources), and artificial light (marinas and fishing piers). To this context of species status and baseline conditions, we add the temporary effects of the proposed action, together with cumulative effects (which are anticipated to be future nonpoint sources of water quality impairment associated with development and stressors associated with climate change), in order to determine the effect of the project on the likelihood of species' survival and recovery. We also evaluate if the project's habitat effects will appreciably diminish the value of designated critical habitat for the conservation of the listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features.

Critical Habitat

The temporary effects on features of designated critical habitat for PS Chinook and PS steelhead will be water quality and benthic disturbance. We expect diminishment of water quality based on turbidity, though suspended sediments will remain high several hours after dredging and capping ceases. Turbidity will diminish water quality for up to 20 days in the work window, and will affect approximately 3.5 acres. Because the duration is brief, primarily occurs when adult fish rather than juveniles are present, occurs when water temperatures are cold, and baseline water quality levels are re-established shortly after the disturbance, the impaired water quality PBF does not diminish conservation values of the action area.

The effects on benthic communities is also temporary, but much more persistent. Recovery time for the affect area is expected to not last longer than three years, with noticeable areas of recovery starting on the outer edges of the dredged area, starting weeks to months after dredging is completed. Despite the duration of this effect, the forage PBF diminishment is not sufficient to diminish conservation values of the action area because only a maximum of three cohorts of juvenile Chinook salmon would experience this decline, and the reduced forage base in most notable in the first year, ameliorating as benthic communities re-establish.

The beneficial effects of removing known contaminants will improve water quality and substrate condition of the habitat. These effects will be incremental but permanent improvements to habitat within the action area.

When added to the baseline, and considered together with the anticipated negative cumulative impact of numerous non-federal effects, the temporary effects of the proposed action are not likely to impair long term conservation values of critical habitat designated for PS Chinook and PS steelhead, particularly because sources of prey are not considered limiting for listed species within the lower river. We have determined that the impairments will not reduce conservation values of the critical habitat to serve the recovery goals for the listed species.

Species

Because the work windows are timed when juvenile salmon migration is largely avoided we expect that juvenile PS Chinook will only minimally be exposed to turbidity in the work window. We do expect adult PS Chinook and PS steelhead will be exposed to turbidity in the work window. These fish are likely to have a behavioral response to this exposure, and any injury (e.g. gill abrasion) is unlikely to impair fitness of the adult fish for spawning.

The most chronic of the temporary effects – reduced benthic prey for up to approximately 3 years – should not affect fitness growth or survival of enough fish to discernibly reduce abundance of any cohort of any population within those 3 years.

Accordingly, NMFS expects only a very small reduction in numbers of PS Chinook salmon and PS steelhead, if any, as a consequence of their exposure to the temporary effects. These effects, even when considered with cumulative effects, are insufficient to alter the productivity, spatial structure, or genetic diversity of any of the species. Therefore, when considered with the environmental baseline in the action area and cumulative effects, the action, as proposed, does not increase risk to the affected populations to a level that would appreciably reduce the likelihood for survival and recovery of the PS Chinook salmon ESU or PS steelhead DPS.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of PS chinook or PS steelhead, or destroy or adversely modify PS chinook or PS steelhead designated critical habitats.

2.9 Incidental Take Statement

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

2.9.1 Amount or Extent of Take

In this biological opinion, NMFS determined that listed species will co-occur with the effects of the proposed action and therefore incidental take is reasonably certain to occur, as follows:

Harm from suspended sediments/contaminants
Habitat modified temporarily by suspended solids and contaminants will impair normal patterns of behavior including rearing and migrating in the action area, and causing potential injury such as gill abrasion, cough, or other transitory health effects.

Take in the form of harm from these causes cannot be accurately quantified as a number of fish. The distribution and abundance of fish within the action area cannot be predicted based on existing habitat conditions, and because of temporal and dynamic variability in population dynamics in the action area, nor can NMFS precisely predict the number of fish that are reasonably certain to respond adversely to habitat modified by the proposed action. When NMFS cannot quantify take in numbers of affected animals, instead we consider the likely extent of changes in habitat quantity and quality that are the source of take, and consider that measure of that physical area, and the duration of those changes, to indicate the extent of take,.

