UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, Washington 98115

Reply To:
NMFS Tracking No.:
2008/03523

January 25, 2010

Daniel M. Mathis
Division Administrator
Federal Highway Administration
Evergreen Plaza Building
711 S. Capitol Way, Suite 501
Olympia, Washington 98501

Re: Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the South Park Bridge Replacement Project, King County, Washington. (Lower Duwamish River, 6th field HUC 171100130399)

Dear Mr. Mathis:

The enclosed document contains a biological opinion (Opinion) prepared by the National Marine Fisheries Service (NMFS) pursuant to Section 7(a)(2) of the Endangered Species Act (ESA) on the effects of the FHWA's funding of the South Park Bridge Replacement Project, in King County, Washington . In this Opinion, NMFS concludes that the action, as proposed, is not likely to jeopardize the continued existence of Puget Sound (PS) Chinook salmon and PS steelhead, or result in the destruction or adverse modification of designated critical habitat for PS Chinook salmon.

As required by Section 7 of the ESA, the Services provided an incidental take statement with the Opinion. The incidental take statement describes reasonable and prudent measures NMFS considers necessary or appropriate to minimize incidental take associated with this action. The take statement sets forth nondiscretionary terms and conditions, including reporting requirements, that the Federal agency and any person who performs the action must comply with to carry out the reasonable and prudent measures. Incidental take from actions that meet these terms and conditions will be exempt from the ESA take prohibition.

This document also includes the results of our analysis of the action's likely effects on essential fish habitat (EFH) pursuant to Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), and includes three conservation recommendations to avoid, minimize, or otherwise offset potential adverse effects on EFH.

The Conservation Recommendations are an identical subset of the ESA Terms and Conditions. Section 305(b) (4) (B) of the MSA requires Federal agencies to provide a detailed written response to NMFS within 30 days after receiving these recommendations.

If the response is inconsistent with the EFH conservation recommendations, the FHWA must explain why the recommendations will not be followed, including the justification for any disagreements over the effects of the action and the recommendations. In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, in your statutory reply to the EFH portion of this consultation, we ask that you clearly identify the number of conservation recommendations accepted.

If you have any questions, please contact Sean Callahan of my staff at the Washington State Habitat Office at (206) 716-1145, by e-mail at sean.callahan@noaa.gov, or by mail at the letterhead address.

Sincerely,

for Michael Dehar

Barry A. Thom
Acting Regional Administrator

cc Pete Jilek, FHWA
Bill Leonard, WSDOT, H&LP
Paul Wagner, WSDOT, HQ

Endangered Species Act Section 7 Consultation
Biological Opinion

And

Magnuson-Stevens Fishery Conservation and Management Act
Essential Fish Habitat Consultation

South Park Bridge Replacement Project, Lower Duwamish River, 6th field HUC 171100130399, King County, Washington

Lead Action Agency:	Federal Highway Administration
Consultation Conducted By:	National Marine Fisheries Service Northwest Region
Date Issued:	January 25, 2010
Issued by:	for Michael Dehar _____ Barry A. Thom Acting Regional Administrator
NMFS No.:	**2008/03523**

TABLE OF CONTENTS

INTRODUCTION 1
Background and Consultation History 1
Description of the Proposed Action 2
Action Area 7
ENDANGERED SPECIES ACT 8
Biological Opinion 8
Status of the Species 8
Status of Critical Habitat 12
Environmental Baseline 13
Effects of the Action 15
Cumulative Effects 25
Conclusion 26
Incidental Take Statement 27
Amount or Extent of Take 27
Reasonable and Prudent Measures 29
Terms and Conditions 29
MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT 32
Essential Fish Habitat Conservation Recommendations 32
Statutory Response Requirement 33
Supplemental Consultation 33
DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW 34
APPENDICES 43
INTRODUCTION 1
PROJECT AREA 3
PILE INSTALLATION LOCATION 3
PILE INSTALLATION 4
METHODOLOGY 5
SIGNAL PROCESSING 7
ANALYSIS 7
REPORTING 8

LIST OF ABBREVIATIONS AND ACRONYMS

BMP - Best Management Practice
BA - Biological Assessment
BRT – Biological Review Team
CHART - Critical Habitat Analysis Review Team
COE - U.S. Army Corps of Engineers
CSL - Clean-Up Screening Level
DPS - Distinct Population Segment
DQA – Data Quality Act
DMMP - Dredged Material Management Program
EAA - Early Action Area
EFH – Essential Fish Habitat
EPA - U.S. Environmental Protection Agency
ESA - Endangered Species Act
ESU - Evolutionarily Significant Unit
FHWA - Federal Highway Administration
H&LP - Highways & Local Programs
HQ - Hazard Quotient
HPA - Hydraulic Project Approval
ITS – Incidental Take Statement
KCDOT - King County Department of Transportation
LID – Low Impact Development
LWD - Large Woody Debris
LDWG - Lower Duwamish Waterway Group
MHHW - Mean-Higher High Water
MTCA - Model Toxics Control Act
NMFS – National Marine Fisheries Service
NTU - Nephelometric Turbidity Unit
Opinion – Biological Opinion
PGIS - Pollution-Generating Impervious Surface
PCB - Polychlorinated Biphenyl
PAH - Polycyclic Aromatic Hydrocarbon
PCE - Primary Constituent Element
PEL - Probable Effect Level
PS – Puget Sound
RPM - Reasonable and Prudent Measure
RCRA - Resource Conservation and Recovery Act
RM - River Mile
SQS - Sediment Quality Standard
SEL - Sound Exposure Level
SPL - Sound Pressure Level
SPCC - Spill Prevention Control and Countermeasures
TESC - Temporary Erosion Sediment Control
TEL - Threshold Effect Level

TNAPs - Temporary Noise Attenuation Piles
TSS - Total Suspended Solids
TRV - Toxicity Reference Value
VSP - Viable Salmonid Population
WDOE - Washington State Department of Ecology
WDFW - Washington State Department of Fish and Wildlife
WSDOT - Washington State Department of Transportation

INTRODUCTION

This document contains a biological opinion (Opinion) and incidental take statement prepared in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, et seq.), and implementing regulations at 50 CFR 402. The National Marine Fisheries Service (NMFS) also completed an essential fish habitat (EFH) consultation, prepared 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. The administrative record for this consultation is on file at the Washington State Habitat Office in Lacey, Washington.

Background and Consultation History

The King County Department of Transportation Road Services Division (KCDOT), the Washington State Department of Transportation Highways and Local Programs Division (WSDOT), and the Federal Highway Administration (FHWA), propose to replace the South Park Bridge, which crosses the lower Duwamish River on 16th Avenue South in unincorporated King County, Washington. The FHWA will pay for part of the project with federal funds which establishes a nexus requiring consultation under section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) (Act).

The NMFS received a biological assessment (BA) and Essential Fish Habitat (EFH) assessment from the FHWA for the South Park Bridge Replacement Project on June 5, 2008. The FHWA requested ESA section 7 and Magnuson-Stevens Fishery Conservation and Management Act consultation. The FHWA concluded the project is likely to adversely affect Puget Sound (PS) Chinook salmon (*Oncorhynchus tshawytscha*) and PS steelhead trout (*O. mykiss*) and designated critical habitat for PS Chinook salmon, and will have no adverse effect on EFH for PS Chinook and coho salmon (*O. kisutch*). Between August 2008 and June 2009, NMFS received the following additional information via electronic mail exchanges and telephone conversations to further refine the proposed action and analysis of effects:
On August 27, 2008, NMFS provided comments and suggestions for the proposed project, and request additional information regarding design elements and potential temporary and permanent effects relevant to the effect determination for PS Chinook salmon and steelhead and designated PS Chinook salmon critical habitat.

On October 2, 2008, NMFS attended a meeting with the FHWA, WSDOT, KCDOT, and consultant staff to discuss recent design changes and NMFS' August 27 requests for additional information.

On February 12, 2009, NMFS received an electronic copy of the Addendum (including attachments) from WSDOT by email.

On February 27, 2009, NMFS received hardcopy of the Addendum from FHWA by mail.

On April 8 and 20, 2009, NMFS received additional information regarding site contamination and proposed pile driving operations by email.

On April 22 and 29, 2009, NMFS staff visited the project site to review conditions in the field.

On May 27, 2009, NMFS provided WSDOT and King County a draft set of proposed minimization measures for the project. On June 30, 2009, FHWA responded with comments and changes to the draft proposed minimization measures. On July 27, 2009, NMFS responded to FHWA's comments on the draft minimization measures. All involved parties scheduled a follow-up meeting to this second round of discussions. On August 6, 2009, FHWA replied with a second round of comments on the revised draft minimization measures. On September 4, 2009, NMFS provided an additional draft minimization measure to KCDOT, WSDOT, and FHWA for comments. On September 11, 2009, FHWA responded with a proposed modification of the additional draft minimization measure. After reviewing their modifications, NMFS initiated consultation and began preparing the Biological Opinion, below.

Description of the Proposed Action

The KCDOT and FHWA propose to fund replacing the South Park Bridge over the lower Duwamish River in unincorporated King County, Washington. The existing South Park Bridge, located along 16th Avenue South and at approximate river mile (RM) 4.0, is aged, structurally deficient, and vulnerable to seismic activity.

The proposed project is a new 5-span, movable center span, bascule bridge to the northwest (downstream) of the existing bridge. The new bridge, approximately 920 feet in total length, will span more than 400 feet of the Duwamish River (including a wider center navigation channel), with two permanent caisson foundations and bascule piers located below the Mean-Higher High Water (MHHW) line. The new bridge abutments and piers 2 and 5 will be located above MHHW with foundations supported on drilled shafts.

The new bridge will have two 58-foot square concrete caisson foundations. Each caisson covers 3,364 square feet, and 6,728 square feet in total below MHHW and occupies 180 cubic feet of the channel below the MHHW. The caissons will be approximately 20 feet closer to the shoreline than the existing bridge pier foundations. Construction of the cast-in-place north/south caisson foundations and bascule piers, demolition of the existing bascule piers, removal/deconstruction of the existing pier protection ("fender") piles, and placement of the new pier protection piles will be completed over three in-water work windows.

Construction is scheduled over a 34-month period (from April 2010 to March 2013), and all work below the MHHW of the lower Duwamish River will be completed during the approved in-water work windows (August 1 to February 15). Specific elements affecting listed species are described below:

Temporary Work Trestle Bridge Construction

Construction requires up to 366 temporary steel piles and 179 permanent steel piles (545 total) below the MHHW. Each set of temporary work trestles and their associated steel sheet pile cofferdams will occupy or cover approximately 16,000 square feet below the MHHW for three in-water windows.

The project will require two sets of temporary work trestles. The first set of temporary work trestles will consist of approximately 170, 24-inch diameter steel piles; 35, 16-inch diameter battered ("leaning") steel piles; steel cross bracing/substructure; and decking. The proponent will install an additional 32, 16-inch diameter steel piles as guides for the placement of two 70-foot square temporary steel sheet pile cofferdams (4,900 square feet each, and 9,800 square feet in total).

The second set of temporary work trestles will consist of approximately 145 24-inch diameter steel piles, 30 16-inch diameter battered steel piles, steel cross bracing/substructure, and decking. The proponent will install additional 16-inch diameter steel piles as guides for the placement of five temporary steel sheet pile cofferdams (approximately 7,600 square feet in total), one each for the existing main bascule piers and three intermediate piers.

The proponent will use barges or floating platforms to stage equipment and materials while completing work below MHHW and/or directly above the Duwamish River. Tugs will move and position barges and adjustable legs will hold barges in-place while completing work. Construction will focus barge operations along the Duwamish River's dredged center channel and will only move barges when water depths are sufficient to minimize the effects of prop-wash (including increased turbidity).

New Bascule Pier Construction

The KCDOT will use caissons as support for the new bridge. These caissons will be cast and pored inside cofferdams. Construction of the two permanent caisson foundations will require careful excavation, handling, storage, testing, treatment, transport, and disposal of native substrates (and water in-contact with substrates) known or suspected of contamination. The KCDOT will install individual pieces of multi-piece cofferdams in sequence to discourage fish from entering the project area and to allow accidentally trapped fish to escape through the downstream opening.

The project will construct permanent foundations for the two new bascule piers using a method of construction referred to as a "sand island caisson." Within the two 70-foot square temporary sheet pile cofferdams described above, the contractor will use a crane-mounted clamshell dredge/bucket (or other similar device) to excavate and remove native substrates to a depth of approximately 30 feet below the bottom of the channel. Within each excavated sheet pile cofferdam, the contractor will place approximately 42 feet of clean, granular fill and a pre-fabricated 58-foot square caisson "cutting shoe." The full vertical height of each caisson foundation will be constructed as a series of cast-in-place segments, each segment cast and then

dredged to sink the foundation to its final depth of approximately 30 feet below the channel bed. Cast-in-place distribution caps and bearing slabs will complete the foundations and precede the largely above-water work necessary to construct the vertical bascule pier walls. Finally, the cofferdams will be removed when turbidity levels within the work area are at or below background levels in the Duwamish River.

Because relatively few PS Chinook salmon and steelhead are expected to occur within the action area, because these structures are small in size relative to the width of the channel, and because listed species are likely to avoid locations where over-water work with heavy equipment is on-going, NMFS does not expect individuals of these species will be trapped within the cofferdams, injured, or otherwise affected by the work. Entrapment within temporary cofferdams and resulting adverse effects to PS Chinook salmon and steelhead are considered so extremely unlikely that they are discountable, and are not considered further in this consultation.

Pier Protection System Removal and Installation

The project will remove approximately 350, 12-inch diameter creosote-treated wood piles (and dolphins) associated with the existing bridge pier protection system. This material and any other treated wood waste produced by the project will be disposed at a properly permitted disposal site(s). The new permanent bridge pier protection system will consist of approximately 180, 24-inch diameter steel piles and fender walls placed along the center navigation channel, approximately 295 linear feet to the south and 390 linear feet to the north. The pier protection removal and subsequent installation will include conducting in-water work concurrently over three successive work windows, of August 1 to February 15.

Shoreline Improvements along Existing Bridge Alignment

The project proponents will complete in-water work necessary to restore and enhance left-bank shallow water, shoreline, and riparian zones in the immediate vicinity of the new bridge. The project will create approximately 6,000 square feet of tidally-influenced emergent wetland, 2,300 square feet of shrub-dominated transition zone, and will plant 4,300 square feet of woody riparian vegetation along approximately 240 linear feet of bank. These improvements will include removal of existing bank armor and replacement with bioengineered slopes and the Large Woody Debris (LWD) to enhance shallow water habitat.

Stormwater Treatment

The proposed project, including realignment/reconstruction and other minor improvements to the local street network, will reduce impervious surface (approximately 0.5 acre) and pollution generating impervious surface (PGIS) (approximately 0.1 acre) within the project area. The bridge and surrounding areas were delineated into southern and northern Threshold Discharge Areas (TDAs). The southern TDA is 0.73 acres, and the northern one is 2.53 acres. The new bridge design will incorporate a solid bridge deck to improve stormwater collection on the bridge surface and transport off the bridge into new stormwater treatment best management practices (BMPs). Stormwater from the northern TDA will be treated by a combination of wet vaults and

low-impact development (LID) facilities (i.e. rain gardens). Stormwater from the southern TDA will be treated by a combination of LID, traditional treatment, and permanent discharge into sanitary sewer for treatment at the West Point Water Treatment Facility, in Seattle.

