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, WA 98115

Refer to NMFS Tracking No.: 2001/01298

March 31, 2008

Mr. Mark Ziminske
Environmental Resources Section
US Corps of Engineers, Seattle District
Regulatory Branch CENWS-OD-RG
Post Office Box 3755
Seattle, Washington 98124-3755

Re: Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Operation and Maintenance of the Lake Washington Ship Canal located in the City of Seattle, King County, Washington. 6th Field HUC 171100120301 - Lower Sammamish River, 171100120302 - Cedar River, and 171100190401 - Shell Creek.

Dear Mr. Ziminske:

The enclosed document contains a Biological Opinion and Essential Fish Habitat Consultation. The National Marine Fisheries Service prepared the Biological Opinion according to section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.). The National Marine Fisheries Service conducted the Essential Fish Habitat consultation under section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act. The proposed action concerns the effects of the operation and maintenance of the Lake Washington Ship Canal, located in the City of Seattle, King County, Washington.

In the Biological Opinion, the National Marine Fisheries Service concludes that the proposed action is not likely to jeopardize the continued existence of the Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*) and Puget Sound steelhead (*O. mykiss*). Furthermore, the proposed action is not likely to adversely modify critical habitat designated for Puget Sound Chinook (critical habitat is not yet designated for Puget Sound steelhead).

The proposed action is not likely to adversely affect Steller sea lion (*Eumetopias jubatus*) and southern resident killer whale (*Orcinus orca*). Additionally, the proposed action is not likely to adversely affect critical habitat designated for the southern resident killer whale. The National Marine Fisheries Service expects the effects of the project to Steller sea lion and southern resident killer whales to be discountable because (1) the low likelihood of the species to be within the project area and (2) the conservation measures that have been incorporated into the project. The National Marine Fisheries Service also expects that there will be no effect to southern resident killer whale critical habitat because the project area is outside of southern resident killer whale critical habitat.

As required by Section 7 of the Endangered Species Act, an incidental take statement prepared by the National Marine Fisheries Service is provided with the Biological Opinion. The incidental take statement describes reasonable and prudent measures the National Marine Fisheries Service considers necessary or appropriate to minimize incidental take associated with this action. It also sets forth nondiscretionary terms and conditions, including reporting requirements, that the Federal agency and applicant, if any, must comply with to carry out the reasonable and prudent measures. Incidental take from actions by the U.S. Army Corps of Engineers that meet these terms and conditions will be exempt from the Endangered Species Act take prohibition.

The Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat consultation includes three conservation recommendations to avoid, minimize, or otherwise offset potential adverse effects to essential fish habitat. These recommendations are non-identical to the Endangered Species Act Terms and Conditions. Section 305(b)(4)(B) of the Magnuson-Stevens Fishery Conservation and Management Act requires Federal agencies to provide a detailed written response to National Marine Fisheries Service within 30 days after receiving these recommendations. If the response is inconsistent with the recommendations, the U.S. Army Corps of Engineers must explain why the recommendation will not be followed, including the justification for any disagreements over the effects of the action and the recommendation. In response to increased oversight of overall essential fish habitat program effectiveness by the White House Office of Management and Budget, National Marine Fisheries Service established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each essential fish habitat consultation and how many are adopted by the action agency.

A complete administrative record of this consultation is on file at the National Marine Fisheries Service Washington State Habitat Office in Lacey, Washington. If you have and comments or concerns, please contact Thomas Sibley of the National Marine Fisheries Service's Washington State Habitat Office at (206) 526-4446.

Sincerely,

for D. Robert Lohn
Regional Administrator

Enclosure

cc: Kenneth Brunner, COE

Endangered Species Act - Section 7 Consultation
Biological Opinion

and

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

Operation and Maintenance of the Lake Washington Ship Canal
Lower Sammamish River 171100120301, Cedar River 171100120302
and Shell Creek 171100190401
King County, Washington State