For this consultation, the best available indicator for the extent of take from suspended contaminants are the temporal and physical extent within contaminant levels increase from project activities to levels that can injure or kill fish in the action area while in-water work is occurring from the proposed actions. In-water work may occur for 20 working days (4 weeks) within the in-water work window, between the dates of October 1 and February 15. The levels of suspended contaminants are expected to be proportional to the amount of injury that the proposed action is likely to cause through physiological stress from elevated suspended sediments and contaminants throughout the duration of the projects' in water activities and throughout the compliance boundary of 150 feet from ongoing activities (roughly 3.5 acres total).

The maximum extent of take is defined by the compliance area for turbidity monitoring within the 150 foot buffer around the project (action area). Within the compliance boundary, injury may occur to listed species present in the area due to increased contaminant exposure, gill abrasion, and behavioral changes.

Harm from reduced prey availability
Habitat modified for up to 3 years by reduced prey abundance and complexity is likely to injure some juvenile individuals of the Puget Sound Chinook ESU in each year by decreasing growth, fitness, and or survival. As above, the number of fish so harmed cannot be predicted due to variability in their abundance, presence, and behavioral patterns, and an extent of take is provided instead. For this source of harm, the best indicator for the extent of take is spatial extent of the modified river bed, the 3.5 acres in which dredging and capping will occur and dredge material 'fall back' settles, where benthic prey communities will be disrupted.

2.9.2 Effect of the Take

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

2.9.3 Reasonable and Prudent Measures

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

1. Minimize incidental take during dredging and capping.

2. Monitor incidental take caused by elevated turbidity and suspended sediments during construction.

3. Ensure completion of a monitoring and reporting program to confirm the take exemption for the proposed action is not exceeded, and that the terms and conditions in this incidental take statement are minimizing incidental take.

2.9.4 Terms and Conditions

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

1. The following terms and conditions implement reasonable and prudent measure 1:

    The COE shall require the applicant to ensure the proposed action is in accordance with permit conditions, which set timing restrictions for 20 working days, consecutive or non-consecutive, during the October 1 to February 15 for in-water work.

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

    The COE shall require the applicant/contractor to monitor turbidity levels in action area during sediment-generating activities when contaminated materials are involved. Monitoring shall be performed at 150 feet from dredging operations. Project activities will be modified or reduced when turbidity conditions exceed water quality monitoring standards as described in the Water Quality Certification issued for this project.

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

    a. Reporting. The COE and contractor must report all monitoring items, including turbidity observations, size of the dredged area, amount of sediment removed, and dates of initiation and completion of dredging to NMFS within 60 days of the close of any work window that had in-water work within it. The contractor must report any exceedance of take covered by this opinion to NMFS immediately. The report must include a discussion of implementation of the terms and conditions in T&C's 1 and 2, above.

b. The contractor must submit monitoring reports to:
ProjectReports.wcr@noaa.gov
Reference project #: WCRO-2019-03112
CC: Lisa.Abernathy@noaa.gov

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).

> The COE should work with the NNMFs to identify more restrictive work windows for dredging activities to protect the biological integrity of jurisdictional waters and promote species conservation.

2.11 Reinitiation of Consultation

This concludes formal consultation for Lehigh Hanson Seattle Terminal Berth Maintenance Dredging Project.

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

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

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

This analysis is based, in part, on the information provided by the COE and descriptions of EFH for Pacific Coast salmon (PFMC 2014) and Pacific Coast groundfish (Pacific Fishery Management Council [PFMC] 2005); contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

The entire action area fully overlaps with identified EFH for Pacific Coast salmon and Pacific Coast Groundfish. The property is located within the Green-Duwamish estuary, where aquatic conditions consist of marine waters from Elliott Bay transitioning with freshwater from the Duwamish River. Groundfish EFH extends to where the salinity drops below 0.5 parts per thousand during the period of average annual low flow within the Green River. The Washington Department of Fish and Wildlife Priority Habitats and Species map indicated usage of the LDW by priority species within the vicinity of the property, including Chinook (*Oncorhynchus tshawytscha*), sockeye (*O. nerko*), and chum (*O. keta*) salmon, steelhead (*O. mykiss*) and residential coastal cutthroat (*O. clorkil*) trout, as well as bull trout (*Salvelinus malma*) (WDFW 2019).