The inclusion of each of these treatment and designed effects minimization elements, and the incrementally small amount of new PGIS added in these TDAs by the proposed action, indicates that discharges will be so small as to be insignificant in their effect to listed PS steelhead, PS Chinook and PS Chinook critical habitat, and so are not considered further in this consultation.

Pile Driving

All piles will be installed with a vibratory hammer, an impact hammer, or a combination of those techniques as site conditions allow. Steel sheet piles may be placed by these same methods or by direct pushing. The load-bearing piles will require impact proofing with the use of a noise attenuation device (such as a confined bubble curtain, a temporary noise attenuation pile, or the functional equivalent of those technologies).

A preliminary test pile program will occur months before the main project begins. The program will help determine baseline underwater noise as well as installation schedule and method. The test pile program will place one or two 24-inch diameter steel piles and one or two steel sheet piles while collecting sound pressure level (SPL) and vibration. This work will require approximately five working days between December 1, 2009 and February 15, 2010. As part of this program, FHWA and King County will be evaluating the performance of a temporary noise attenuation piles (TNAPs). TNAPs have achieved attenuation levels of -30 dB and more in test settings (MacGillivray et al. 2007). An approved noise attenuation system will be used during impact proofing and will reduce the maximum SPLs and SELs by at least -20 dB. The FHWA and WSDOT will employ confined air bubble curtains, TNAPs, or functional equivalent that attenuates the underwater noise from impact pile driving by a minimum of 20 dB. This performance standard will substantially reduce the extent of the potential impacts from steel-pile impact-installation on juvenile and adult PS Chinook salmon and juvenile PS steelhead, but will not eliminate impacts entirely.
Before installing the trestle-piles or steel sheet pile cofferdams, the contractor will place a six to 12 inch-deep blanket of clean, granular sand to reduce the amount of sediment that may be disturbed and re-suspended during the course of pile installation and removal, minimizing turbidity. The contractor will spread the sand blanket over as much as 35,000 square feet (0.8 acre) of the bottom below MHHW. The performance standard for this BMP will include specifications that will prevent resuspension of sediments during seasonal high flow events, avoiding turbidity effects later in time. FHWA and King County also plan to evaluate the sand cap integrity and depth through visual observations during low tide or by divers, auger sampling, or other appropriate method, depending on location, water clarity, and safety.

Temporary piles and sheet piles will be removed by direct pulling, a vibratory hammer, or a combination thereof. If piles break-off during extraction, or their removal cannot be achieved by these methods, the project will cut piles off at the mud line or top of the sand blanket.

Minimization Measures

The following additional measures included in the project directly or incidentally benefit ESA-listed fish and their habitat:

- Cofferdams will be used for worksite isolation and the joints will be sealed by an interlock sealant.

- All wastewater pumped from the cofferdam will be properly treated and disposed of an approved facility.

- Floating booms will be used to contain any debris that could enter the water during removal of the existing fender system.

- A containment system will be installed below the bridge spans to capture any debris from demolition activities.

- Barges will be monitored for overall displacement against expected tides to avoid grounding.

- Low draft skiffs will be used to eliminate sediment disturbance from prop wash.

- The project will use tugs to move and position barges or modular barges, but "spuds" or adjustable legs will hold barges in-place while completing work.

- Barge operations will be focused along the Duwamish River's dredged center channel and will only be moved when water depths are sufficient in order to minimize turbidity.

- The project will use a variety of BMPs to ensure safe handling, storage, and transport of contaminated or potentially contaminated river sediments and substrate (e.g., spill aprons, drop curtains, gated hoppers operating from fixed locations, sealed containers, etc.)

- The contractor shall furnish, install, and operate a temporary noise attenuation system such as a confined bubble curtain, TNAPs, or a functional equivalent for all in-water impact pile driving activities.

- The proponent will implement protocols for waste sampling and characterization. Any characteristically hazardous or toxic waste (or wastewater) will be disposed according to all applicable state and Federal requirements, at an approved upland disposal site or at an approved in-water dredged material disposal site operating under the Dredge Material Management Plan (DMMP).

The measures described above are in the submitted BA. The NMFS' relied on the inclusion of these measures in conducting this consultation, including all stated performance standards. The realities of completing such actions often involve changes in on-the-ground practices,

construction methods, and construction design and such changes can bear on the environmental effects of the action and the conclusions reached during the consultation. Therefore, the action agency or other cooperating party must inform NMFS of any changes to ensure the conclusions drawn during consultation remain valid.

Interrelated and Interdependent Actions

Interrelated actions are defined as actions that are part of a larger action and depend on the larger action for their justification. Interdependent actions are defined as actions "that have no independent utility apart from the action under consideration" (50 CFR section 402.02). Off-site disposal of characteristically hazardous or toxic waste (or wastewater) is the only interrelated action identified during consultation. The proposed project calls for disposal of these materials at an approved upland disposal site or in-water dredged material disposal site operating under a Dredged Material Management Plan (DMMP) (WDNR 2009). Sites operating under the DMMP were addressed under an earlier consultation (NMFS Tracking No. 2005/00484) and found not to jeopardize listed species. Therefore, dredge spoils management are not considered further in this Biological Opinion.

Action Area

The action area includes all areas directly or indirectly affected by the Federal action, as well as areas affected by interrelated and/or interdependent activities (50 CFR 402.2). For this consultation, the action area includes the Duwamish River in the area of the South Park Bridge, both up- and downstream of the existing bridge. The action area is framed by different ranges in which noise from pile driving will affect fish. The outside range of noise effects is approximately 2,350 ft upstream and 8,200 ft downstream, limited by channel geometry and bends in the river beyond which harmful levels of sound will not travel. Within that range, noise from unattenuated pile driving will be sufficient to injure or kill fish within a distance of 3818 feet upstream and downstream of pile installation. The unattenuated pile driving will only be necessary when working in close proximity to the existing bascule piers to avoid catastrophic failure of the bridge (i.e., 10 to 15 piles located within 50 feet of the existing piers). Therefore, "full installation with an impact hammer" will occur no more than approximately two working days (KCDOT 2008). The two day period includes the set-up time for each of the piles as well the monitoring. The actual impact pile driving will occur over an approximate 2 hour period.

The action area is within the geographic range of the PS Chinook salmon Evolutionarily Significant Unit (ESU) and the PS steelhead Distinct Population Segment (DPS) 1, both listed as threatened under the ESA. These fish rear, migrate, and complete the transition from freshwater to saltwater in the action area. The action area also includes designated critical habitat for PS Chinook salmon. Finally, the Duwamish River has designated EFH for Chinook salmon and coho salmon (*O. kisutch*) (PFMC 1999). The environmental effects of the proposed project may adversely affect EFH for Chinook, and coho salmon.

---

1 An "evolutionarily significant unit" (ESU) of Pacific salmon (Waples 1991) and a "distinct population segment" (DPS) of steelhead (71 FR 834; January 5, 2006) are both "species" as defined in Section 3 of the ESA.

ENDANGERED SPECIES ACT

Section 7(a)(2) of the ESA requires federal agencies to consult with NMFS to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The biological opinion (Opinion) that follows records the results of the interagency consultation for this proposed action. An incidental take statement (ITS) is provided after the Opinion that specifies the impact of any taking of threatened or endangered species that will be incidental to the proposed action, reasonable and prudent measures that NMFS considers necessary and appropriate to minimize such impact, and nondiscretionary terms and conditions (including, but not limited to, reporting requirements) that must be complied with by the Federal agency, applicant (if any), or both, to carry out the reasonable and prudent measures.

Biological Opinion

To complete the jeopardy analysis presented in this Opinion, NMFS reviewed the status of each listed species of Pacific salmon and steelhead considered in this consultation, the environmental baseline in the action area, the effects of the action, and cumulative effects (50 CFR 402.14(g)). From this analysis, NMFS determined whether effects of the action were likely, in view of existing risks, to appreciably reduce the likelihood of both the survival and recovery of the affected listed species.

For the critical habitat adverse modification analysis, NMFS considered the status of the entire designated area of the critical habitat considered in this consultation, the environmental baseline in the action area, the likely effects of the action on the function and conservation role of the affected critical habitat, and cumulative effects. NMFS used this assessment to determine whether, with implementation of the proposed action, critical habitat would remain functional, or retain the current ability for the PCEs to become functionally established, to serve the intended conservation role for the species (Hogarth 2005).

Status of the Species

The NMFS reviewed the condition of the species affected by the proposed action using criteria that describe a 'Viable Salmonid Population' (VSP) (McElhaney et al. 2000). These viability characteristics are the levels of abundance, productivity, spatial structure, and genetic diversity that give a population the capacity to adapt to various environmental conditions and the ability to become self-sustaining in the natural environment.

Puget Sound Chinook Salmon

Factors for the decline of PS Chinook salmon include a variety of human activities that have degraded extensive areas of PS Chinook salmon spawning and rearing habitat. Development has limited fish access to historical spawning grounds and altered downstream flow and thermal conditions. Urbanization effects many part of the aquatic environment. It has caused direct loss of riparian vegetation and soils, significantly altered hydrologic and erosion rates and processes by creating impermeable surfaces (roads, buildings, parking lots, sidewalks etc.), and polluting waterways. Urbanization throughout the Puget Sound region has increased sedimentation, raised water temperatures, and decreased large woody debris recruitment. In addition, this urbanization has also decreased gravel recruitment, reduced river pools and spawning areas, and dredged and filled estuarine rearing areas (Bishop and Morgan 1996). Large areas of lower river meanders (formerly mixing zones between fresh and salt water) have been channelized and diked for flood control and to protect agricultural, industrial and residential development. In spite of this, habitat degradation in upstream areas has exacerbated flood events in these areas with adverse effects on Chinook salmon populations (NMFS 1998). The BRT found moderately high risks for all VSP categories (Good et al. 2005) for PS Chinook salmon.

Diversity and Spatial Structure. The PS Chinook salmon ESU includes all naturally-spawned populations of Chinook salmon from rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River, eastward, including rivers and streams flowing into Hood Canal, South Sound, North Sound and the Strait of Georgia in Washington (64 FR 14208, March 24, 1999). The PS Chinook salmon ESU is composed of 31 historically quasi-independent populations, 22 of which are believed to be extant (PSTRT 2001). The nine populations presumed extinct are mostly early- run fish; most of these are in mid- to southern Puget Sound or Hood Canal and the Strait of Juan de Fuca. Up to twenty-six artificial propagation programs are part of the ESU. Eight of the programs are directed at conservation, and are specifically implemented to preserve and increase the abundance of native populations in their natal watersheds where habitat needed to sustain the populations naturally at viable levels has been lost or degraded. The remaining programs are operated primarily for fisheries harvest augmentation purposes (some of which also function as research programs) using transplanted within-ESU-origin Chinook salmon as broodstock.

These artificially-propagated stocks are no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (NMFS 2005). Assessing extinction risk for the PS Chinook salmon ESU is complicated by high levels of hatchery production and a limited availability of information on the fraction of natural spawners that are of hatchery-origin.

***Abundance and Productivity*.** Most populations have a recent five-year mean abundance of fewer than 1,500 natural spawners. Currently observed abundances of natural spawners in the ESU are several orders of magnitude lower than estimated historical spawner capacity, and well below peak historical abundance (approximately 690,000 spawners in the early 1900s) (NMFS 2005). Recent five-year and long-term productivity trends remain below replacement for the majority of the 22 extant populations of PS Chinook salmon. The Biological Review Team

(BRT) was concerned about the concentration of the majority of natural production in just a few subbasins, the disproportionate loss of early run populations, and the pervasive use of Green River stock and stocks subsequently derived from the Green River stock. Together these factors may reduce the genetic diversity and fitness throughout the ESU.

In terms of productivity, the hatchery programs collectively do not substantially reduce the extinction risk of the ESU in-total (NMFS 2004). Long-term trends in abundance for naturally spawning populations of Chinook salmon in Puget Sound indicate that approximately half the populations are declining, and half are increasing in abundance over the length of available time series. The median over all populations of long-term trend in abundance is 1.0 (range 0.92–1.2), indicating that most populations are just replacing themselves.

Puget Sound Steelhead

Puget Sound steelhead was listed as threatened on May 11, 2007 (72 FR 26722). The principal factor for decline for PS steelhead is the present or threatened destruction, modification, or curtailment of its habitat or range. Barriers to fish passage and adverse effects on water quality and quantity resulting from dams, the loss of wetland and riparian habitats, and agricultural and urban development activities have contributed and continue to contribute to the loss and degradation of steelhead habitats in Puget Sound. Existing regulatory mechanisms inadequately protect habitats as evidenced by the historical and continued threat posed by the loss and degradation of nearshore, estuarine, and lowland habitats due to agricultural activities and urbanization. Ocean and climate conditions can have profound impacts on the continued existence of steelhead populations. (72 FR 26722, May 11, 2007)

***Spatial Structure and Diversity*.** The DPS includes all naturally spawned anadromous winter-run and summer-run steelhead populations, in streams in the river basins of Puget Sound, as well as the Green River natural and Hamma Hamma winter-run steelhead hatchery stocks. The majority of hatchery stocks are not considered part of this DPS because they are more than moderately diverged from the local native populations (NMFS 2005). Resident steelhead occur within the range of PS steelhead but are not part of the DPS due to marked differences in physical, physiological, ecological, and behavioral characteristics (71 FR 15666; March 29, 2006). The PS steelhead DPS includes more than 50 stocks of summer- and winter-run fish.

Abundance and Productivity. No estimates of historical (pre-1960s) abundance specific to the PS steelhead DPS are available. Of the 21 independent stocks for which adequate escapement information exists, 17 stocks have been declining and four increasing over the available data series, with a range from 18 percent annual decline (Lake Washington winter steelhead) to seven percent annual increase (Skykomish River winter steelhead). Eleven of these trends (nine negative, two positive) were significantly different from zero. The two basins producing the largest numbers of steelhead (Skagit and Snohomish Rivers) both have overall upward trends. Hatchery fish in this DPS are widespread, spawn naturally throughout the region, and are largely derived from a single stock (Chambers Creek). The proportion of spawning escapement comprised of hatchery fish ranged from less than one percent (Nisqually River) to 51 percent (Morse Creek). In general, hatchery proportions are higher in Hood Canal and the Strait of Juan

de Fuca than in Puget Sound proper. Most of the hatchery fish in this region originated from stocks indigenous to the DPS, but are generally not native to local river basins. Summer steelhead stocks within this DPS are all small, occupy limited habitat, and most are subject to introgression by hatchery fish.

Specifically, the BRT concluded that there is: (1) a high risk to the viability of PS steelhead due to declining productivity and abundance; (2) a moderate risk due to reduced spatial complexity of, and connectivity among, populations; and (3) a moderate risk due to the reduced life-history diversity of populations and the potential threats posed by artificial propagation and harvest practices in Puget Sound. Of the multiple extant populations/runs that make up the listed ESU and DPS evaluated in this Opinion, only the Green River Chinook salmon population of PS Chinook, and the Green River summer and winter runs of PS steelhead will be affected.

Status of Salmon and Steelhead Populations in the Green/ Duwamish River

The lower Duwamish River plays an important role as migratory habitat for all salmon and steelhead of the Green-Duwamish watershed; these populations include: Green River Chinook salmon *(status rated as "healthy"*), *and Green River summer and winter steelhead (status "depressed" and "healthy" respectively) (*WDFW 2002).