Lead Action Agency: United States Army Corps of Engineers

Consultation Conducted By: National Marine Fisheries Service
Northwest Region

Date Issued: March 31, 2008

Approved by:

for D. Robert Lohn
Regional Administrator
National Marine Fisheries Service

NMFS No: 2001-01298

TABLE OF CONTENTS

ACRONYMS, ABREVIATIONS AND DEFINITIONS

Acronym or abbreviation	Definition
ACZA	Ammoniacal Copper Zinc Arsenate
BA	biological assessment
BRT	biological review team
CH	critical habitat
COE	Army Corps of Engineers
DO	Dissolved Oxygen
Ecology	Washington Department of Ecology
ECS	emergency closure system
EFH	essential fish habitat
ERGO	environmental review guide for operations
ESA	Endangered Species Act
ESU	evolutionarily significant unit
GI	general investigations
lock complex	Hiram Chittenden locks and associated structures
LWD	large woody debris
LWSC	Lake Washington ship canal
MIT	Muckleshoot Indian Tribe
MLLW	Mean Lower Low Water
MSA	Magnuson-Steven Fisheries Conservation and Management Act
NLAA	may affect, not likely to adversely affect
NMFS	National Marine Fisheries Service
O&M	operation and maintenance
Opinion	biological opinion
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PFMC	Pacific Fishery management council
PIT	passive integrated transponder
ppt	Parts per thousand
PS	Puget Sound
RHA	Rivers and Harbors Act
SRKW	southern resident killer whale
TRT	technical review team
USFWS	United States Fish and Wildlife Service
VSP	viable salmonid population
WDFW	Washington Department of Fish and Wildlife
WRDA	Water Resources Development Act

INTRODUCTION

This Biological Opinion (Opinion) and incidental take statement portions of this consultation were prepared by the National Marine Fisheries Service (NMFS) in accordance with Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*), and implementing regulations at 50 CFR 402. With respect to designated critical habitat, the following analysis relied only on the statutory provisions of the ESA, and not on the regulatory definition of "destruction or adverse modification" at 50 CFR 402.02[1]. This document also contains a consultation on the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 *et seq.*) and implementing regulations at 50 CFR 600.

The U.S. Army Corps of Engineers (COE) determined that the action associated with the proposed Operation and Maintenance (O&M) of the Lake Washington Ship Canal (LWSC) and Hiram M. Chittenden Locks and associated facilities (lock complex) "may affect, and is likely to adversely affect" the Puget Sound Chinook (PS Chinook) salmon (*Oncorhynchus tshawytscha*), and Critical Habitat (CH) of PS Chinook. This Opinion will address adverse effects to the PS Chinook and CH of PS Chinook that are associated with the O&M of the LWSC.

The COE also requested informal consultation on the Steller sea lion (*Eumetopias jubatus*), Southern Resident Killer Whale (SRKW) (*Orcinus orca*), CH of SRKW, and concurrence on no jeopardy on Puget Sound steelhead (PS steelhead) (*O. mykiss*) in accordance with section 7(a)(2) of the Act (16 U.S.C. 1531 *et seq.*). NMFS believes that sufficient information has been provided on project effects to the Steller sea lion to concur with these effect determinations. Our concurrence is provided in the attached cover letter. PS steelhead were listed as threatened under the ESA on May 11, 2007, 72 FR 26722. Therefore, an analysis of effects to PS steelhead is included in this Opinion.

Background and Consultation History

The Opinion contained in this document is based on NMFS's review of proposed O&M of the LWSC by the COE Seattle District Office, Seattle, Washington. The actions are carried out under the Rivers and Harbors Act of 1899, section 1135 of the Water Resources Development Act, and the Sundry Civil Act. The Essential Fish Habitat (EFH) consultation was prepared by NMFS in accordance with section 305(b)(2) of the MSA. Puget Sound is designated as EFH for various life stages of 46 species of groundfish, four species of coastal pelagics, and three species of Pacific salmon (Table 1, inserted after the Literature Cited section).

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

This document is based on the best available scientific information, provided in the COE's Biological Assessment (BA), supplements to the BA, numerous meetings, phone calls, and letters, and other sources. The following provides a partial list of significant correspondence and meetings.