3.2 Adverse Effects on Essential Fish Habitat

The proposed actions will cause negative impacts on the quality of habitat by increasing suspended sediment, benthic disturbance, and increased concentrations of waterborne contaminants. These effects will occur during the work window with negative impacts on water quality quickly fading after the 4-week project is complete, and benthic prey reductions will quickly begin to improve, but full recovery to baseline levels of abundance and prey species complexity may take up to 3 years across the affected area. There will be improvement of habitat quality and ecological function over the long term with the removal of contaminated sediments.

Several effects-minimization measures are being implemented:

- Use of a clamshell dredge. A clamshell dredge is the best available technique to minimize sediment input into the water column, reducing the likelihood of significant increases in turbidity/suspended sediment.

- Turbidity and other water quality parameters will be monitored to ensure that construction activities are in compliance with Washington State Surface Water Quality Standards per Washington Administrative Code 173-201A.

- Appropriate BMPs will be employed to minimize sediment loss and turbidity generation during dredging. BMPs may include, but are not limited to, the following:
    - Eliminating multiple bites while the bucket is on the bottom
    - No stockpiling of dredged material on the sea bed
    - No marine bed leveling

- The barge will be managed such that the dredged sediment load does not exceed the capacity of the barge. The load will be placed in the barge to maintain an even keel and avoid listing.

- The dredging contractor will inspect fuel hoses, oil or fuel transfer valves, and fittings on a regular basis for drips or leaks in order to prevent spills into the surface water.

- The contractor shall be responsible for the preparation of a Spill Prevention, Control and Countermeasure Plan to be used for the duration of the Project to safeguard against an unintentional release of fuel, lubricants, or hydraulic fluid from construction equipment.

- The clean sand layer placed after maintenance dredging will be conducted in a controlled manner to minimize turbidity.

- Dredged materials will be disposed of in an approved upland site.

Implementation of these minimization measures would avoid or minimize potential adverse effects of the proposed action.

3.3 Essential Fish Habitat Conservation Recommendations

Implementation of the following conservation recommendations would further minimize and/or avoid adverse effects on EFH for Pacific Coast Salmon an Pacific Coast Groundfish that are likely to result from the proposed action.

1) Compliance of water quality standards by conducting water quality monitoring during dredging activities. At the point of compliance, turbidity shall not exceed 5 NTUs more than background turbidity when the background turbidity is 50 NTUs or less, or there shall not be more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTUs.
2) Dredging should be carried out in a manner that minimizes spillage of excess sediments from the bucket and minimizes the potential entrainment of fish. This includes, but is not limited to:
    a) Using effective materials such as hay bales or fi1ter fabric on the barge to avoid contaminated sediment and water from being deposited back into the river.
    b) Avoiding the practice of washing contaminated material off the barge and back into the water. This can be accomplished by the use of hay bale and/or filter fabric.
    c) Using filter fabric or some other device (hay bales, eco-blocks, etc.) to minimize spillage of material into the water during the unloading of the barge to the upland facility.

3) Contractor should have the most current, accurate Global Positioning System (GPS) dredge positioning to control the horizontal and vertical extent of the dredge. A horizontal and vertical control plan will be prepared, submitted to the contractor, and adhered to by the dredge contractor to ensure dredging does not occur outside the limits of the dredge prism.

4) Ensure that an emergency cleanup plan is in place in the event the barge, truck, or railcar has an incident where contaminated material is spilled. This plan will be on-board the vehicle at all times.

3.4 Statutory Response Requirement

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

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

3.5 Supplemental Consultation

The COE must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations (50 CFR 600.920(l)).

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this opinion is the COE and Lehigh Hanson. Individual copies of this opinion were provided to the COE. The format and naming adheres to conventional standards for style.