Ruggerone et al (2006) conducted a study on juvenile PS Chinook in the Duwamish River. Up to 14 nearshore sites were sampled on a weekly basis in the lower Duwamish River (RM 6.6-8.5), Transition Zone (RM 4.6-6.5), and Duwamish estuary (RM 1 to RM 3.5) from February 3 to July 12, 2005. The Duwamish River and Turning Basin locations are approximately a one mile downstream and upstream of the South Park Bridge Project located at RM 4.0. Ruggerone et al (2006) found that on average, catches of non-hatchery Chinook salmon in the Transition Zone versus the lower estuary (RM 1 to 3.5) were 57 percent greater February 3 to March 21, 259 percent greater March 28 to May 16, and 118 percent greater May 23 to July 12. Thus, both Chinook fry and fingerlings were more abundant in the Transition Zone compared with the lower estuary (Ruggerone et al. 2006).

Much of the studies were conducted near the end of the WDFW work window and concentrated on juvenile life histories. The studies assumed that adult species migrate through this section fairly quickly. Ruggerone et al (2006) also found that mean lengths of natural subyearling Chinook salmon captured in the lower river and estuary increased steadily from 37 mm on January 20 to 82.8 mm on May 10. On May 16 mean length declined to 78 mm, then length remained relatively constant until a slight increase during late June. The WDFW sampled downstream migrating juvenile salmonids at the RM 34.5 screw trap from January 10 to July 15, 2005. Small numbers of subyearling natural Chinook salmon were captured during the first week of sampling in mid-January (less than 10 fry per night), increasing to approximately 250 fry per night on January 21 near the end of the work window (Ruggerone et al 2006).

Hard et al (2007) indicates that Green River winter-run steelhead enter freshwater in mid-October with peak spawning occurring in April. WDFW has identified 53 populations of steelhead in this ESU, of which 37 (69.81 percent) are winter run (Hard et al 2007). However,

no abundance estimates exist for most of the summer run populations; all appear to be small, most averaging less than 200 spawners annually. Summer run populations are distributed throughout the ESU but are concentrated in northern Puget Sound and Hood Canal (Hard et al 2007).

Status of Critical Habitat

The NMFS has not yet designated critical habitat for Puget Sound steelhead. NMFS designated critical habitat for the PS Chinook ESU on September 2, 2005. The Primary Constituent Elements (PCEs) for PS Chinook salmon critical habitat are the sites and the physical characteristics' of such sites, which are essential to support one or more life stages of the ESU. The PCEs of PS Chinook salmon critical habitat are:

PCE 1--Freshwater spawning sites with water quantity and quality conditions and substrate that support spawning, incubation, and larval development;

PCE 2--Freshwater rearing sites with (1) water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility, (2) water quality and forage that support juvenile development, and (3) natural cover such as shade, submerged and overhanging large wood, logjams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks;

PCE 3--Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks that support juvenile and adult mobility and survival;

PCE 4--Estuarine areas free of obstruction and excessive predation with (1) water quality, water quantity, and salinity conditions that support juvenile and adult physiological transitions between fresh water and salt water, (2) natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels, and (3) juvenile and adult foraging opportunities, including aquatic invertebrates and prey fish, supporting growth and maturation;

PCE 5--Nearshore marine areas free of obstruction and excessive predation with (1) water quality and quantity conditions and foraging opportunities, including aquatic invertebrates and fishes, supporting growth and maturation, and (2) natural cover including submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels;

> PCE 6--Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

The critical habitat for Puget Sound Chinook includes 18 subbasins containing 61 occupied watersheds as well as 19 nearshore marine zones. The conservation value of each watershed and

marine zone was ranked for its relative value toward conservation. Considering the raw scores for each area, and that area's contribution in relation to other areas and in relation to the overall population structure, the CHARTs rated each habitat area as having a ''high,'' ''medium,'' or ''low'' conservation value. Twelve areas area ranked low, nine are ranked medium, and the remainder are ranked with high conservation value. Throughout the designated area, multiple PCEs are degraded or impaired in some degree, negatively affecting multiple life history stages. Information specific to the condition of the essential elements of the PCEs in the action area are found in the Environmental Baseline section, below. Of the three watersheds comprising PS Chinook salmon critical habitat within the action area, the CHART ranked the watersheds as providing high conservation value.

Environmental Baseline

The 'environmental baseline' includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

The action area includes a portion of the Duwamish River and Waterway downstream of the Duwamish Turning Basin. The Turning Basin is the point farthest upriver to which saltwater penetrates on the full tide. Certain populations of Puget Sound Chinook salmon and PS steelhead rear in, migrate through, and complete the physiological transition from fresh to saltwater life histories in the action area (PCEs 2, 3, and 4, freshwater rearing, freshwater migration, and estuarine areas).

Habitat conditions in the Duwamish River are highly influenced by the surrounding land uses. Land use throughout the action area is almost exclusively industrial, commercial/light-industrial, and dense urban residential. Throughout the action area the lower Duwamish River and its floodplain are very heavily developed. Prior to 1853, the action area would have been entirely in the estuary of the Duwamish River. Since the late 1800s these portions of the lower Duwamish River have been the focus of a long succession of flood control, navigational, port, industrial, and other related activities (LDWG 2009a). Less than two percent of the lower Duwamish River's pre-development estuarine mud flat, sand flat, and intertidal wetlands remain intact today (Kerwin and Nelson 2000). This means that all elements of PCE 4 are largely absent in the action area.

Manmade and natural events have altered conditions in the Duwamish River since the early 1900s. Diversion of tributaries (Cedar and White Rivers) reduced the river's drainage basin by 71 percent and its average flow by more than 70 percent. At about the same time, the lower river was dredged to create the Duwamish Waterway, replacing nine meandering miles of river with a straight, deep, four-mile-long navigation channel (EBDRP 1994).

Of the two percent of remaining estuarine habitat in the action area, most PCE components (salinity conditions; natural cover such as submerged and overhanging large wood, aquatic

vegetation, large rocks and boulders, and side channels; juvenile and adult foraging opportunities; water quality, water quantity) are degraded. Typically, estuaries provide habitat in which juvenile Chinook salmon complete their osmoregulatory transition from freshwater to saltwater; rear, feed, and grow gaining fitness for their subsequent ocean life history; and migrate to the ocean. Estuaries also supply holding habitat for adult salmon waiting for sufficient flows to ascend the river to spawning grounds. In functioning estuaries, juvenile Chinook salmon use distributary channels and tidal sloughs for feeding, avoiding predators, and resting over several weeks to months. This juvenile life history is also a period of rapid growth when preferred food is abundantly present (Simenstad 1980, Nelson et al., 2004). In the Duwamish Waterway, the historical off-channel distributary channels and tidal sloughs have largely been eliminated, confining the estuarine functions to the river itself (Kerwin and Nelson 2000).

The action area also lacks or provides poorly functioning riparian zones with little or no functioning riparian vegetation. Riparian vegetation, especially trees near and beside streams and rivers contribute a source of insects and other organic debris that provide food for juvenile salmon and steelhead, support the building blocks of the food web. Riparian trees also shade water and help regulate water temperature, among other things that are mostly not occurring in the action area.

Water quality issues in the action area include high temperature, low dissolved oxygen, and chemical contamination. Temperatures can reach stressful levels during the adult migration holding period, but little information is available on the physiological conditions of migrating Chinook salmon in recent years (Ruggerone and Weitkamp 2004). Ruggerone et al., (2006) sampled water temperature in the nearby Duwamish River Turning Basin nearshore in 2005 and found that temperature averaged 8 degrees C in February and increased to an average of 12 degrees C in July. In the lower Duwamish waterway, several instances of adult Chinook mortality have been reported, likely due to low dissolved oxygen (DO) levels, which can also affect gametes on a sublethal level (Averill 2004).

A large portion of the Duwamish Waterway is on the National Priorities ("Superfund") List (WDOE 2009a). Sources of toxic surface water and sediment contamination, and the feasibility of various source control and corrective actions, have been the focus of intensive study since the mid-1970s (LDWG 2009a). Corrective actions began as early as the 1950s and 60s with the curtailment of toxic industrial discharges and improved or replaced sewer and water treatment infrastructure, and have continued to the present in the form of hazardous waste disposal programs, preservation and/or restoration of intertidal habitats, control and/or retrofit of combined sewer overflows and further improvements to sewer and water treatment infrastructure, and clean-up (removal and disposal) of soil, water, and sediment contamination at a number of locations along the lowermost 6 miles (approximate) (LDWG 2009a,b). The members of the Lower Duwamish Waterway Group (LDWG), including the Port of Seattle, City of Seattle, King County, and the Boeing Company, have entered into a voluntary agreement with the EPA and WDOE to improve and better coordinate investigative and feasibility studies, and to prioritize, strategically plan, and complete corrective actions and clean-ups.

The action area is within one of seven "Early Action Areas" (EAAs) identified for the Lower Duwamish Waterway Superfund Site (Boeing Plant 2 / Jorgensen Forge), and is also just downstream of a second EAA (Terminal 117) (WDOE 2009a). The Boeing Plant 2 / Jorgensen Forge EAA is bisected by 16th Avenue South and the South Park Bridge (Figure 5). Clean-up and other remedial actions are at various stages of completion at additional EAAs, both upstream and downstream of the South Park Reach (LDWG 2009b).

To initiate consultation, the FHWA provided sediment sampling data collected from approximately 226 separate locations within 500 meters upstream and downstream of the existing South Park Bridge. These data were collected from both surface and sub-surface samples. Individual Aroclor PCBs, Total PCBs, carcinogenic PAHs, phthalates, and metals have been identified as contaminants of concern for the Boeing Plant 2 / Jorgensen Forge EAA (WDOE 2009b). Boeing Plant 2 is an approximately 107-acre site in operation since 1936. Boeing is currently investigating and cleaning-up contaminated soil and groundwater from the site under a Resource Conservation and Recovery Act (RCRA) order (EPA 2009a). To date, interim control measures at Boeing Plant 2 have included removal of PCB-contaminated soils, groundwater treatment, and closure of storm drains to prevent discharges to the Duwamish River (EPA 2009a). Jorgensen Forge is an approximately 22-acre site in operation as a steel and alloy forging plant and distribution center since 1942 (WDOE 2009c). Investigations at the Jorgensen Forge site have detected soil concentrations exceeding applicable clean-up levels for PCBs, total petroleum hydrocarbons, and various heavy metals.

Sediments located within 10 vertical feet of the channel bed or bottom are contaminated, that sediments located between 10 and 18 feet below the channel bed or bottom should be presumed contaminated until testing demonstrates otherwise, and that sediments and native substrate located more than 18 feet below the channel bed or bottom are presumably uncontaminated (KCDOT 2009). These conclusions are consistent with the findings of the Remedial Investigation completed by the LDWG for the Lower Duwamish Waterway Superfund Site (LDWG 2009a).

Effects of the Action

Effects of the action are the direct and indirect effects of an action on the listed species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). As mentioned above, no interdependent actions are considered in this analysis. The direct and indirect effects of the proposed bridge replacement will include noise from pile driving and water quality effects from increased turbidity and suspension of contaminated sediment. Finally, the presence of construction structures might temporarily affect passage at the site of those structures.

Underwater Noise from Pile Driving

The proponent will install up to 545 hollow steel pilings in the Duwamish River for the temporary work trestles and pier protection system. Pile installation for each of the three temporary structures is expected to occur on as many as 100 days during one in-water work

window for each structure, with only one temporary structure being constructed per year, for three consecutive years. To reduce the exposure of listed fish to underwater noise levels, installation is limited to the period from August 1 through February 15; the lifestages of listed fish that are present are less vulnerable (i.e. larger body size) to the potential effects. To further reduce potential effects, the proponent will use a vibratory hammer to install the piles, limiting the use of an impact hammer to that needed for proofing, and attenuate sound down to a twenty-five percent corridor of the river where listed species can migrate around the in-water work. These measures will reduce the intensity and duration of sound that migrating PS Chinook adult salmon and steelhead in the lower Duwamish River will experience. Juvenile Chinook salmon and steelhead are not expected to be present, as available data indicate that these life history forms will have out migrated to marine habitats before the beginning of the in-water work window.

The proposed action calls for impact pile driving under three different scenarios: 1) impact driving of a limited number of test piles without a noise attenuation device for determining baseline sound levels; 2) impact driving to refusal or top depth--approximately 12,000 pile strikes per day , based on eight piles per day at approximately 1,500 strikes per pile); and 3) impact pile driving in combination with vibratory driving as site conditions require, followed by impact proofing (approximately 4,800 pile strikes resulting from; eight piles per day at approximately 600 strikes per pile).

Except when driving test piles to determine baseline sound levels, the proponent will conduct all impact pile driving operations using a noise attenuation device. Pile installation will require impact pile driving on as many as 100 working days (KCDOT 2009), but full installation with an impact hammer should be necessary only when working in close proximity to the existing bascule piers to avoid catastrophic failure of the bridge (i.e., 10 to 15 piles located within 50 feet of the existing piers). Therefore, “full installation with an impact hammer” should not be necessary on more than approximately two working days (KCDOT 2008).

Few experimental studies on the effects to fishes from the noise generated during pile driving have been carried out. Those that have been conducted were primarily opportunistic studies that took advantage of pile driving activities to examine the effects to caged fishes, and had varying results. Two studies in California (Abbott and Bing-Sawyer 2002; Caltrans 2002) described significant levels of injury in caged fishes at distances as far as 311 meters from the pile and peak pressures as low as 198 dB (re: 1 µPa)2 and exposed to approximately 4,000 pile strikes. Risk of injury from underwater noise appears related to the effect of rapid pressure changes, termed barotraumas, especially on gas-filled spaces in the bodies of exposed organisms (Turnpenny et al. 1994b). In these studies, the effects of underwater noise on organisms range from no observable effects to immediate death. Over this continuum of effect, there is no easily

---

2 Throughout this document, the reference value for dB peak pressure 1 µPa.

identifiable point at which behavioral responses occur, or where they transition to physical injury.

At certain levels and/or over a sustained period, noise from impact pile driving causes fish mortality and injury (Stotz and Colby 2001; Fordjour 2003; Gaspin 1975; Hastings and Popper 2009; Abbott et al. 2005; John Stadler, NMFS, pers. obs. 2002). Fish with swimbladders, including salmonids, are more susceptible to barotraumas from impulsive sounds (sounds of very short duration with a rapid rise in pressure) because of swimbladder resonance (vibration at a frequency determined by the physical parameters of the vibrating object). When a sound pressure wave strikes a gas-filled space, such as the swimbladder, it causes that space to vibrate (expand and contract) at its resonant frequency. When the amplitude of this vibration is sufficiently high, the pulsing swimbladder can press against, and strain, adjacent organs, such as the liver and kidney. This pneumatic compression causes demonstrable injury, in the form of ruptured capillaries, internal bleeding, and maceration of highly vascular organs (Caltrans 2002). Hastings and Popper (2009) also noted that sound waves can cause different types of tissue to vibrate at different frequencies, and that this differential vibration can cause tearing of mesenteries and other sensitive connective tissues. Exposure to high noise levels can also lead to injury through "rectified diffusion," the formation and growth of bubbles in tissues. These bubbles can cause inflammation, cellular damage, and blockage or rupture of capillaries, arteries, and veins (Crum and Mao 1996; Stroetz et al. 2001; Vlahakis and Hubmayr 2000). These effects can lead to overt injury or even mortality. Death from barotrauma and rectified diffusion injuries can be instantaneous, or delayed for minutes, hours or even days after exposure.