1. Letter of transmittal for the BA from the COE dated September 10, 2001.
2. NMFS met with the COE on April 24, 2002, to discuss the project and to request additional information.
3. November 5, 2002, the COE responded to NMFS's request for additional information. After review, NMFS requested additional information.
4. August 14, 2003, NMFS met with the COE to discuss the project.
5. December 3, 2003, NMFS met with the COE to discuss information requests.
6. December 11, 2003, NMFS met with the COE to discuss further needed information.
7. January 23, 2004, NMFS sent a letter to the COE initiating formal consultation.
8. June 3, 2004, NMFS sent a letter to the COE requesting a 90-day extension.
9. June 6, 2006 addendum to the BA sent to NMFS.
10. August 31, 2007, addendum to the BA sent to NMFS.
11. Numerous additional telephone conversations and correspondence between the Services and the COE.

A complete administrative record for this consultation is on file in NMFS's Washington State Habitat Office in Lacey, Washington.

<u>Tribal Consultation</u>

The Muckleshoot Indian Tribe (MIT) and Suquamish Tribes are co-managers of fishery resources with the Washington Department of Fish and Wildlife (WDFW) within the boundaries of their usual and accustomed fishing areas in the Lake Washington watershed. Specific fishing areas for the Suquamish Tribe include: Shilshole Bay below the lock complex, Elliott Bay, and the Duwamish River estuary upstream to the Spokane Street Bridge. Specific fishing areas for the MIT include: Shilshole and Elliott Bays, Management Area 10 of Puget Sound, Lake Washington, Lake Sammamish, and the Cedar, Green, and Puyallup/White Rivers. The MIT has been a leading proponent of salmon protection and recovery efforts within the Lake Washington basin (COE 1999a).

The MIT was the initial local sponsor for the WRDA section 1135 project that initiated changes in operations and physical components to improve survival of salmonids traversing the lock complex. The MIT provided direct funding for the Waterways Experimental Station evaluation of the slow fill procedures (Waller et al. 1998) that were shown to be beneficial to juvenile salmon and were thus instituted.

Description of the Proposed Action

The COE proposes continuing the O&M of the LWSC. The LWSC is a human constructed waterway connecting Lake Washington to Puget Sound. The LWSC consists of the lock complex, the 5,800 foot (1,768 meters) Fremont Cut between Salmon Bay and Lake Union, and the 2,500 foot (762 meters) Montlake Cut between Lake Union and Lake Washington.

The lock complex spans the LWSC near its western end. At this location, the LWSC orientation is east-west. The lock complex spans the LWSC in a north-south orientation. Lake level elevations are maintained through conjunctive operation of the large and small locks, spillway gates in the dam, smolt passage flumes (smolts are the emigrant life history stage of salmon and steelhead that are physiologically capable of entering salt water), and saltwater drain system. The following description of the lock complex begins on the north side of the LWSC and proceeds to the southern side. On the upland on the north side of the LWSC is the Carl S. English, Jr. Garden, visitor center, administration building, and most of the support facilities. The various components of the lock complex, from north to south, are the large lock chamber, the small lock chamber, the spillway, and the fish ladder (located at the southern side of the LWSC). The large lock chamber has an intermediate miter gate that allows the lock complex operators to fill only one-half of the chamber if vessel passage demand is low, thus conserving water. Also, within or associated with the large lock are outer miter gates, intake culverts, and filling culverts. The filling and intake culverts are used to fill and drain the lock chamber(s). At the eastern end of the large lock is the entrance to a saltwater drain located on the bottom of the LWSC. The saltwater drain was installed to move saltwater out of the LWSC that accumulated upstream of the lock complex. The source of the saltwater was via the large lock during lockages that moves vessels from Puget Sound into the LWSC. Saltwater flows east while fresh water flows west. Saltwater that enters the saltwater drain goes to two locations: (1) into the LWSC below the lock complex, and (2) into the fish ladder where the saline water is added to the fresh water in the fish ladder to attract returning adults to the fish ladder entrance.

The small lock does not have an intermediate miter gate given its small size and is the preferred lock for most pleasure craft. The small lock components are intake culverts, filling culverts, and outer miter gates. The small lock does not have a saltwater drain associated with it because the bottom of the lock chamber is located at a higher elevation relative to Mean Lower Low Water (MLLW) than the large lock chamber, and allows for passage of only a minor amount of saltwater into the freshwater portion of the LWSC.