4.2 Integrity

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

4.3 Objectivity

Information Product Category: Natural Resource Plan

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

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.
Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

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

5. REFERENCES

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

Arkoosh, M.R., E. Casillas, E. Clemons, B. McCain, and U. Varanasi. (1991). Suppression of immunological memory in juvenile Chinook salmon (Oncorhynchus tshawytscha) from an urban estuary. Fish Shellfish Immunology. 1, 261-277.

Arkoosh, M.R., E. Casillas, P. Huffman, E. Clemons, J. Evered, J.E. Stein, and U. Varanasi. (1998). Increased susceptibility of juvenile Chinook salmon (Oncorhynchus tshawytscha) from a contaminated estuary to the pathogen Vibrio anguillarum. Trans. Am. Fish. Soc, 127, 360-374.

Barton, A., B. Hales, G.G. Waldbuster, C. Langdon, and R. Feely. 2012. The Pacific Oyster, Crassostrea gigas, Shows Negative Correlation to Naturally Elevated Carbon Dioxide Levels: Implications for Near-Term Ocean Acidification Effects. *Limnology and Oceanography*. 57:12.

Burgner, R.L., J.T. Light, L. Margolis, T. Okazaki, A. Tautz, and S. Ito, 1992. Distribution and origins of steelhead trout (Oncorhynchus mykiss) in offshore waters of the North Pacific Ocean. International North Pacific Fisheries Commission, Bulletin 51. 91 pp.

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

Dernie, K.M., M.J. Kaiser, E.A. Richardson and R.M Warwick. 2003. Recovery of soft sediment communities and habitats following physical disturbance. Journal of Experimental Marine Biology ad Ecology. Volumes 285-286, 12 Feb, 2003, pp 415-434.

DMMO (Dredged Material Management Office), 2004. Memorandum for Record, Subject: Determination of the suitability of dredged material tested under DMMP evaluation procedures for Lehigh Northwest Inc. (Cadman Site) Dredging Project (with proposed disposal at the Elliott Bay open water disposal site. April 17, 2004.

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

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

Ecology (Washington State Department of Ecology), 2011. Lower Duwamish Waterway RM 1.0 to 1.2 East (King County Lease Parcels), Source Control Action Plan. Ecology Publication Number 11-09-131. January 2011.

Eisler, R. 1986. Polychlorinated Biphenyl Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review Biological Report 85. U.S. Fish and Wildlife Service

Eisler, R. 1987. Polycyclic Aromatic Hydrocarbon Hazards to Fish, Wildlife, and Invertebrates: a Synoptic Review. Biological Report 85. U.S. Fish and Wildlife Service.

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

Fish and Wildlife Service and the National Marine Fisheries Service. 1998. Endangered Species Act Section 7 Consultation Handbook. Fish and Wildlife Service and the National Marine Fisheries Service. Endangered Species Act Section 7 Consultation Handbook. 315p.

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

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

Havis, R.N. 1988. Sediment resuspension by selected dredges. Environmental Effects of Dredging Technical Note EEDP-09-2. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Herbich, J.B. and S.B. Brahme. 1991. Literature review and technical evaluation of sediment resuspension during dredging. Center for Dredging Studies. Texas A&M University. College Station, Texas. For U.S. Army Corps of Engineers. Improvement of Operations and Maintenance Techniques Research Program Contract Report HL-91-1. January. 153 pp.

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

Independent Scientific Advisory Board (ISAB). 2007. Climate change impacts on Columbia River basin fish and wildlife. Northwest Power and Conservation Council. Portland, Oregon. Accessed 9/13/2011 at www.nwcouncil.org/library/isab/isab2007-2.pdf.

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

Karrow, N.H. Boermans, D. Dixon, A. Hontella, K Solomon, J. Whyte, and N. Bois. 1999. Characterizing the immunotoxicity of creosote to rainbow trout (Oncorhynchus mykiss): a microcosm study. Aquatic Toxicology 45:223-239.

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

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

Lanham KA., R.E. Peterson, W. Heideman 2011 Sensitivity to dioxin decreases as zebrafish mature. Toxicological Science.

LaSalle, M.W. 1988. Physical and chemical alterations associated with dredging: an overview. Pages 1-12 in C.A. Simenstad, ed. Effects of dredging on anadromous Pacific coast fishes. University of Washington, Seattle, Washington.