When noise does not reach lethal levels, elevated noise levels can still cause sublethal injuries that later affect survival and fitness. Fish suffering damage to hearing organs may suffer equilibrium problems, and may have a reduced ability to detect predators and prey (Turnpenny et al. 1994b; Hastings et al. 1996). Other types of sub-lethal injuries can place the fish at increased risk of predation and disease. Adverse effects on survival and fitness can occur even in the absence of overt injury. Exposure to elevated noise levels can cause a temporary shift in hearing sensitivity (referred to as a temporary threshold shift, or TTS), decreasing sensory capability for periods lasting from hours to days (Turnpenny et al. 1994b; Hastings et al. 1996).

The severity of effects from noise produced by impact-driving steel piles depends on several factors, including the size and species of fish exposed. Regardless of species, smaller fish appear to be far more sensitive to injury of non-auditory tissues (Yelverton et al. 1975). For example, NMFS biologists observed that approximately 100 surf perch from three different species (*Cymatogaster aggregata, Brachyistius frenatus,* and *Embiotoca lateralis*) were killed during impact pile driving of 30-inch diameter steel pilings at Bremerton, Washington, (Stadler, NMFS, pers. obs. 2002). Dissections revealed complete swimbladder destruction across all species in the smallest fish (80 mm FL), while swimbladders in the largest fish (170 mm FL) were nearly intact. However, swimbladder damage was typically more extensive in *C. aggregata* when compared to *B. frenatus* of similar size. Because of their large size, adult salmon are expected to tolerate higher noise levels and are generally less sensitive to injury of non-auditory tissues than juveniles (Hubbs and Rechnitzer 1952). However, no information is available to determine whether or not the risk of auditory tissue damage decreases with increasing size of the fish.

The scientific literature does not correlate peak pressure with injury to non-auditory tissues in fishes with swimbladders (e.g., Yelverton et al. 1975; Teleki and Chamberlain 1978;). Instead, current data suggests that the applicable metric for injury to these tissues is an energy index that

is indicative of mechanical work done on the tissues, and can be estimated using cumulative sound exposure level (SEL), however, the most relevant data (Yelverton et al. 1975; Wiley et al. 1981; Bailey et al. 1996; Stuhmiller et al. 1996) are not reported in cumulative SEL, and the raw data necessary to calculate SEL is not available.

Recently, a multi-agency working group of Federal and state transportation and resource agencies, including underwater acoustics experts, fish biologists, and transportation specialists, released agreed-upon "interim criteria" for evaluating the potential for physical effects (i.e., injury) from underwater noise levels caused by pile driving (FHWG 2008). These criteria are based on the information reported above (Popper et al. 2003; Carlson et al. 2007; Hastings 2009) and represent threshold values of the two sound metrics proposed by Carlson et al. (2007) (peak pressure and accumulated SEL) for assessing the risk of direct injury, including TTS, and account for the repeated strikes required to drive a pile. Injury is expected if either: 1) the peak pressure of any strike exceeds 206 dB (re: 1µPa); or 2) SEL, accumulated over all pile strikes, exceeds 187 dB (re: 1 μPa^2*sec) for fishes 2 grams or larger and 183 dB (re: 1 μPa^2*sec) for fishes smaller than 2 grams. Because all ESA-listed salmonids in the action area during pile driving are expected to be larger than 2 grams, the threshold for accumulated SEL used in this analysis is 187 dB.

Behavioral effects are observed at far lower noise levels than those associated with injury. Root mean square (rms) SPLs are commonly used in behavioral studies. The Fisheries Hydroacoustic Working Group (FHWG) currently believes that rms SPLs in excess of 150 dB(re: 1µPa)3 are likely to elicit temporary behavioral changes, including a startle response or other behaviors indicative of stress and recommends this value as a threshold for possible behavioral effects. While SPLs of this magnitude are unlikely to lead to permanent injury, depending on a variety of factors (e.g., duration of exposure) they can still indirectly result in potentially lethal effects. For example, temporary threshold shifts or altered behavior may increase the vulnerability of individual fish to predation. Feist et al. (1996) noted that juvenile pink and chum salmon exposed to pile driving noise were less likely to startle and flee when approached by an observer. Popper (2003) suggests that behavioral response of fishes to loud sounds may include swimming away from the sound source, thereby decreasing potential exposure to the sound, or "freezing" (staying in place), thereby becoming vulnerable to possible injury. Alternatively, fish could effectively abandon favorable habitats affecting long-term behavior and subsequent survival and reproduction, as found by Engas et al. (1996) when evaluating the response of gaddids to the impulsive sounds from seismic surveys. Based on the above information, the Services use an SPL of 150 dB_{rms} as a guideline for when behavioral effects can be expected.

Extent and Duration of Underwater Noise from Pile Driving. To assess the extent of effects from pile driving, NMFS uses the "interim criteria" described above. The effects of underwater noise from pile driving will occur over a period of 100 days between August 1 to February 15 each year, for three consecutive years during construction of the three temporary work trestles and pier protection structures.

---

3 Throughout this document, reference value for rms dB is 1 µPa.

Impact Pile Driving: Unattenuated Noise. The first scenario includes impact driving of a limited number of test piles without noise attenuation to collect baseline noise level data. Baseline data will help confirm attenuation system performance, as specified in hydroacoustic monitoring plan requirements. Unattenuated pile driving will occur for approximately two minutes on each of the five piles being monitored for a total of approximately 10 minutes or 15 strikes per pile for a total of 75 strikes. More extreme effects, including injury and mortality of migrating adults, could potentially occur during limited unattenuated pile driving used to collect baseline data for hydroacoustic monitoring.

The maximum noise levels produced by this activity will be 212dBpeak, 189 dB_{rms}, and a single-strike SEL of 181 dB. The effects include exceeding the 206 dBpeak for 82 feet and the threshold cumulative SEL of 187 dB for a distance of 233 feet from the pile. Channel geometry will prevent underwater sound propagation much beyond the first upstream and downstream channel bends, located at approximately 2,350 ft upstream and 8,200 ft downstream. The calculated distance for sound levels that could cause fish behavioral modification is 13,061. But underwater noise levels that could affect fish are unlikely to spread beyond bends in the river (for a total distance of 10,550). This means that the extent of the Duwamish River in which noise will be sufficient to change normal fish behavior will be no more than approximately 2,350 ft upstream and 8,200 ft downstream from the source. The number of fish that might be injured by such changes cannot be estimated. The distances where noise thresholds, described above, are exceeded represent a worst case scenario. Furthermore, the duration of these effects will be limited to approximately two working days (KCDOT 2008).

Impact Pile Driving: Attenuated Noise. The contractors will be impact pile driving with noise attenuation in two different scenarios. During both scenarios, attenuation should achieve an average of 20 dB decrease. The first scenario includes full installation with an impact hammer only when working in close proximity to the existing bascule piers (10 to 15 piles located within 50 feet of the existing piers). The second scenario involves pile driving by a combination of vibratory and impact driving as site conditions allow, followed by impact proofing. The cumulative SEL will exceed 187 dB for a distance of 177 feet from the pile. In addition, the practical spreading model predicts that rms pressures will not drop below 150 dB for 607 feet from pile driving activities.

During construction, both PS Chinook salmon and PS steelhead will use this section of the action area only as a migratory corridor. Individual fish will move through the action area at varying rates but are not expected to remain stationary for extended periods during construction. Simply put, the corridor through the action area presents little habitat function for these fish other than as passage from Elliot Bay to the Green River, and the habitats present are generally suitable only as a migration corridor. The presence of adult and juvenile steelhead and juvenile Chinook salmon in the action area during the in-water work window is highly unlikely. Therefore, steelhead and juvenile Chinook salmon are not likely to be adversely affected by this activity and these effects are not considered further here.

To ensure the action area continues to provide passage function, noise from impact pile driving must be minimized below levels capable of causing injury. The Duwamish River at the project location is approximately 400 feet wide. To secure a passable corridor, the action must include sufficient noise attenuation to limit the threshold exposure distance to less than the entire width

of the waterway. NMFS believes that a corridor 100 feet to 140 feet wide is sufficient in the action area for adult migration.

Although sound should be attenuated sufficiently to avoid injury and death of individual fish, elevated SPLs from impact and vibratory pile driving could alter normal migration behavior by delaying the upstream migration of Chinook salmon and steelhead. Listed species will not be in the area long enough for the duration of exposure to be meaningful. In addition, daily pile driving activities will be separated by overnight rest periods when migration can proceed uninhibited, upstream migration of Chinook salmon and steelhead is not expected to be significantly delayed.

Water Quality—Re-suspension of Sediments and Associated Contaminants

Turbidity and Deposition. Construction and removal of temporary in-water structures, and construction of permanent structures can disturb bottom sediments creating turbid conditions that will induce a number of responses in fish that are present. Turbid water can disrupt feeding, cause physiological stress and reduce growth, and adversely affect fish survival (Bash et al 2001; Berg and Northcote 1985; Bisson and Bilby 1982; Waters 1995). Exposure duration is a critical determinant of physical or behavioral effects. Effects of turbid water on fish are diminished or aggravated by the season, frequency, and the duration of the exposure, and by the life stage of the species (NMFS 2005c). The first behavioral response of fish to turbidity is avoidance (DeVore et al. 1980; Birtwell et al. 1984). Salmonids have been observed to move laterally and downstream to avoid turbid plumes (Sigler et al. 1984; Lloyd 1987; Servizi and Martens 1991).

Sediment settling out of turbid water degrades spawning incubation, and emergence, and negatively affects primary and secondary productivity. Although there is no spawning occurring in the action area, reduced primary production could affect the already limited extent of juvenile forage produced in the action area. Reduced forage availability could reduce growth and survival of juvenile PS Chinook (Cordone and Kelley 1961; Bjorn et al. 1974). Particulate materials physically abrade and mechanically disrupt respiratory structures and respiratory epithelia of benthic macroinvertebrates, adversely affecting food for salmonids (Rand and Petrocelli 1985).

Contaminants. Sediment in the area around the bridge has been sampled to assay levels of contaminants in the area. Review of the sampling indicates that median metal sediment concentrations along the South Park Reach approach or exceed contaminant-specific marine standards Sediment Quality Standards (SQSs) and Clean-Up Screening Levels (CSLs), interim freshwater sediment guidelines including Threshold Effect Levels (TELs) and Probable Effect Levels (PELs), and Model Toxics Control Act (MTCA) Level A clean-up levels, (KCDOT 2008). In addition, Sandahl *et al*. (2007) documented sensory physiological impairment, and related disruption to predator avoidance behaviors, in juvenile coho at concentrations as low as 2 µg/L dissolved copper. Sprague (1968) found that at concentrations as low as 5.6 µg/L dissolved zinc juvenile rainbow trout exhibit avoidance behavior. By comparison, predicted equilibrium concentrations in any resulting contaminant plume are approximately 1.31 µg/L dissolved copper and 1.15 µg/L dissolved zinc (Herrera 2007).

The replacement of the existing bridge with a new moveable span bascule bridge will require extensive in-water construction. These activities include the driving and removal of piles and

sheet piles. Sediments in the action area are highly contaminated such that this area that has been designated a Superfund Site (EPA 2009c, EPA 2009e). Polychlorinated biphenyls (PCBs) are present in these soils and are harmful to listed salmonid species (Giesy and Kannan 1998). Finally, polycyclic aromatic hydrocarbons (PAHs) are also present in the action area. In-water construction activities are likely to re-suspend sediments, which could lead to the transfer of sediment-borne contaminants to the water column. Although the timing of in-water construction will be constrained, and other mitigation measures will be used to minimize sediment disturbance, some re-suspension of contaminated sediment will be unavoidable, and some exposure of listed fish to contaminants is likely. The likelihood of fish exposure to contaminants in the action area is considered below.

Polycyclic Aromatic Hydrocarbons. PAHs are a class of organic chemical compounds, consisting of fused aromatic rings, commonly found in oil, coal, and tar and frequently occurring in nature as a byproduct of fuel burning and/or incomplete combustion. As an environmental pollutant or contaminant, these compounds are of concern because of their documented carcinogenic, mutagenic, and teratogenic properties, and because they show an apparent tendency for bioaccumulation (EPA 2009d). Many of the PAHs are potent carcinogens, but a host of other (i.e., non-cancer-causing) potential biological effects are poorly understood. In aquatic systems, the high molecular-weight PAHs tend to exhibit greater toxicity than do the low-molecular weight PAHs. The toxicological literature reports inhibited reproduction, delayed emergence, liver disease or malfunction, morphological abnormalities, immune system impairment, and mortality as effects to benthic invertebrates and/or fish resulting from exposure to PAHs (EPA 2009d). Although the timing of in-water construction will be constrained, and other mitigation measures will be used to minimize sediment disturbance, some re-suspension of contaminated sediment will be unavoidable, and some exposure of listed fish to PAHs is likely. The likelihood of fish exposure to PAHs in the action area is considered below.

Polychlorinated Biphenyls. PCBs are a class of synthetic organic chemical compounds, consisting of 1 to 10 chlorine atoms attached to biphenyl group (two bonded benzene rings). Where found in nature these compounds may have originated from various industrial sources and processes, including dielectric fluids in transformers and capacitors, coolants, lubricants, electrical wiring and components, pesticides, cutting oils, flame retardants, hydraulic fluids, sealants, adhesives, paints and finishes, and dust control agents (EPA 2009d). As an environmental pollutant or contaminant, these compounds are of concern because of their documented carcinogenic, mutagenic, and teratogenic properties, and because they show an apparent tendency for bioaccumulation and food web bioconcentration. The toxicological literature reports reduced fertilization success and egg survival, reproductive failure, reduced growth, liver malfunction, and altered blood and enzyme function as effects to benthic invertebrates and/or fish resulting from exposure to PCBs (EPA 2009d).

In the aquatic environment, PCBs are usually found in much higher concentrations in sediments than in the overlying water column. PCBs have a high affinity for suspended solids, especially those higher in organic carbon. Exposure to PCBs will still result from this project through sediments dislodged and suspended during the operation that are not extracted and treated. PCB exposure is known to result in impaired immunity in juvenile salmonids (Fisher 1989; Arkoosh

et al. 1994). Arkoosh further linked impaired immunity to increased susceptibility to disease and increased predation in the marine environment. Other adverse effects attributed to PCBs include death, reduced growth and reproduction, hormonal alterations, enzyme induction, neurotoxicity, behavioral responses including reduced predator avoidance ability (Fisher et al. 1994), disease susceptibility and mutagenicity. Many of these effects correlate with the tissue-burden of PCBs that can be quantified in exposed salmonids (Meador et al. 2002).

Although the timing of in-water construction will be constrained, and other mitigation measures will be used to minimize sediment disturbance, some re-suspension of contaminated sediment will be unavoidable. Exposure of listed fish to PCBs is likely. The likelihood of fish exposure to PCBs in the action area is considered below.