The spillway is composed of six gates that regulate the water level during high flows. The forebays are located on the east side of the spillway with the stilling basin located to the west. Each year in summer through early fall, smolt flumes are attached near the top of one or more of the spillways. A smolt flume spans the width of a spillway, funnels water into a smaller opening, and reduces the amount of water necessary to pass smolts. Compared with many other possible routes, the smolt flumes provide the least dangerous way for smolts to move through the facility on their way to Puget Sound. The smolt flumes can be equipped with passive integrated transponder (PIT) tag readers to provide data on smolt migration.

The fish ladder, located at the southern edge of the LWSC, was designed to let adult salmonids move from the stilling basin to the fresh water portion of the LWSC without the necessity of passing through either the large or small lock during their return migration. Six of the lower 11 ladder chambers have grating in the bottom where saline water from the saltwater drain mixes with freshwater flowing down the fish ladder. Also, some of the fish ladder chambers have windows that allow the public to view adult salmonids as they traverse the ladder.

Adult salmonids migrate into the LWSC primarily via the fish ladder and the lock complex. Some may enter the saltwater drain (this is possible from either end) and find their way into the diffuser wells beneath the fish ladder. Once in the diffuser wells, it is unlikely they will find their way back out because of the design and construction of the water passages (Eric Warner, MIT biologist, personal communication). Juvenile salmonids migrating out of the LWSC can pass through the lock complex many different ways including the culverts used to divert freshwater into the locks, the smolt passage flumes (when operating), the large and small lock, the spillway gates, or the fish ladder.

The COE will also establish a scientific committee to determine the specific actions necessary to improve estuarine conditions for fish passage in the LWSC. The aquatic environment above the lock complex is subject to high temperatures and low dissolved oxygen as well as salt water intrusion. The scientific committee will make recommendations to improve conditions after which the COE will obtain funding to implement the recommendations.

<u>Seasonal Operations</u>

The operation of the lock complex including the LWSC, and Lake Washington, can be divided into four seasonal periods. Each season is related to the status of the water supply based on forecasts of water availability. The definitions follow:

- the spring refill period from February 15 until May 1, when the lake level is allowed to rise to 22 feet (6.7 meters) (COE datum);
- the summer conservation period, when the lake level is maintained at the May 1 level as long as possible, and involuntary draw-down commences usually in late June or early July;
- the fall drawdown period beginning at the onset of the fall rains and continuing until December 1; and
- the winter holding period, from December 1 through February 15, when the lake level is maintained at 20 feet (6.1 meters) (COE datum).

It should be noted that water temperatures in the LWSC exhibit an increasing trend, especially in late summer and fall (Newell and Quinn 2005, Quinn et al. 2002, King County 2007, Goetz et al. 2006).

Large and Small Locks

The large lock is 825 feet (251.5 meters) long between the upper and lower service gates, is 80 feet (24.4 meters) wide, and is divided into two chambers by an intermediate gate. The downstream and upstream chambers are 375 feet (114.3 meters) and 450 feet (137.2 meters) long, respectively. The intermediate gate can serve as either an upper or lower gate when the entire lock is not required for ship transit. There is also a saltwater barrier in the bottom of the large lock that can be erected by filling it with air. This is used only when needed. The saltwater barrier is designed to impede saltwater flow from Puget Sound into the LWSC. The large lock operates 24 hours per day, seven days per week. Operations entail the filling and emptying of the locks by gravity flow to allow vessel traffic to move from Salmon Bay to Puget Sound and vice versa. Vessel traffic is greatest during summer months.

The small lock is 150 feet (45.7 meters) long by 30 feet (9.1 meters) wide, and is a single chamber without an intermediate gate. It is designed for smaller vessels with drafts up to 16 feet (4.9 meters), lengths less than 123 feet (37.5 meters), and widths less than 28 feet (8.5 meters). The small lock operates 24 hours per day, seven days per week. Operations entail the filling and emptying of the lock by gravity flow to allow vessel traffic to move from Puget Sound to Salmon Bay and vice versa. As with the large lock, vessel traffic is greatest during summer months.