LaSalle, M.W., D.G. Clarke, J. Homziak, J.D. Lunz, and T.J. Fredette. 1991. A framework for assessing the need for seasonal restrictions on dredging and disposal operations. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. Dredging Operations Technical Support Program Technical Report D-91-1. July. 77 pp.

Lawrence, J.F. and D.F. Weber. 1984. Determination of polycyclic aromatic hydrocarbons in some Canadian commercial fish, shellfish, and meat product by liquid chromatography with confirmation by capillary gas chromatography-mass spectrometry. J. Agric. FoodChem. 32:789-794

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

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

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

McCabe, G. T., S. A. Hinton, and R. L. Emmett. 1996. Benthic invertebrates and sediment characteristics in Wahkiakum County Ferry Channel, Washington, before and after dredging. Coastal Zone and Estuarine Studies Division, Northwest Fisheries Science Center, National Marine Fisheries Service. Seattle, WA.

McLellan, T.N., R.N. Havis, D.F. Hayes, and G.L. Raymond. 1989. Field studies of sediment resuspension characteristics of selected dredges. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. Improvement of Operations and Maintenance Techniques Research Program Technical Report HL-89-9. April. 111 pp.

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

Meador, J.P., T.K. Collier, and J.E. Stein. 2002. Use of tissue and sediment-based threshold concentrations of polychlorinated biphenyls (PCBs) to protect juvenile salmonids listed under the US Endangered Species Act. Aquatic Conserv: Mar. Freshw. Ecosyst. 12: 493–516.

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

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

Mitchell, S.B., J.R. West, I. Guymer. 1999. Dissolved-Oxygen/Suspend –Solids concentration relationships in the Upper Humber Estuary. Water and Environment Journal. J.CIWEM, 1999, 13, October.

Mote, P.W., J.T. Abatzoglou and K.E. Kunkel. 2013. Climate: Variability and Change in the Past and the Future. Chapter 2 in M.M. Dalton, P.W. Mote and A.K. Snover (eds.) Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Island Press, Washington D.C.

Mote, P., A. K. Snover, S. Capalbo, S. D. Eigenbrode, P. Glick, J. Littell, R. Raymondi, and S. Reeder. 2014. Ch. 21: Northwest. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, T. Richmond, and G. Yohe, Eds., U.S. Global Change Research Program, 487-513. doi:10.7930/J04Q7RWX. http://nca2014.globalchange.gov/report/regions/northwest

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

Nelson, T., G. Ruggerone, H. Kim, R. Schaefer, and M. Boles, 2004. Juvenile Chinook Migration, Growth and Habitat Use in the Lower Green River, Duwamish River and Nearshore of Elliott Bay, 2001-2003. King County Department of Natural Resources and Parks. May 2004.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management. 16:34.

NMFS. 2005. Endangered Species Act - Section 7 Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the U.S. Army Corps of Engineers Columbia River Channel Operations and Maintenance Program, Mouth of the Columbia River to Bonneville Dam. NMFS Tracking. No. 2004/01041.

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

Ostrander, G.K., M.L. Landolt, and R.M. Kocan. 1988. The ontogeny of Coho salmon (Oncorhynchus kisutch) behavior following embryonic exposure to benzo(a)pyrene. Journal of Aquatic Toxicology., 13, 325-346.

Palermo, M.R., J. Homziak, and A.M. Teeter. 2009. Evaluation of clamshell dredging and barge overflow, Military Ocean Terminal, Sunny Point, North Carolina. U.S. Department of the Army, Waterways Experiment Station, Vicksburg, Mississippi. Dredging Operations Technical Support Program Technical Report D-90-6. March. 76 pp.

Peterson R.E., H.H. Theobald, G.L. Kimmel. 1993 Developmental and reproductive toxicity of dioxins and related compounds: cross-species comparisons. Critical Review of Toxicology. 23:283-335.

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

Quinn, T.P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. UW Press.