Estimated Intensity and Duration of Fish Exposure to Contaminants. In-water construction activities that disturb sediments will suspend contaminated sediments into the water column, which will then be dispersed downstream by river flow. The extent of contaminated sediment transport will be based on water velocity and the weight of the various sediment fractions. Initially, chemicals of potential concern (COPCs) that are desorbed to the re-suspended sediment will partition between the sediment and the water column based on the Log Kow (the log of the partitioning ratio between octanol [an organic solvent] and water) {Schwarzenbach and Westallt, 1981). These heavier weight solvents remain sorbed to the sediment and redeposit to in-situ sediments within the localized area. The lower molecular weight contaminants will remain in the water column longer and drifting further away from the action area (King County 2008).

The duration and intensity of exposure for listed species will be brief and episodic depending upon the timing of the construction activities. The in-water work, which resuspends contaminated sediment, will be limited to the work window referenced in the pile driving section of this Opinion.

The proposed action incorporates the tiered approach of BMP implementation which includes the application of a sand cap before any pile driving or sheet pile installation and removal activities. Monitoring will also be included to assess when water quality exceedances are observed. The water quality exceedances are defined as turbid water (i.e. 10 percent NTU increase over background conditions) extending beyond a 300 foot distance, upstream and downstream of the in-water work. If exceedances occur, the proponent will utilize BMPs to further minimize effects. For example, a silt curtain or functional equivalent will be deployed around the specific activity (i.e. not the entire river width). These BMPs are applied in localized areas around the source of disturbance thus minimizing the extent of exposure. This will allow listed species an opportunity to avoid the plume of turbid water created by in water activities. Based on the likely extent of sediment suspended during construction, and the average flow of the Duwamish River in the action area during the work window, and considering tidal influence in the action area, the space within the action area in which fish are reasonably certain to be exposed to increased turbidity is no more than 600 total feet, including 300 feet upstream and downstream of each in-water work site.

Over-Water Structures and River Bed

The presence of the temporary work trestles will require placement of approximately 20,000 square feet of over water coverage on the Duwamish River. This footprint, including support piles, will render a large area of benthic habitat unavailable to the aquatic ecosystem throughout the period of construction (broken into separate periods at each trestle site). In addition to overwater structures, the proponent is applying a sand cap over the area where pile driving is occurring in order to minimize sediment resuspension. This impact includes an approximate 35,000 square foot of disturbance to the riverbed. Both of these areal impacts represent a potential decrease in food web productivity; however the extent of this effect is likely to be insignificant. Marine macroinvertebrates and other organisms have a demonstrated ability to recolonize disturbed substrates (Dernie et al. 2002). This area is within tidal and salinity influence of Elliott Bay.

Therefore, once the trestles, support pilings, and area sand coverage are removed and or naturally dispersed, the bed substrate displaced by the piles is expected to be rapidly recolonized. Pile holes in exposed till that does not collapse during pile removal are expected to be refilled by natural sediment transport. More importantly, the vertical piles and overwater structures provide habitat for predatory fish and bird species, potentially increasing predation related mortality of juvenile salmonids that pass through the action area.

The work trestles will be located outward from the shore, in an area that represents a migratory corridor, not rearing, meaning that they will pose minimal barriers to juvenile Chinook salmon migration. Juvenile steelhead and adult steelhead and Chinook salmon migrating through the Duwamish River are likely to encounter the pilings and shading effects. This may result in changes in behavior, including delayed or altered migration. The extent of this effect is not likely to be significant however, as larger salmonids do not have the same level of sensitivity to overwater structure effects exhibited by small juvenile salmonids. In addition, these structures do not encompass or cross the Duwamish River.

Relevance of Effects on Individual Fish to the Affected Populations

The South Park Bridge Replacement project will adversely affect small numbers of PS Chinook salmon and PS steelhead. Of the multiple extant populations/runs that make up the listed ESU and DPS evaluated in this Opinion, only the Green River Chinook salmon population of PS Chinook, and the Green River summer and winter runs of PS steelhead will be affected. An unquantifiable, but small number of individual adult Green River fall-run Chinook salmon, as well as a small number of adult PS steelhead, migrating and potentially rearing through the lower Duwamish River are likely to be exposed to elevated underwater noise of sufficient intensity to cause injury or alter behavior. Impact pile proofing will occur up to 100 working days during each work window with sufficient noise attenuation allowing for a 25 percent migration corridor. The most significant direct effects (noise related impacts from pile driving, resuspension of contaminated sediments, and temporary overwater and riverbed coverage) will be limited to periods when juvenile fish are unlikely to be present. The most significant effects of the action will therefore be limited to adult Chinook salmon and steelhead from a small number of local spawning subpopulations.

In the case of PS Chinook salmon, this population includes Chinook salmon from Duwamish/Green basins, as well as all small, independent tributaries to central PS. In addition, the median over all populations of long-term trend in abundance is 1.0 (range 0.92–1.2), indicating that most populations are just replacing themselves. In the case of PS steelhead, most of the hatchery fish in this region originated from stocks indigenous to the DPS, but are generally

not native to local river basins. Summer steelhead stocks within this DPS are all small, occupy limited habitat, and most are subject to introgression by hatchery fish. Winter steelhead stocks primarily occur in Northern Puget Sound basins.

The proposed action will result in take of adult Chinook salmon and steelhead from a small number of subpopulations within these two larger ESU/DPS component populations and will not affect either abundance and productivity or spatial structure and diversity of the subpopulations of PS Chinook and steelhead. It is not possible to definitively estimate the number of individuals in each subpopulation that will be affected. However, the take of even moderate numbers of individuals from these subpopulations is not expected to represent a threat to the viability of the larger ESU/DPS component populations, and therefore viability at the ESU/DPS level.

Effects on Critical Habitat

Designated CH within the action area consists of freshwater migration (PCE 2), rearing, (PCE 3) and estuarine (PCE 4) habitat and their essential physical and biological features in the Duwamish River. The effects of the proposed action on these features are summarized as a subset of the habitat-related effects of the action that were discussed more fully above with the exception of temporary effects temporary in-water and over-water structures which is discussed in the ensuing applicable CH sections.

Water Quality. Water quality is an essential element of the rearing, migration, and estuarine PCEs in the action area, and will be directly affected by the proposed action. Pile driving and cofferdam installation and removal activities will cause short term increases in turbidity within 300 feet upstream and downstream of those activities in the Duwamish River. The tiered approach to implementing BMPs including a sand cap, monitoring, and potential deployment and location of a turbidity curtain around individual or groups of piles means that even within this zone, associated turbidity and sediment movement will be low. The NMFS expects that turbidity levels will return to background levels in a few hours after the completion of the in-water work. The temporary water quality degradation will not impair the ability of the action area to support juvenile rearing or migration of PS Chinook salmon.

Passage. Habitat free of obstruction is an essential element of freshwater migration PCE that the proposed action will directly, but temporarily, affect. In-water and over-water structures will occupy or cover more than 20,000 square feet below MHHW, are reasonably certain to create a temporary, partial barrier to free movement through the action area during construction, for approximately 26 months (August 2010 through October 2012). The presence of and noise from impact driving and proofing of steel pilings will also impair function of the migratory corridor intermittently, but for only approximately 100 working days between December 1, 2009 and October 31, 2012. The sound attenuation proposed for this project will allow PS Chinook and steelhead a corridor of less noise disturbance in which to migrate through the work area. Construction activities will also temporarily degrade surface water quality around a localized area (i.e. a group of piles or cofferdam sheeting) by creating a zone of turbidity that is likely to create an avoidance reaction during migration, over each of the three work windows. The proposed action will not create or contribute to any permanent physical, biological, or water quality impediments to migration or free movement.

Forage. Forage is an essential element of each of the three PCEs present in the action area that will be directly affected by the placement of work trestle bridges and cofferdams. These activities will temporarily eliminate invertebrate production on approximately 35,000 square feet of riverbed habitat, when measures are taken to minimize resuspension of sediments during in-water work (e.g., sand capping). The action area presently provides very little forage productivity. The proposed action will temporarily contribute to that condition. However, the action area is reasonably certain to return to preconstruction conditions for the availability of forage as productivity typically increases through the rapid recolonization by forage species once disruptions terminate (Barton 1977, Korsu 2004, Fowler 2004). In the long term, temporarily depressed invertebrate production will not diminish forage function in support of the rearing, migration, and estuarine PCEs in the action area.

Relevance of Action Area Effects to Designated Critical Habitat. Designated CH within the Lower Duwamish River watershed, in which the action area occurs, is rated as having 'high' conservation value for PS Chinook salmon due to the importance of this location for rearing, migration, and estuarine PCEs. Episodic and intermittent, construction-related impacts to the water quality PCE, the passage PCE, the forage PCE, and obstruction free PCEs in designated critical habitat in the lower Duwamish River are primarily from pile and cofferdam installation and removal activities. The PCEs will be affected during three successive work windows by a variety of activities, impairing all of the above referenced PCEs for a few weeks each time. The scale and duration of these impacts is insufficient to alter the ability of the action area to support, migration and rearing behaviors of PS Chinook salmon. In addition, beneficial effects to critical habitat include the removal of approximately 350 creosote-treated wood piles (and dolphins) associated with the existing bridge pier protection system. To offset construction-related effects, the project will also create or enhance approximately 6,000 square feet of tidally-influenced emergent wetland marsh, and restore approximately 2,300 square feet of shrub-dominated transition zone in the vicinity of the new and existing bridges. For this reason NMFS believes the conservation value of the watershed in which the action area lies will improve.

Cumulative Effects

'Cumulative effects' are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02).

Future actions with particular relevance for the action area include planned clean-up and remedial actions to address toxic soil, surface/groundwater, and sediment contamination throughout the lower Duwamish River and floodplain. Several large and heavily-contaminated sites, among them the Boeing Plant 2 / Jorgensen Forge EAA, have not yet benefited from planned, comprehensive clean-up actions. The LDWG, EPA, and WDOE expect that these actions will be on-going for many years into the future.

Future actions to clean-up the lower Duwamish River's surface waters and sediment will improve the quality and function of critical habitat in the action area. The members of the Lower

Duwamish Waterway Group (LDWG), including the Port of Seattle, City of Seattle, King County, and the Boeing Company, have entered into a voluntary agreement with the EPA and WDOE to improve and better coordinate investigative and feasibility studies, and to prioritize, strategically plan, and complete corrective actions and clean-ups. Corrective actions began as early as the 1950s and 60s, and have continued to the present in the form of hazardous waste disposal programs, preservation and/or restoration of intertidal habitats, control and/or retrofit of combined sewer overflows and further improvements to sewer and water treatment infrastructure, and clean-up (removal and disposal) of soil, water, and sediment contamination at a number of locations along the lower-most six miles (LDWG 2009a,b).

At the scale of the action area, we expect these actions will address an important limiting factor on PS Chinook salmon reproduction, growth, and survival. These actions will improve long-term conditions for PS Chinook salmon and steelhead and their prey, will address to some degree existing impediments to free movement and function of the migratory corridor, and will allow one or more PCEs of designated PS Chinook salmon critical habitat to become more completely established and functional within the action area.

Conclusion

After reviewing the best available scientific and commercial information regarding the status and biological requirements of ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, NMFS concludes that the proposed action will not alter viability of the populations of affected PS Chinook salmon or PS steelhead. As such, the effects of the action, when considered with these other factors, will not appreciably reduce the likelihood of survival and recovery of the PS Chinook salmon ESU or the PS steelhead DPS. Therefore, the proposed action is not likely to jeopardize the continued existence of PS Chinook salmon or PS steelhead. This conclusion is based on the determination that the direct and indirect effects associated with the proposed action, by not impairing relevant characteristics of population viability, are not expected to diminish the potential for survival or recovery of any component population, including the Green River Chinook salmon populations and PS steelhead populations. On this basis, while take of individuals of each species may occur, the aggregate level of take will not be significant at the component population or the ESU/DPS level.

The NMFS also concludes that the proposed action will not diminish the conservation value of CH designated for PS Chinook salmon. The effects of the action bear on individual PCEs of critical habitat in the action area by temporarily diminishing their function in the action area. However, periods of decreased function are unlikely to diminish the conservation role the action area plays in the watershed as the action area is primarily a migration corridor through which PS Chinook salmon and PS steelhead transit quickly. Furthermore, temporary effects such as those from noise impacts, increased turbidity, and temporary structures over the Duwamish River and on the riverbed are unlikely to persist long enough to impair the migratory capacity of the area. As such, the effects of the action are not likely to appreciably diminish the conservation role or value of the watershed in which the action area lies. Therefore, the proposed action will not adversely modify or destroy critical habitat.

Reinitiation of Consultation

Reinitiation of formal consultation is required and shall be requested by the Federal agency or by the Services where discretionary Federal involvement or control over the action has been retained or is authorized by law and: (a) if the amount or extent of taking specified in the ITS is exceeded; (b) if new information reveals effects of the action that may affect listed species or designated CH in a manner or to an extent not previously considered; (c) if the identified action is subsequently modified in a manner that has an effect to the listed species or designated CH that was not considered in the Opinion; or (d) if a new species is listed or CH is designated that may be affected by the identified action (50 CFR 402.16).
In addition to the general requirements stated above, consultation must be reinitiated for the proposed action if:
The area of elevated noise levels from impact pile driving exceeds the levels stated for the areas affected as described in the effects analysis above.

Incidental Take Statement

Section 9(a) (1) of the ESA prohibits the taking of endangered species without a specific permit or exemption. Protective regulations adopted pursuant to section 4(d) extend the prohibition to threatened species. Among other things, an action that harasses, wounds, or kills an individual of a listed species or harms a species by altering habitat in a way that significantly impairs its essential behavioral patterns is a taking (50 CFR 222.102). Incidental take refers to 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) requires the Services to identify the level of Incidental Take expected from a proposed action, the impact of that take on the species, and reasonable and prudent measures to minimize that impact. Section 7(o) (2) exempts from the taking prohibition any take that meets the terms and conditions of a written incidental take statement.

<u>Amount or Extent of Take</u>

Juvenile and adult PS steelhead and PS Chinook salmon are likely to encounter adverse effects caused by the proposed action, therefore, incidental take of PS steelhead and PS Chinook salmon in the form of harm is reasonably certain to occur. This take is likely to be in the form of harm. Harm in the definition of “take” for PS Chinook salmon and PS steelhead includes habitat modification or degradation which 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). Take in the form of harm will occur when listed fish are exposed to elevated underwater noise from pile driving, to increased turbidity, and to decreased forage. Each of these things will actually injure or kill individual fish by significantly impairing their normal behaviors in the action area as the result of modified habitat, or by wounding or killing them.
NMFS cannot estimate the number of individual fish that will be injured or killed by their exposure to these sources of habitat modification because activities causing habitat modification will occur intermittently, causing temporary degradation over the 28 months of construction. This fact alone prevents NMFS from deriving an assumption regarding the density of fish in the

affected areas during construction from which an estimate of the number of exposed fish could be predicted. Furthermore, exposed fish will respond in various ways to their exposure, ranging from death to non-lethal behavioral changes, to no response and NMFS cannot discern any reliable proportion of fish response within this range. When estimating the amount of take in numbers of affected fish is impossible, NMFS estimates the extent of take based on the extent of habitat modified by those elements of the proposed action that will cause harm as defined in the preceding paragraph. The extent of habitat change to which present and future generations of fish will be exposed is readily discernable and presents a reliable measure of the extent of take that can be monitored and tracked. Therefore, when the specific number of individuals "harmed" cannot be predicted, NMFS quantifies the extent of take based on the extent of habitat modified (51 FR 19926 at 19954; June 3, 1986).