Both locks are dewatered annually for approximately 14 days, the large lock in late November to early December and the small lock at the end of March, for maintenance. Pumps located in the pump-well beneath the administration building are used to drain the lock chambers. Part of the annual maintenance is removal of barnacles by scraping and using high-pressure water in the large lock. No chemicals are used. Only high-pressure water is used for cleaning the small lock.

Saltwater Barrier and Drain

During upstream lockages (eastward movement) saltwater flows into the bottom of the large lock. When the lower gate is closed, saltwater is trapped in the lock chamber and flows out of the large lock into the LWSC when the upper gate is opened. In 1966, the COE constructed the saltwater barrier in the large lock and a saltwater basin with a drain located just upstream of the large lock. The saltwater drain was installed to minimize saltwater movement into the LWSC and subsequently into Lake Washington. Initially, the saltwater drain simply allowed saltwater to pass through the complex and out into the stilling basin.

Modifications were made to the salt water drain to allow salt water to be piped into the fish ladder. Thus, the saltwater return system now consists of the saltwater basin, a drain-intake in the saltwater basin, and concrete pipes that direct the saltwater to both the stilling basin or the diffuser wells in the fish ladder. The intake to the saltwater drain is a 192-square-foot (17.8-square-meters). Up to 140 cubic feet per second (4.0 cubic meters per second) of saline water is returned directly to Puget Sound. Another (approximately) 160 cubic feet per second (4.5 cubic meters per second) of saline water goes to the diffuser wells beneath the fish ladder. The salinity of the water in the saltwater drain ranges from approximately 3 to 16 parts per thousand (ppt).

The saltwater barrier, located in the large lock chamber, is a hinged hollow steel box structure that is erected by filling it with air. When erected, it reduces saltwater intrusion, but does not block it completely because the barrier does not fit tightly against the sides or bottom of the lock chamber. As the lock fills, the barrier becomes buoyant, rotating upward to a 70 degree angle, stopping as it makes contact with bumpers embedded in the large lock walls. With every eastbound (upstream) lockage through the large lock, saltwater enters the large lock chamber. Most of this saltwater is either blocked by the saltwater barrier, preventing movement farther upstream, or it enters the saltwater drain and is conveyed back to Puget Sound. However, during the summer period of heavy boating activity, less freshwater is available for saltwater control and a saltwater layer can intrude into Lake Union and beyond. The Washington Department of Ecology (Ecology) has imposed a special condition that salinity shall not exceed one ppt at any point or depth along a line that transects the LWSC at the University Bridge (WAC 173-210A-130(58)). The University Bridge is located approximately 4 miles east of the lock complex. The criterion was one of the motivating factors for construction of the saltwater barrier in the large lock. A barrier/drain system is not required for the small lock since the elevation of the bottom of the small lock (relative MLLW) is sufficiently high to preventing significant saltwater intrusion.

Periodically, the saltwater drain requires maintenance due to cracks or holes in the concrete structure. Typically, divers inspect the drain every five years to evaluate structural integrity and determine locations where repair may be necessary. Repair of the pipes and openings occurs approximately every 15 years by installing a structure that acts as a coffer dam so water can be removed from the work area, thereby isolating any newly poured concrete and rebar in areas where repairs are necessary. On-going maintenance includes removal of detritus and sediment upstream of the intake.

Emergency Operations

In the event of an emergency (i.e., gate malfunction), an Emergency Closure System (ECS) is implemented to contain the flow through the lock complex. The ECS consists of the installation of stoplogs in the large lock and/or small lock, which provide a physical barrier to block freshwater from exiting the LWSC.

Spillway

The surface elevations of the LWSC and Lake Washington are similar. Lake Washington acts as a water storage reservoir for the lock complex operations throughout each year.

The water level in the LWSC/Lake Washington system typically fluctuates about two feet, from a low of 20 feet in December to a high of 22 feet (COE datum) in May. The six spillway gates are used by the COE to regulate water level during high flows. The upper water level (22 feet) is the highest level that can be tolerated without causing damage to infrastructure that depends on lake level (e.g., the floating bridges). The amount of water released through the gates depends on environmental conditions at the time of discharge (i.e., flow from the Cedar River and other tributaries of Lake Washington) (COE 1998). Winter discharges typically range from 1,948 to 3,054 cubic feet per second at each gate, with a maximum spillway discharge capacity totaling 18,324 cubic feet per second for all gates. In general, the gates are usually closed or minimally open (0.5 to 1.0 foot) from April to October. During this time period, discharges may range from 200 to 465 cubic feet per second at each gate.