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

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

Richardson, M. D., A.G. Carey, and W. A. Colgate. 1977. Aquatic disposal field investigations Columbia River disposal site, Oregon. Appendix C: the effects of dredged material disposal on benthic assemblages. Rep. to U.S. Army Corps of Engineers, Waterways Expt. Station, Vicksburg, MS.

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

Servizi, J.A., and D.W. Martens. 1991. Effect of temperature, season, and fish size on acute lethality of suspended sediments to Coho salmon (Oncorhynchus kisutch). *Canadian Journal of Fisheries and Aquatic Sciences*. 48:493-497.

SHNIP (Seattle Harbor Navigation Improvement Project). 2016 Biological Assessment. Prepared by the Seattle District U.S. Army Corps of Engineers. Seattle, WA

Simenstad, C.A. 1988. Effects of dredging on anadromous Pacific Coast fishes. Workshop Proceedings Sept 8-9, 1988. University of Washington, Seattle, Washington.

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

Stober, Q.I., D.B. Ross, C.L. Melby, P.A. Dinnel, T.H. Jagielo, and E.O. Salo. 1981. Effects of suspended volcanic sediment on coho and Chinook salmon in the Toutle and Cowlitz Rivers. Technical Completion Report. Washington state Department of Fisheries, contract Number 14-34—0001—1417. Fisheries Research Institute, University of Washington, Seattle, WA. FRI—UW—8 124.

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

Tierney, K.B., A.P. Farrell, and C.J. Brauner. 2014. Organic chemical toxicology of fishes. Fish physiology, 33. Academic Press.

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

Truitt, C.L. 1988. Dredged material behavior during open-water disposal. Journal of Coastal Research, 4(3): 4879-497.

Van Brummelen, T., B van Huttum, T. Crommentuijn, and D. Kalf. 1998. Bioavailability and Ecotoxicity of P AH. Pp. 203-263. In Neilson, A., editor. P AH and relate compounds Biology (Volume 3-J, The handbook of environmental chemistry). Springer-Verlag. Berlin Heidenberg.

Van Dolah, R. F., D.R. Dalder, and D. M. Knott. 1984. Effects of dredging and open-water disposal on benthic macroinvertebrates in a South Carolina estuary. Estuaries 7:28-37.

Varanasi, U., J.E. Stein, and M. Nishimoto. 1989. Biotransformation and disposition of PAH in fish. In Metabolism of Polycyclic Aromatic Hydrocarbons in the Aquatic Environment, Varanasi U., editor. CRC Press: Boca Raton, FL; 93-149.

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

Walker M.K., R.E. Peterson. 1992. Toxicity of polychlorinated dibenzo-p-dioxins, dibenzofurans, and biphenyls during fish early development. In: Colborn T, Clement C, editors. Chemically Induced Alterations in Sexual and Functional Development: The Wildlife/Human Connection, Mehlman, MA. Princeton, New Jersey: Princeton Scientific Publishing, Co., Inc; 1992. pp. 195-202.

Walker M.K., R.E. Peterson. 1994 Aquatic toxicity of dioxins and related chemicals. In: Schecter A, editor. Dioxins and Health. New York: Plenum Press. pp. 347-387.

WDFW (Washington Department of Fish and Wildlife), 2018. WDFW Priority Habitats and Species on the Web. Accessed September 13, 2018. Available at: https://wdfw.wa.gov/conservation/phs/

WDFW. 2019. Priority Habitats and Species Maps. http://apps.wdfw.wa.gov/phsontheweb/.

WES (Waterways Experiment Station). 1978. Army Engineers Waterways Experiment Station Vicksburg Mississippi, Effects of Dredging and Disposal on Aquatic Organisms. Accessed at https://apps.dtic.mil/dtic/tr/fulltext/u2/a058989.pdf.

West, W.R., P.A. Smith, P.W. Stoker, G.M. Booth, T. Smith-Oliver, B.E. Butterworth and M.L. Lee. 1984. Analysis and genotoxicity of PAC-polluted river sediment. In: M. Cooke and A.J. Dennis (eds.) Polynuclear Aromatic Hydrocarbons: Mechanisms, Methods and Metabolism. Battelle Press, Columbus, OH. P.1395-4I11.

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

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