Extent of Take from Underwater Sound. The NMFS anticipates take from pile driving both with and without sound attenuation.4 However, the size of the area within which adverse effects are likely to occur is determined by the cumulative exposure criteria because the number of attenuated pile strikes during construction is significantly greater than the unattenuated strikes during initial monitoring. Assuming that the attenuation system will achieve a minimum of 20 dB average reduction:

1. The area in which physical injury or death of listed fish can be expected to occur (i.e. where the Services expect that peak underwater noise levels experienced by ESA-listed fish will exceed the 212 dB_{peak} injury threshold for single pile strikes from unattenuated impact pile driving necessary to establish the baseline SPLs) can be expected to extend 3818 feet from unattenuated impact pile driving activities for approximately two days, and;
2. The area in which behavioral modification can be expected to occur (i.e. underwater noise in excess of 150 dB_{rms} for single pile strikes from unattenuated impact pile driving necessary to establish the baseline SPLs) can be expected to extend approximately 2,350 ft upstream and 8,200 ft downstream of pile driving activities, and spanning the entire estimated 400-foot wetted width of the waterbody for approximately two days, and;
3. The area in which physical injury or death of listed fish can be expected to occur (i.e. cumulative underwater noise exposure exceeding 187 dB SEL) can be expected to extend 177 feet from pile driving activities, and;

4. The area in which behavioral modification can be expected to occur (i.e. underwater noise in excess of 150 dB_{rms}) can be expected to extend 607 feet upstream and downstream of pile driving activities, and spanning the entire estimated 400-foot wetted width of the waterbody, and;

---

4 Take from noise without attenuation will only occur as necessary to determine baseline SPLs and only as specified in the hydroacoustic monitoring plan.

Extent of Take from Water Quality Degradation. Take caused by degradation of surface water quality during all in-water construction activities, is expected intermittently in an area up to 4,500 square feet within the Duwamish Waterway, during the three construction windows.

Extent of Take from Depressed Forage Production and Predation. Take from depressed production of invertebrate prey will occur through the modification of:

1. A temporary loss or degradation of preybase over approximately 20,000 square feet of the Duwamish River for approximately 26 months, and
2. A temporary loss or degradation of preybase over approximately 35,000 square feet of riverbed habitat over for approximately 26 months.

The estimated extent of habitat affected by construction activities represents the extent of take exempted in this incidental take statement. These extents are readily observable and therefore suffice to trigger reinitiation of consultation, if exceeded and necessary (see H.R. Rep. No 97-567, 97th Cong., 2d Sess. 27 (1982).

Reasonable and Prudent Measures

The following measures are necessary and appropriate to minimize the impact of incidental take of listed species from the proposed action:

The FHWA shall:

1. Minimize incidental take from pile driving activities within the Mean Lower Low Water mark by a minimum of 20 dB reduction.

2. Minimize incidental take from temporary degradation of surface water quality from in-water construction activities.

3. Minimize incidental take resulting from reduced forage and predation.

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

Terms and Conditions

The measures described below are non-discretionary, and must be undertaken by the FHWA or, if an applicant is involved, must become binding conditions of any permit or grant issued to the applicant, for the exemption in section 7(o)(2) to apply. The FHWA has a continuing duty to regulate the activity covered by this incidental take statement. If the FHWA (1) fails to assume and implement the terms and conditions or (2) fails to require an applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. To monitor the impact of incidental take, the FHWA or applicant must report the progress of the action and its

impact on the species to the Service as specified in the incidental take statement.

1. To implement RPM Number 1 (pile driving), the FHWA shall ensure that WSDOT will use specific performance standards for impact pile driving/proofing activities in the Duwamish River, as follows:

    a. To the fullest extent practicable and through design, testing, and careful implementation, maximize effectiveness of the noise attenuation device with the goal of achieving a 20 dB attenuation measured at a distance of 10 meters from the pile in order to prevent an accumulated SEL of 187 dB from extending over more than 75 percent of the wetted channel width.

    b. As the science evolves, use the best available underwater sound attenuation technology for any actions where there will be impact pile driving in the presence of listed species.

2. To implement RPM Number 2 (water quality degradation), the FHWA shall:

    a. Monitor downstream turbidity levels in the Duwamish River during sediment-generating activities (i.e. during in-water construction). The FHWA shall include items identified below (i-iv) into the monitoring plan as part of there submittal or shall submit to NMFS for review no fewer than 60 days prior to in-water construction, a functionally-equivalent proposal for effective monitoring:

        i. Monitoring shall be conducted at a distance of 300 feet downstream of in-water construction activities.
        ii. If results indicate exceedances after two consecutive sampling events, operations will cease and a turbidity curtain or functional equivalent will be deployed around the specific activity, as close as practicable.
        iii. Submit a monitoring report by December 31 following each in-water construction season to include, at a minimum, the following: (a) dates and times of in water construction activities; (b) monitoring results; sample times, locations, and measured turbidities (in NTUs); (c) summary of in-water construction activities and measured turbidities associated with those activities; and, (d) summary of corrective actions taken to reduce sediment/turbidity.
        iv. All reports shall be sent to National Marine Fisheries Service, Washington State Habitat Office, Attention: (Sean Callahan, 510 Desmond Drive SE, Suite 103, Lacey, Washington 98503).

3. To implement RPM Number 3 (forage reduction), the FHWA shall ensure that WSDOT will:

    a. Limit the area of temporary impacts from structures in the Duwamish River to 20,000 square feet and 35,000 square feet of riverbed habitat, respectively.

4. To implement RPM Number 4 (monitoring of pile driving), the FHWA shall ensure that WSDOT will:

   a. Develop and implement a hydroacoustic monitoring plan to document the effectiveness of the approved sound attenuation system.

      i. Submit the design specifications for the selected sound attenuation system to NMFS for review a minimum of 60 days prior to initiation of impact pile driving activities. If alternative sound attenuation technologies (i.e., other than confined bubble curtains) are employed, provide additional information documenting the effectiveness of these technologies if available and appropriate.

      ii. Notify the Services within 24 hours if noise monitoring indicates that take limits will be exceeded.

      iii. Submit hydroacoustic monitoring report to the Services for review within 120 days of the completion of monitoring activities.

      iv. The hydroacoustic monitoring plan, attenuation system specifications, and hydroacoustic monitoring results must be prepared and implemented by individuals with proven and appropriate expertise in the fields of underwater acoustics and sound attenuation technologies, the biological effects of hydroacoustic stressor exposure, and related data collection.

   NOTICE: If a sick, injured or dead specimen of a threatened or endangered species is found in the action area, the finder must notify NMFS Law Enforcement at (206) 526-6133 or (800) 853-1964, through the contact person identified in the transmittal letter for this Opinion, or through the NMFS Washington State Habitat Office. The finder must take care in handling sick or injured specimens to ensure effective treatment, and in handling dead specimens to preserve biological material in the best possible condition for later analysis of cause of death. The finder should carry out instructions provided by Law Enforcement to ensure evidence intrinsic to the specimen is not disturbed unnecessarily.

   NOTICE: To follow inactive projects and, if necessary, withdraw the opinion for an incomplete project, the FHWA shall provide an annual report even if no actual work was completed in a particular year.

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

The consultation requirement of section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions, or proposed actions that may adversely affect EFH. Adverse effects include the direct or indirect physical, chemical, or biological alterations 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 to EFH may result from actions occurring within EFH or outside EFH, 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 may be taken by the action agency to conserve EFH.

The Pacific Fishery Management Council (PFMC) designated EFH for groundfish (PFMC 2006), coastal pelagic species (PFMC 1998), and Chinook salmon, coho salmon, and Puget Sound pink salmon (PFMC 1999). The proposed action and action area for this consultation are described in the Introduction to this document. The action area includes areas designated as EFH for various life-history stages of Chinook and coho (PFMC 1999).

Based on the EFH consultation, NMFS concludes that proposed action will have the following adverse effects on EFH designated for Chinook, and coho (PFMC 1999). The effects of the proposed action on EFH are degradation of in-water habitat due to elevated noise (SPLs from impact pile driving); degradation of water quality from project construction; and degradation of habitat by the reduction of forage. These effects will occur in the riverine bottom (unconsolidated) and riverine (water column) habitat types affecting 0.75 total acres of EFH.

Essential Fish Habitat Conservation Recommendations

The NMFS believes that the minimization and mitigation measures incorporated into the proposed action by the FHWA and the reasonable and prudent measures are applicable to and protective of salmon EFH. Therefore, NMFS incorporates those measures here as EFH conservation recommendations. In addition, these two conservation measures are also necessary to avoid, mitigate, or offset the impact of the proposed action on EFH. These conservation recommendations are a subset of the ESA terms and conditions.

1. Noise. Follow Term and Conditions No. 1 and No. 4 as presented in the incidental take statement of the Opinion, to demonstrate that these activities are being implemented and monitored thereby limiting the level of effects considered. The following terms and conditions would apply here as conservation measures: 4a (i-iv).

2. Water quality: Follow Term and Condition No. 2 as presented in the incidental take statement of the Opinion. The following terms and conditions would apply here as conservation measures: 2a (i-iv).

3. Forage: Follow Term and Condition No. 3 as presented in the incidental take statement of the Opinion. The following terms and conditions would apply here as conservation measures: 3a.

Statutory Response Requirement

Federal agencies are required to provide a detailed written response to NMFS' EFH conservation recommendations within 30 days of receipt of these recommendations (50 CFR 600.920(k)(1)). The response must include a description of measures proposed to avoid, mitigate, or offset the adverse affects of the activity on EFH. If the response is inconsistent with the EFH conservation recommendations, the response must explain the reasons for not following the recommendations. The reasons must include the scientific justification for any disagreements over the anticipated effects of the proposed action and the measures needed to avoid, minimize, mitigate, or offset such effects.

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.

Supplemental Consultation

The FHWA 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)(1)).

DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) (Data Quality Act) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the Biological Opinion addresses these Data Quality Act (DQA) components, documents compliance with the DQA, and certifies that this Opinion has undergone pre-dissemination review.

Utility: Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. These users include FHWA, NMFS, WSDOT, King County, and the Cities of Seattle and Tukwila.

Individual copies were provided to the above-listed entities. This consultation will be posted on the NMFS Northwest Region website (http://www.nwr.noaa.gov). The format and naming adheres to conventional standards for style.

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.

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 600.920(j).

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the Literature Cited section. The analyses in this Opinion/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 Northwest Region ESA quality control and assurance processes.

LITERATURE CITED

Abbott, R., and E. Bing-Sawyer. 2002. Assessment of pile driving impacts on the Sacramento blackfish (*Othodon microlepidotus*). Draft report prepared for Caltrans District 4. October 10, 2002.

Abbott, R.R., J.A. Reyff, and G. Marty. 2005. Monitoring the Effects of Conventional Pile Driving on Three Species of Fish. Final Report, submitted to Manson Construction Company, Richmond, California (April 8, 2005). 131 p.

Averill D., D. Myers, and S. Redman. 2004. Regional Nearshore and Marine Chapter for the Puget Sound Recovery Plan. Draft. Prepared for Shared Strategy for Puget Sound.

Bailey, M.R., D. Dalecki, S.Z. Child, C.H. Raeman, D.P. Penney, D.T. Blackstock, and E.L. Carsentensen. 1996. Bioeffects of positive and negative acoustic pressures *in vivo*. Journal of the Acoustical Society of America 100:3941-3946.

Bash, J., C. Berman, and S. Bolton. 2001. Effects of turbidity and suspended solids on salmonids. Center for Streamside Studies, University of Washington, November 2001.

Berg, L., and T.G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (Oncorhynchus kisutch) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences 42: 8pp. 1410-1417.

Bishop, S. And A. Morgan, editors. 1996. Critical Habitat Issues by Basin for Natural Chinook Salmon Stocks in the Coastal and Puget Sound Areas of Washington State. Northwest Indian Fisheries Commission, Olympia.

Blomberg, G., C. Simenstad, and P. Hickey. 1988. Changes in Duwamish River Estuary Habitat Over the Past 125 Years. Proceed. First Annual Meeting Puget Sound Research, Vol. 2, pp. 627-632. Puget Sound Water Quality Authority, Seattle WA.

Caltrans (California Deaprtment of Transportation). 2002. Biological Assessment for the Benicia Martinez New Bridge Project for NMFS. Prepared by Caltrans for U.S. Department of Transportation, (October 2002). 37 p.

COE (U.S. Army Corps of Engineers). 2005. Biological Assessment. FY 2000-2001 Maintenance Dredging. Turning Basin and Navigational Channel. Upper Duwamish Waterway. Seattle District.

Cordell, J.R., L.M. Tear, C.A. Simenstad, and W.G. Hood. 1994. Duwamish River Coastal America restoration and reference sites: results and recommendations from one year pilot and monitoring studies. University of Washington School of Fisheries, Fisheries Resource Institute, FRI-UW-9416, Seattle, WA.

Cordell, J.R., L.M. Tear, C.A. Simenstad, and W.G. Hood. 1996. Duwamish River Coastal America restoration and reference sites: Results from 1995 monitoring studies, University of Washington School of Fisheries, Fisheries Resource Institute, FRI-UW-9612, Seattle, WA.

Cordell, J.R., L.M. Tear, K. Jensen, and V. Luiting. 1997. Duwamish River Coastal America Restoration and Reference Sites: Results from 1996 Monitoring Studies. University of Washington, Fisheries Research Institute, FRI-UW-9709, Seattle, Washington.

Crum, L.A. and Y. Mao. 1996. Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. Journal of the Acoustical Society of America 99(5): 10pp. 2898-2907.

Cudahy, E. and W.T. Ellison. 2002. A review of the potential for in vivo tissue damage by exposure to underwater sound. Naval Submarine Research Laboratory, Department of the Navy, Groton, Connecticut. 6 p.

Dernie, K.M., M.J. Kaiser, E.A. Richardson, and R.M. Warwick. 2002. Recovery of Soft Sediment Communities and Habitats Following Physical Disturbance. Journal of Experimental Marine Biology and Ecology 4069: 1-20.

EBDRP. 1994. Elliott Bay/Duwamish Restoration Program. Concept Document. Panel Publ. 7. Seattle WA. June 1994.

Engas, A., S. Lokkeborg, and A.V. Soldal. 1996. Effects of seismic shooting on local abundance and catch rates of cod (Gadus morhua) and haddock (Melanogrammus aeglefinus). Canadian Journal of Fisheries and Aquatic Sciences 53: 12pp. 2238-2249.

EPA (U.S. Environmental Protection Agency), Region 10. 2009a. Boeing Plant 2. Seattle, Washington. <<http://yosemite.epa.gov/R10/CLEANUP.NSF/LDW/Boeing+Plant+2>>. Accessed 8/27/2009.

EPA (U.S. Environmental Protection Agency), Region 10. 2009b. Lower Duwamish Waterway Site. Seattle, Washington. <<http://yosemite.epa.gov/r10/cleanup.nsf/sites/Duwamish>>. Accessed 8/27/2009.

EPA (U.S. Environmental Protection Agency). 2009c. Contaminated sediment in water (publications). Washington, D.C. <<http://www.epa.gov/waterscience/cs/library/guidelines.htm>>. Accessed 8/27/09.

EPA (U.S. Environmental Protection Agency), Region 5. 2009d. Ecological toxicity information. Chicago, Illinois. <<http://www.epa.gov/R5Super/ecology/html/toxprofiles.htm>>. Accessed 8/27/09.