Fish Passage

The fish ladder is located on the south side of the spillway, and was designed to operate within NMFS and the USFWS 1976 fish passage criteria at Lake Washington elevations of 18.5 feet to 22 feet (COE datum), and Puget Sound tidal elevations of 0.5 to 12 feet MLLW. The fish ladder is eight feet wide, with three adjustable weirs at the upper fish exit end, 18 fixed weirs with submerged orifices, and one adjustable and one fixed slot in the stilling bay entrance. The downstream entrance is only slightly wider than an adult PS Chinook female. The lower six weirs are equipped with fiberglass grates that allow brackish water from the salt water drain to enter the fish ladder. This brackish water provides transportation flow and attracts adult salmon (COE 1992). Water is released through the fish ladder year-round, except when the fish ladder is undergoing annual maintenance (typically one week in late May or early June). Flow through the fish ladder includes 23 cubic feet per second freshwater from the surface of the LWSC, as well as 160 cubic feet per second of brackish water from the salt water drain. Water temperature in the LWSC has been increasing for over two decades (Newell and Quinn 2005, Quinn et al. 2002, King County 2007, Goetz et al. 2006).

Juvenile PS Chinook move through the large and small locks, the large and small lock filling culverts, the saltwater drain, the spillway gates, the fish ladder, and the smolt passage flumes (when operational). To improve survival of smolts passing through the lock complex, the COE implemented a smolt passage restoration project as part of its standard O&M program. This program, authorized under section 1135 of the WRDA, includes several elements designed to:

- reduce the flow velocity at the filling culvert intakes and within the conduits to minimize smolt entrainment and injury;
- annually remove abrasive materials (barnacles) from within the culverts;
- annually install (during immigration periods) low-flow surface water collectors (smolt passage flumes) in the spillway gates (total discharge 405 cubic feet per second);

- install 36 strobe lights at the entrance to the large lock-filling culverts (18 lights per culvert intake) to deter smolts from gathering near, and being drawn (entrained) into, the culvert intakes when the large lock is filling.

The Fremont and Montlake Cuts

The Fremont Cut starts about one-half mile east of the lock complex and extends to Lake Union. Concrete sills, bolstered by riprap, line both sides of the Fremont Cut. The banks on each side of the cut are lined with a single row of Lombardy poplars (*Populus nigra)*. The poplars form a nearly uninterrupted colonnade from the Fremont Drawbridge to Seattle Pacific University. These trees have historic status and appear on historic photographs as early as 1931. The ground cover along the Fremont Cut consists primarily of cultivated grass, with understory vegetation of woody ornamental and native shrubs, some of which overhang the bank. Vegetation on both sides of the canal consists of a mixture of native and non-native trees, shrubs, ground cover, and grasses. Tree species include European birch (*Betula pendula)*, big-leaf maple (*Acer macrophyllum*), flowering cherry (*Prunus serrulata*), blieriana plum (*Prunus Blieriana*), and European mountain ash (*Sorbus aucuparia)*.

The Montlake Cut begins in the eastern side of Portage Bay and extends about one-half mile to the western side of Union Bay. Concrete revetments line both sides of the Montlake Cut. The tops of the concrete revetments are used as waterside walks. On the south shore, a recreational trail connects to the Washington Park Arboretum trail. The Montlake Cut is characterized by steep side slopes, planted with a combination of ornamental English ivy (*Hedera helix*), deciduous and evergreen trees, and native shrubs and grasses. Trees consist primarily of native conifers. In addition, a row of approximately 12 Lombardy poplars lines the west end along the north shore.

Along both sides of the Fremont and Montlake cuts, the Project Master Plan calls for protection and maintenance of the concrete embankments, including retention and preservation of the terrain and significant landscape features, which are considered historic resources. Several sections of the Fremont and Montlake cuts have required repair due to erosion (COE 1999b). The COE does necessary maintenance to the Fremont and Montlake cuts to maintain existing conditions. This may include replacement of concrete bulkheads, concrete sills, riprap, etc.