EPA (U.S. Environmental Protection Agency), Region 8. 2009e. Toxicity assessment. Denver, Colorado. <<http://www.epa.gov/region8/r8risk/eco_toxicity.html>>. Accessed 8/27/09.

FHWG (Fisheries Hydroacoustic Working Group). 2008. Agreement in principle for interim criteria for injury to fish from pile driving activities. Memorandum of agreement between NOAA Fisheries Northwest and Southwest Regions, USFWS Regions 1 and 8, California/Washington/Oregon Departments of Transportation, California Department of Fish and Game, and U.S. Federal Highway Administration. Available at: June 12, 2008. http://www.wsdot.wa.gov/Environment/Biology/BA/default.htm#Noise.

Fordjour, K. 2003. Bremerton Dolphin Replacement - Report of Fish Kill. Washington State Department of Transportation, Seattle.

Gaspin, J.B. 1975. Experimental investigations of the effects of underwater explosions on swimbladder fish, 1: 1973 Chesapeake Bay Tests. Naval Surface Weapons Center, White Oak Laboratory, Publication NSWC/WOL/TR 75-58, Silver Springs, Maryland (June 20, 1975). 76 p.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. Commer., NOAA Tech. Memo. NMFSNWFSC- 66. 598 p.

Hard, J.J., J.M. Myers, M.J. Ford, R.G. Cope, G.R. Pess, R.S. Waples, G.A. Winans, B.A. Berejikian, F.W. Waknitz, P.B. Adams. P.A. Bisson, D.E. Campton, and R.R. Reisenbichler. 2007. Status review of Puget Sound steel head *(Oncorhynchus mykiss)*. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-81, 117 p.

Hastings, M.C., A.N. Popper, J.J. Finneran, and P. Lanford. 1996. Effects of low-frequency underwater sound on hair cells of the inner ear and lateral line of the teleost fish Astronotus ocellatus. Journal of the Acoustical Society of America 99(3): 8pp. 1759-1766.

Hastings, M.C. and A.N. Popper. 2009. The Effects of Anthropogenic Sources of Sound on Fishes. Journal of Fish Biology (2009) - 75. 35 p. 455-489.

Hogarth, W.T. 2005. Memorandum from William T. Hogarth, to Regional Administrators, Office of Protected Resources, NMFS, Regarding Application of the "Destruction or Adverse Modification" Standard Under Section 7(a)(2) of the Endangered Species Act, 3p. November 7.

Hubbs, C.L. and A.B. Rechnitzer. 1952. Report on experiments designed to determine effects of underwater explosions on fish life. California Fish and Game 38: 33pp. 333-365.

Kerwin, J. and T.S. Nelson, editors. 2000. Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island). Washington State Conservation Commission and the King County Department of Natural Resources, Seattle, Washington (December 2000). 770 p. http://dnr.metrokc.gov/Wrias/9/Recon.htm

LDWG (Lower Duwamish Working Group – Port of Seattle, City of Seattle, King County, and the Boeing Company). 2009a. The LDW then and now – Duwamish River chronology. Seattle, Washington. http://www.ldwg.org/history.htm. Accessed 8/28/09.

LDWG (Lower Duwamish Working Group - Port of Seattle, City of Seattle, King County, and the Boeing Company). 2009b. Duwamish Waterway Superfund Cleanup – 2006 Progress Report. Seattle, Washington. p.4. Accessed 8/28/09.

Locke, A., and S. Corey. 1985. Terrestrial and freshwater invertebrates in the neuston of the Bay of Fundy, Canada. Canadian Journal of Zoology 64: 7pp. 1535-1541.

Lloyd, D.S., J.P. Koenings, and J.D. LaPierriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management. 7:18-33, 16p.

MacGillivray, A., J. Laughlin, E. Ziegler. 2007. Underwater Acoustic Measurements from Washington State Ferries 2006 Mukilteo Ferry Terminal Test Pile Project. Prepared for the Washington State Ferries and Washington State Department of Transportation by Jasco Research, Vancouver, BC, Canada. March 6, 2007.

McElhany, P., M. Ruckleshaus, M. J. Ford, T. Wainwright, and E. Bjorkstedt. 2000. Viable Salmon Populations and the Recovery of Evolutionarily Significant Units. U. S. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS-NWFSC-42. 156 p. htp://www.nwfsc.noaa.gov/publications/techmemos/tm42/tm42.pdf

Nelson, T.S., G. Ruggerone, H. Kim, R. Shaefer, and M. Boles. 2004. Juvenile Chinook migration, growth and habitat use in the Lower Green River, Duwamish River and nearshore Elliot Bay, 2001-2003. Draft report prepared by the King County Department of Natural Resources and Parks, Water and Land Resources Division, Science Section.

NMFS (National Marine Fisheries Service). 1998. Factors Contributing to the Decline of Chinook Salmon: An Addendum to the 1996 West Coast Steelhead Factors For Decline Report.

NMFS (National Marine Fisheries Service). 2002. Use of tissue and sediment-based threshold concentrations of polychlorinated biphenyls (PCBs) to protect juvenile salmonids listed under the US Endangered Species Act. NOAA Fisheries Environmental Conservation Division, Northwest Fisheries Science Center. Seattle, WA.

NMFS (National Marine Fisheries Service). 2004. Artificial Propagation Evaluation Workshop Report. NOAA Fisheries, Northwest Region, Protected Resources Division. May 18, 2004. Available on the internet at: www.nwr.noaa.gov/1srd/Prop_Determins/

NMFS (National Marine Fisheries Service). 2005. Updates to the May 18, 2004, Salmonid Hatchery Inventory and Effects Evaluation Report. Salmon Recovery Division.

Popper, A.N. 2003. Effects of anthropogenic sounds on fishes. Fisheries 28(10): 8pp. 24-31.

PFMC (Pacific Fishery Management Council). 1998. The Coastal Pelagic Species Fishery Management Plan: Amendment 8. Pacific Fishery Management Council, Portland, Oregon. December. 41 p. http://www.pcouncil.org/cps/cpsfmp.html.

PFMC (Pacific Fishery Management Council). 1999. Amendment 14 to the Pacific Coast Salmon Plan. Appendix A: Description and identification of essential fish habitat, adverse impacts and recommended conservation measures for salmon. Pacific Fishery Management Council, Portland, Oregon. March. 145 p. http://www.pcouncil.org/salmon/salfmp/a14.html.

PFMC (Pacific Fishery Management Council). 2006. Final Environmental Impact Statement (FEIS) for the Proposed ABC/OY Specifications and Management Measures for the 2007-2008 Pacific Coast Groundfish Fishery / Amendment 16-4 to the Groundfish Fishery Management Plan. Pacific Fishery Management Council, Portland, Oregon. October. 734 p. http://www.pcouncil.org/groundfish/gfspex/gfspex07-08.html.

PSTRT (Puget Sound Technical Recovery Team). 2001. Planning ranges and preliminary guidelines for the delisting and recovery of the Puget Sound Chinook salmon evolutionary significant unit. http://www.nwfsc.noaa.gov/trt/trt_puget.htm

Ruggerone, G.T. and D.E. Weitkamp. 2004. WRIA 9 Chinook Salmon Research Framework. Identifying Key Research Questions about Chinook Salmon Life Histories and Habitat Use in the Middle and Lower Green River, Duwamish Waterway, and Marine Nearshore Areas. Prepared for the WRIA 9 Steering Committee.

Ruggerone, G.T., T.S. Nelson, J. Hall, E. Jeanes. 2006. Habitat Utilization, Migration Timing, Growth, and Diet of Juvenile Chinook Salmon in the Duwamish River and Estuary. Prepared for the WRIA 9 Technical and Steering Committee.

Servizi, J.A., and DW 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: 5pp. 493-497.

Shared Strategy. 2005. Draft Puget Sound Recovery Plan. Available at: ww.sharedsalmonstrategy.org

Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113: 9pp. 142-150.

Simenstad, C.A. and E.O. Salo. 1980. Foraging success as a determinant of estuarine and nearshore carrying capacity of juvenile chum salmon (Oncorhynchus keta) in Hood Canal, Washington. North Pacific Aquaculture Symposium. Alaska Sea Grant Report. University of Alaska, Fairbanks, Alaska.

Simenstad, C.A., K.L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. In: Salmon in Washington's Estuaries. Academic Press.

Spence, B. C., G. A. Lomnicky, R. M. Hughes, R. P. Novitzki. 1996. An Ecosystem Approach to Salmonid Conservation. Prepared for National Marine Fisheries Service.

Stadler, J.H. 2002. Notes from site visit, Winslow Ferry Terminal, to observe pile driving and monitoring of noise levels and effects to fishes.

Stotz, T. and J. Colby. 2001. January 2001 Dive Report for Mukilteo Wingwall Replacement Project. Washington State Department of Transportation, Washington State Ferries Memorandum, Seattle, Washington (April 30, 2001). 19 p.

Stroetz, R.W., N.E. Vlahakis, B.J. Walters, M.A. Schroeder, and R.D. Hubmayr. 2001. Validation of a new live cell strain system: Characterization of plasma membrane stress failure. Journal of Applied Physiology 90: 10pp. 2361-2370.

Stuhmiller, J.H., K.H. Ho, M.J. Vander Vost, K.T. Dodd, T. Fitzpatrick, and M. Mayorga. 1996. A model of blast overpressure injury to the lung. J. Biomechanics 29:227-234.

Teleki, G.C., and A.J. Chamberlain. 1978. Acute effects of underwater construction blasting on fishes in Long Point Bay, Lake Erie. J. Fish. Res. Bd. 35:1191-1198.

Tanner, C. D. 1991. Potential Intertidal Habitat Restoration Sites in the Duwamish Estuary. Prepared for the Port of Seattle Engineering Department and The U.S. Environmental Protection Agency, Environmental Evaluations Branch. Seattle Washington.

Turnpenny, A. and J. Nedwell. 1994a. The Effects on Marine Fish, Diving Mammals and Birds of Underwater Sound Generated by Seismic Surveys. Fawley Aquatic Research Laboratories Limited, Marine and Freshwater Biology Unit, Southampton, Hampshire, UK. 48 p.

Turnpenny, A.W.H., K.P. Thatcher, and J.R. Nedwell. 1994b. The effects on fish and other marine animals of high-level underwater sound. Fawley Aquatic Research Laboratory, Ltd., Report FRR 127/94, United Kingdom (October 1994). 79 p.

USDD (U.S. Department of Defense). 2002. Record of Decision for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. Federal Register 67(141): 10pp., 48145-48154.

Varanasi, U., E. Casillas, M. R. Arkoosh, T. Hom, D. A. Misitano, D. W. Brown, S. L Chan, T. K. Collier, B. B. McCain, and J. E. Stein. 1993. Contaminant exposure and associated biological effects in juvenile chinook salmon (Oncorhynchus tshawytscha) from urban and nonurban estuaries of Puget Sound. NOAA Technical Memorandum NMFS-NWFSC-8.

Vlahakis, N.E. and R.D. Hubmayr. 2000. Plasma membrane stress failure in alveolar epithelial cells. Journal of Applied Physiology 89: 7pp. 2490-2496.

Waples, R.S. 1991. Definition of 'Species' under the Endangered Species Act: Application to Pacific salmon. U.S. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memo. NMFS-F/NWC-194, Seattle, Washington. 18 p. http://www.nwfsc.noaa.gov/publications/techmemos/tm194/waples.htm

Waters, Thomas F. 1995. Sediment in Streams: Sources, Biological Effects, and Control. American Fisheries Society Monograph 7.

WDF (Washington Department of Fisheries), and WWTIT (Western Washington Treaty Indian Tribes). 1993. 1992 Washington State salmon and steelhead stock inventory (SASSI). Internal Report to Washington Department of Fisheries and Wildlife, Olympia, Washington Wash. Dep. Fish Wildlife., Olympia, WA. 212 p.

WDNR (Washington State Department of Natural Resources). 2009. Fact Sheet – Dredged Material Management Program. Olympia, Washington. http://www.dnr.wa.gov/Publications/aqr_dmmp_fact_sheet.pdf. Accessed 8/28/09

WDOE (Washington State Department of Ecology). 2009a. Toxics Cleanup Program – Lower Duwamish Waterway. Lacey, Washington. http://www.ecy.wa.gov/programs/tep/sites/lower_duwamish/lower_duwamish_hp.html. Accessed 8/28/09

WDOE (Washington State Department of Ecology). 2009b. Lower Duwamish Waterway Source Control Investigation – Early Action Area 4 (Boeing Plant2/Jorgensen). Lacey, Washington. http://www.ecy.wa.gov/programs/tep/sites/lower_duwamish/sites/early_action_area_4/early_action_area_4.htm. Accessed 8/28/09

WDOE (Washington State Department of Ecology). 2009c. Toxics Cleanup Program – Lower Duwamish Waterway. Lacey, Washington. http://www.ecy.wa.gov/programs/tep/sites/jorgensen/forge_hp.html. Accessed 8/28/09

Wiley, M.L., J.B. Gaspin, and J.F. Goertner. 1981. Effects of underwater explosions on fish with a dynamical model to predict fishkill. Ocean Science and Engineering 6(2):223-284.

Yelverton, J.T., D.R. Richmond, R.E. Fletcher, and R.K. Jones. 1973. Safe Distance from Underwater Explosions for Mammals and Birds. Lovelace Foundation for Medical Education and Research, Albuquerque, New Mexico. 64 p.

Yelverton, J.T., D.R. Richmond, W. Hicks, K. Saunders, and R.E. Fletcher. 1975. The Relationship Between Fish Size and Their Response to Underwater Blast. Lovelace Foundation for Medical Education and Research, Albuquerque, NM (June 18, 1975). 39 p.

Yelverton, J.T. and D.R. Richmond. 1981. Underwater explosion damage risk criteria for fish, birds, and mammals. 102nd Meeting of the Acoustical Society of America, November 30 - December 4, Miami Beach, Florida. Department of Biodynamics, Lovelace Biomedical and Environmental Research Institute, Alberquerque, New Mexico.

APPENDICES

Appendix A – In-water Construction Monitoring Report Form Template

Start Date: _____

End Date: _____

Waterway: _____ in _____ County

Construction Activities:
_____
_____
_____
_____
_____

Number of fish observed: _____
Number of salmonid juveniles observed (what kind?):
_____

Number of salmonid adults observed (what kind?):
_____

What were fish observed doing prior to
construction?_____
_____
_____

What did the fish do during and after construction?

_____
_____
_____

Number of fish stranded as a result of this activity: _____

How long were the fish stranded before they were captured and released to flowing water?

_____
_____
_____

Number of fish that were killed during this activity: _____

South Park Bridge Test Pile Project - King County - UNDERWATER NOISE MONITORING PLAN

Prepared by:
Washington State Department of Transportation
Office of Air Quality, Noise and Energy
15700 Dayton Avenue North, P.O. Box 330310
Seattle, WA 98133-9710

August 2009

INTRODUCTION

The King County, Road Services Division (KCRSD), proposes to do in-water test pile driving, including driving and then removing up to four pipe piles, and four sheet piles near the South Park Bridge in the Duwamish River (Figure 1). Work will be done in the Duwamish using barge-mounted pile driving equipment over a period of approximately one week sometime during the August 1, 2009 to February 15, 2010 in-water construction window established to minimize impacts to threatened fish species. In-water pile driving and removal activities are estimated to take one day but may require up to five working days, depending on conditions that are encountered. In order to avoid barge grounding on the south side (closest to the South Park Community) during lower tide levels, the barge will be positioned near mid-channel in the navigable waterway and all work will be performed from there using a barge mounted crane. The north side (closest to Boeing facilities) has sufficient water depth that the barge may be partially positioned behind the fender pier if necessary to reach the pile test areas.