Lake Washington Water Management

The COE is mandated by Congress (Public Law 74-409, August 30, 1935) to maintain the level of Lake Washington between 20 feet and 22 feet (COE datum) as measured at the lock complex. The COE regulates the lake level based on lake level forecasts, lake level measurement, and projected demand for smolt passage flumes, saltwater drain, and lock operation.

The spillway is operated as needed to maintain the minimum water level of Lake Washington at 20 feet from December 1 until the refill starts. The spillway gates are opened in a specific order to minimize scouring below the lock complex and to maximize attraction of anadromous fish to the fish ladder during times of their upstream migration.

Dolphin Replacement

Dolphins (many piling driven and tied together that form a anchor point of barrier for ships), located downstream of the rail bridge and at the end of the large lock waiting pier, consist of approximately 20 to 30 creosote pilings. Each piling is replaced with ammoniacal copper zinc arsenate (ACZA) pilings as needed. This activity will result in the total removal of the creosote piling over time.

Annual Maintenance of the Large and Small Locks

Annual maintenance is conducted by dewatering the specific lock chamber. Timbers that need replacement in the large lock are removed and replaced by ACZA treated timbers. The wooden sills at the bottom of each lock chamber gate need periodic replacement where the gates meet each gate clappersill. Currently, the sills consist of creosote-treated timber. The worn sills will be replaced with ACZA-treated wood when replacement is necessary. The sills generally need replacement every seven years on the saltwater side and every 20 years on the freshwater side of the lock complex. The decks and walls of each lock chamber are washed as needed with high-pressure tap water. Barnacles are removed from the large lock chamber and the filling culverts. No chemicals are used.

Special Operations

Occasionally, project operations are modified to facilitate adult salmon fish harvest. The locks or spillway gates may be closed for short periods at the request of various resource agencies or the MIT. At times, these agencies and MIT may need to examine the saltwater layer, conduct salmon studies, or observe salmon behavior, all of which may require changes in flows through the lock complex.

Pier Maintenance

Pier pilings along the western guide pier at the north and south lock walls and the center guide pier between the large and small locks are replaced as needed with ACZA-treated pilings. Pilings need to be replaced approximately every seven to 15 years. Such work is timed to occur during periods when there are minimal or no fish present.

Facilities Maintenance

Buoy maintenance, including battery replacement, is done by lock complex personnel using small boats. The gates and gate rams are lubricated daily with a lithium/graphite-based grease. This grease is not sprayed over the water. Petroleum-based grease is applied directly to the gate knuckles. However, the COE is considering food-grade grease (vegetable oil) to replace these petroleum-based lubricants and may be used if it allows the gates to function properly and perform to required specifications. Divers periodically inspect all underwater areas in the immediate vicinity of the lock complex to document any areas in need of repair and to assist in the placement of fish monitoring equipment.

Considerable amounts of driftwood, miscellaneous flotsam, and other debris accumulates on the eastern side of the lock complex. The sources of this material are numerous, but mainly debris tossed overboard from vessels located in the LWSC and Lake Washington. Some of the debris passes through the lock complex, while the remainder is collected and stored on barges that are moored along the north side of the eastern guide pier of the large lock. The debris is then transported upland and disposed of via environmentally sensitive means including hazardous waste land fills if appropriate.

Maintenance of the Carl S. English garden, located along the north side of the lock complex, includes mowing, weeding, edging, pruning, plant replacement, watering, and fertilizing. The use of fertilizer is minimal (about six pounds of nitrogen per year). Weeding is accomplished by hand or spot treatment with a biodegradable herbicide (i.e., Rodeo). The Environmental Review Guide for Operations (ERGO) describes regulations relevant to herbicide usage and is consulted if herbicides are needed. No chemicals are sprayed in winds greater than five miles per hour or during rains heavier than a mist. No pre-emergent herbicides or insecticides are used. In the botanical garden greenhouse, biological control of pest species is the primary method employed. Elsewhere, for larger pests such as rats, live trapping is used to confirm that only the targeted species is removed.