The purpose of this test pile project is to provide additional information that will assist with:

1. Determining pile load capacity requirements for the ongoing design and engineering for replacement of temporary construction trestle,
2. Assess the effects on the existing South Park Bridge in accordance with the Environmental Impact Statement (EIS) that is being prepared. Additionally, the bridge test pile program will:
3. Help determine temporary construction trestle foundation pile load capacity,
4. Assess the effects installing and removing pipe piles (temporary construction trestle) and sheet pile (cofferdam),
5. Measure the amount of vibration produced during pile driving, and
6. Evaluate the efficacy of Best Management Practices BMPs for in-water noise attenuation and sediment containment during piling installation and removal.

Pipe Piles

Up to four steel pipe piles will be driven by a barge mounted crane to a maximum depth of 130 feet below the mud line or until they achieve the desired maximum bearing capacity of 200 tons. The pipe piles will be a maximum 24 inches in diameter, 0.5 inches thick, and will either be driven with an impact hammer. To reduce acoustic impacts in the Duwamish Waterway, a double wall temporary noise attenuation pile will be used for each pipe pile during impact driving operations.

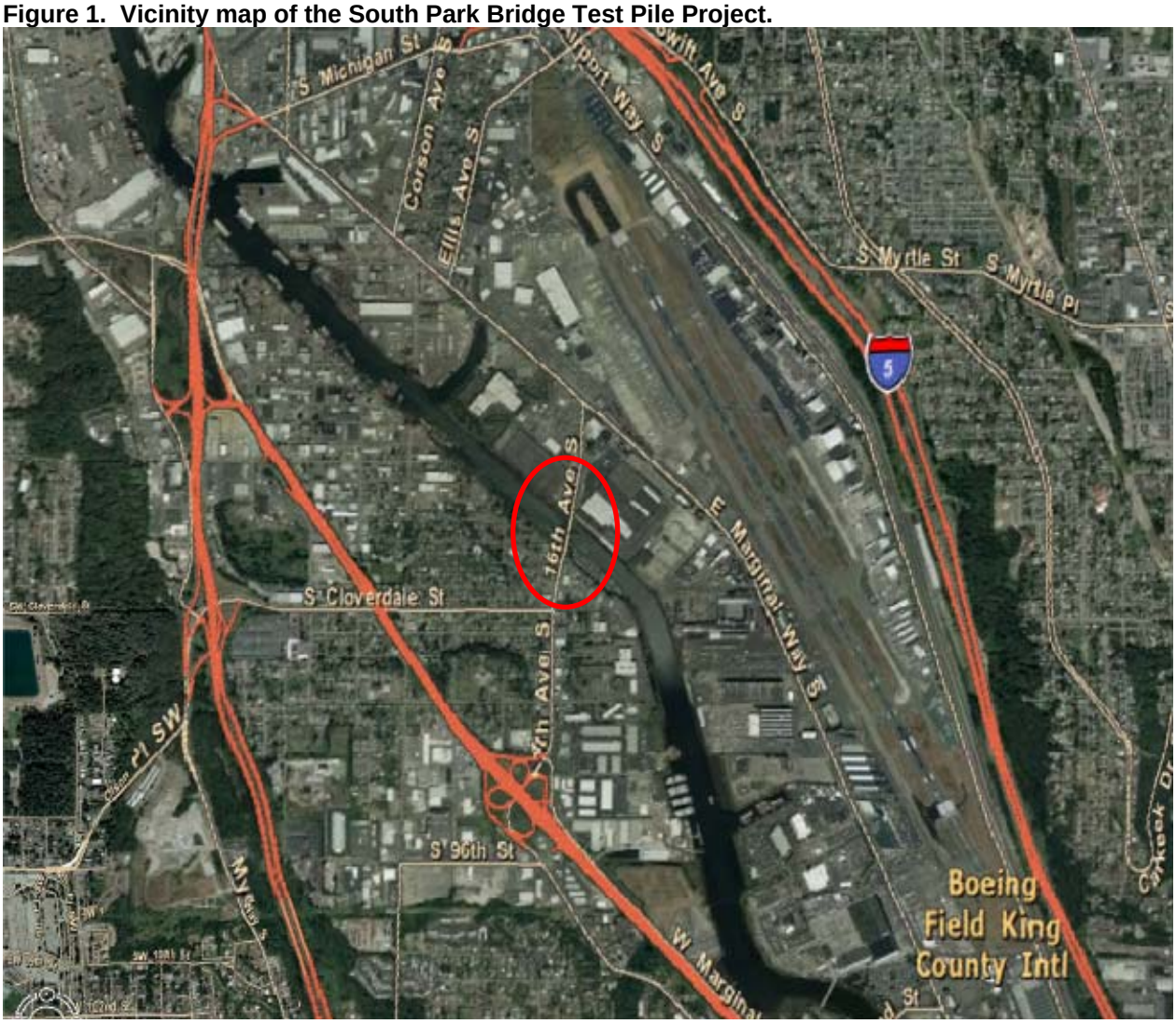
The first test pile location will be near the existing bascule pier on the south side. The second test pile location will be near the existing in-water bridge piers on the north side. One pile will be driven at each location where the proposed work trestles for construction of the new bridge will be closest to the existing bridge piers. An additional pile driving attempt may be necessary at one or both these locations if the initial pile driving attempt exceeds the monitoring thresholds established for bridge movement, vibration, or settlement, or if the field engineer halts the operation due to other concerns. In the event that a second pile driving attempt is needed on the north or south side, the distance from the existing bridge of that supplemental pile driving attempt will be determined by the field engineer, based on the results of the first attempt that had to be halted, but will remain within the established

pipe pile test area. As part of the test, the pipe piles will be removed by the barge-mounted crane pulling and vibrating them out of the waterway bottom (See Figure 2).

Sheet Piles

Up to four steel sheet pile sections will be impact driven, vibrated, or pressed into place to depths of approximately 50 to 70 feet below the mud line at proposed coffer dam locations within both the north and south test areas. As part of the test, the sheet piles will be removed by a barge-mounted crane pulling and vibrating them out of the riverbed. See attached drawing of sheet pile test area (Figure 2).

Figure 1. Vicinity map of the South Park Bridge Test Pile Project.



PROJECT AREA

The project is located in the Duwamish River west of Boeing Field just outside the Seattle city limits on 16th Avenue South (Figure 1). The bridge is operated by the King County government and approximately 20,000 vehicles use the bridge daily.

Two test piles will first be driven using a vibratory hammer and then proofed using an impact hammer. To allow the contractor to work outside of the normal in-water work window the Services have required King County to use a foam lined Temporary Noise Attenuation Pile (TNAP).

PILE INSTALLATION LOCATION

Figure 2 indicates the approximate locations of the pipe piles that will be impact driven, the sheet piles that may be driven using an impact hammer and the location of the hydrophones for the impact noise monitoring at the South Park Bridge. There will be up to 4 test pipe piles and up to 4 sheet pile sections impact driven as part of the South Park Bridge Test Pile Project. The hydrophones will be located 10 meters from each pile with a clear line-of-sight between the pile and the hydrophone.

Figure 2. Location of the Pipe Piles, Sheet Piles and Hydrophones at the South Park Bridge (locations are approximate).

PILE INSTALLATION

Hydroacoustic monitoring will be conducted during the first five piles struck with an impact hammer, which are driven in water depths that are representative of mid-channel or typical water depths at the project location where piles will be driven. Bathymetry, total number of piles to be driven, depth of water, and distance from shore will also be taken into consideration when choosing representative piles. Hydroacoustic monitoring of steel pipe and sheet pile driving will include:

- Measuring underwater ambient levels,
- Monitoring of 5 steel piles (minimum),
- Testing sound attenuation system effectiveness.

Table 1 lists the structure to be installed, the water depth, and the number and size of piles that will be installed.

Table 1
Structures to be Installed at the South Park Bridge

Structure	Water Depth	Structural Components Installed
Test Pile	5 feet to 10 feet	Up to 4 24-inch hollow steel piles
Sheet Pile	3 feet to8X feet	Up to 4 steel sheet piles

METHODOLOGY

Ambient underwater noise levels will be measured for a minimum of one minute in the absence of construction activities to determine background sound levels. Ambient sound levels will be reported as Root Mean Square (RMS) and include a spectral analysis of the frequencies.

A total of up to four 24-inch diameter steel pipe piles and/or up to four steel sheet piles or some combination of both will be selected for hydroacoustic monitoring. All pipe piles monitored will be tested with the sound attenuation system, on and off (presence and absence) to test its effectiveness. The pile should be driven with the TNAP in place and then the TNAP removed and the pile struck an additional 10 times to gather the unattenuated data. Table 2 details the equipment that will be used to monitor underwater sound pressure levels.

Table 2.
Equipment for underwater sound monitoring (hydrophone, signal amplifier, and calibrator). All have current National Institute of Standards and Technology (NIST) traceable calibration.

Item	Specifications	Quantity	Usage
Hydrophone with 200 feet of cable	Reson TC4013	1	Detect underwater sound levels
Signal Conditioning Amplifier (4-channel)	Brüel & Kjær NEXUS model 2690	1	Reduce high sound levels from hydrophones to levels compatible with recording equipment
Calibrator	GRAS Type 42AC	1	Calibration of hydrophones in the field.
Portable Dynamic Signal Analyzer (4-channel)	Dactron Photon	1	Analyzes and transfers digital data to laptop hard drive

Piezoelectric air microphone	Ono Sokki MI 1233	1	Monitoring airborne sounds from pile driving activities.
Laptop computer	Itronix Go-Book	1	Record digital data on hard drive and signal analysis.
Real Time and Post-analysis software	RT-Pro 5.04	1	Monitor real-time signal and post-analysis of sound level signals
Weighted nylon line marked in 5-foot increments to attach hydrophones.	-	1	Takes the strain off of the hydrophone cables preventing damage.

Monitoring equipment will be set to a minimum frequency range of DC to 10 KHz and a sampling rate of 24,000 Hz. To facilitate further analysis of data the underwater signal will be recorded as a text file (.txt).

One hydrophone will be placed at mid water depth at distance of 10 meters from each pile being monitored. A weighted tape measure will be used to determine the depth of the water. The hydrophone will be attached to a nylon cord or a steel chain if the current is swift enough to cause strumming of the line. The nylon cord or chain will be attached to an anchor that will keep the line 10 meters from the pile. The nylon cord or chain will be attached to a float or tied to a static line at the surface 10 meters from the pile. The distance will be measured by a tape measure, where possible, or a range-finder. There should be a direct line of sight between the pile and the hydrophone in all cases.

The hydrophone calibration will be checked at the beginning of each day of monitoring activity. Prior to the initiation of pile driving, the hydrophone will be placed at the appropriate distance and depth as described above.

Ambient underwater sound levels will be measured for 1 to 2 minutes prior to initiation of pile driving as well as in the absence of construction activities. It will be necessary to have the inspector/contractor inform the acoustics specialist when pile driving is about to start because the monitoring equipment will need to be shut down between recordings to change batteries or conserve battery power.

Underwater sound levels will be continuously monitored during the entire duration of each pile being driven. Peak levels of each strike will be monitored in real time. Sound levels will be measured in Pascals which are easily converted to decibel (dB) units (e.g. 1000 Pascals = 180 dB).

To test the effectiveness of the sound attenuation system, the following on/off regime will be utilized during the pile installation:

Pile Driving Timeframe	Sound Attenuation Device Condition
Initial 30 seconds	Off
Next minute (minimum)	On
Middle 30 seconds	Off
Next minute (minimum)	On
Final 30 seconds	Off

The goal is to test the effectiveness of the sound attenuation device throughout the pile driving event to account for varying loads as the pile is driven. If a pile is expected to be driven in less than 5 minutes, the sound attenuation system should not be turned off for the middle 30 seconds.

Prior to and during the pile driving activity environmental data will be gathered such as wind speed and direction, air temperature, humidity, surface water temperature, water depth, wave height, weather conditions, and other factors that could contribute to influencing the underwater sound levels (e.g. aircraft, boats, etc.). Start and stop time of each pile driving event and the time at which the TNAP is turned on and off (presence and absence) will be recorded.

The chief inspector will supply the acoustics specialist with the substrate composition, hammer model and size, hammer energy settings and any changes to those settings during the piles being monitored, depth pile driven and blows per foot for the piles monitored.

SIGNAL PROCESSING

Post-analysis of the sound level signals will include determination of absolute peak overpressure and underpressure levels recorded for each pile, Root Mean Square (RMS) value for each absolute peak pile strike, rise time, average duration of each pile strike, number of strikes per pile, percent of strikes exceeding 206 dB_{peak}, percent of strikes exceeding 150 dB_{rms}, Sound Exposure Level (SEL) of the absolute peak pile strike, mean SEL, and cumulative SEL (Accumulated SEL = single strike SEL + 10*log (# hammer strikes) and a frequency spectrum both with and without mitigation, between 0 and 10,000 Hz for up to eight successive strikes with similar sound levels.

ANALYSIS

Analysis of the data from the San Francisco-Oakland Bay Bridge Pile Driving Demonstration project (PIDP) indicated that 90 percent of the acoustic energy for most pile driving impulses occurred over a 50 to 100 milliseconds period with most of the energy concentrated in the first 30 to 50 milliseconds. The RMS values computed for this project will be computed over the duration between where 5% and 95% of the energy of the pulse occurs. Cumulative energy levels and Sound Exposure Levels (SEL) will be calculated from data between 5% and 95% of the energy of the pulse. The cumulative SEL energy plot will assist in interpretation of the single strike waveform.

In addition a waveform analysis of the individual absolute peak pile strikes will be performed to determine any changes to the waveform with the TNAP operating. A comparison of the frequency content with and without mitigation will be conducted. Units of underwater sound levels will be dB re: 1 micropascal.

REPORTING

An analysis of the change in the waveform and sound levels with and without TNAP operating will be conducted.

A draft report including data collected and summarized from all phases will be submitted to the Services within 60 days of the completion of hydroacoustic monitoring. The results will be summarized in graphical form and include summary statistics and time histories of impact sound values for each pile. A final report will be prepared and submitted to the Services within 30 days following receipt of comments on the draft report from the Services. The report shall include:

1. Size and type of piles impact driven and proofed.
2. A detailed description of the noise attenuation device, including design specifications.
3. The impact hammer force used to drive the piles.
4. A description of the monitoring equipment.
5. The distance between hydrophone and pile.
6. The depth of the hydrophone.
7. The distance from the pile to the shoreline.
8. The depth of water in which the pile was driven.
9. The depth into the substrate that the pile was driven and proofed.
10. The physical characteristics of the bottom substrate into which the piles were driven and proofed.
11. The ranges and means for peak, RMS, and SEL's for each pile.
12. The results of the hydroacoustic monitoring, including the frequency spectrum, peak and RMS SPL's, and single-strike and cumulative SEL with and without the attenuation system.
13. A description of any observable fish or bird behavior in the immediate area will and, if possible, correlation to underwater sound levels occurring at that time.
14. Ambient underwater noise levels.