Pest control elsewhere along the LWSC is achieved through an integrated pest management program. As such, no large-scale applications of herbicides or pesticides occur. One exception is the community-wide spraying for Asian gypsy moths, conducted by the Washington State Department of Agriculture. The ERGO describes regulations relevant to pesticide usage and is utilized if pesticides are needed. No chemicals are sprayed in winds greater than five miles per hour or during rains heavier than a mist.

Painting is required periodically on COE facilities associated with the LWSC. This maintenance activity is ongoing as needed and standard methods are used to contain paint and avoid spillage. When painting occurs, all areas to be painted are roped off to minimize disruption of the painting process by unauthorized personnel. When not in use, all paints are stored in lockers located in the paint storage room in Warehouse 3 of the lock complex.

The Programmatic Agreement developed for compliance with the National Historic Preservation Act requires the in-kind repair or replacement of the existing concrete walls along the Fremont and Montlake Cuts. Walkways along the LWSC require periodic repair or partial replacement. Best management practices are used to ensure that repair activities do not affect water quality or other sensitive habitats.

Gallery Drains

Because the lock complex is a concrete structure, water leaks into lock galleries where some of the machinery is housed. A series of drains in the lock galleries allows water to drain from the galleries to Puget Sound. This water does not contact any of the machinery in the galleries.

Channel Tidelands

Two parcels of channel tidelands, totaling 12.6 acres (5.1 hectares), are owned by the COE as part of the LWSC. The tidelands are located west of the lock complex and were acquired along with other lands to guarantee navigation. Both parcels are considered environmentally sensitive areas in the LWSC Master Plan, and the objective of management is to preserve the parcels in a natural state. Any activities that potentially degrade fish and wildlife habitat are prohibited.

Guide Pier

The large lock guide and small lock waiting piers (western end) are rehabilitated by replacing the creosote-treated timbers with ACZA-treated timber. The rehabilitation of the guide piers is part of the continuing O&M of the LWSC.

Spill Response Plan

In the event any potentially hazardous or toxic material is spilled in or above the lock complex, the COE ceases operation of the large and small locks and keeps them closed until the spill has been contained. This action is intended to prevent transportation of any contamination downstream to Puget Sound. An Environmental Compliance Coordinator is employed and is responsible for monitoring and controlling wastes, such as oils, lubricants, solvents, paints, and asbestos. All hazardous wastes are kept covered, labeled, and locked away in appropriate storage sheds. Three spill kits are located near the storage areas in case of an accidental spill.

Lake Washington General Investigation Study

The Lake Washington General Investigation (GI) study requires annual funding from the City of Seattle, King County, and the Federal Government. The study is designed to evaluate various projects that may contribute to the restoration of ecological processes or functions within the Lake Washington Basin. A primary objective of the GI study is to conserve water at the lock complex to provide more flow for juvenile and adult fish passage. The study also includes restoration of habitats in the basin and environmental monitoring. The GI study complements post-smolt passage flume construction monitoring that has been performed as part of a LWSC Smolt Passage, Section 1135 Restoration Project. Monitoring activities in the GI study include:

- Passive Integrated Transponder tagging and detection at various locations in the LWSC;

- beach seine sampling in Lake Washington and in the saltwater environments below the lock complex,

- a study of food habits of juvenile PS Chinook in Lake Washington and of piscine predators below the lock complex;

- water velocity studies associated with fish attraction to the flumes;

- water quality studies upstream and downstream of the lock complex to evaluate effects of Dissolved Oxygen (DO) (decreasing trend), temperature (increasing trend), and salinity on both juvenile and adult salmonids;

- fish entrainment into the large lock culverts and subsequent injury and mortality;

- fish entrainment in the saltwater drain; and

- adult PS Chinook upstream migration.

Scientific Committee

The aquatic environment above the lock complex is subject to high temperatures and low Dissolved Oxygen as well as salt water intrusion. As part of the proposed action, the COE will establish a scientific committee to determine the specific actions necessary to improve estuarine conditions for fish passage in the LWSC. The Scientific committee will be composed of no fewer than four and no more than six individuals. These individuals will be expert in the following fields: (1) physical hydrodynamic processes; (2) salmon behavior in brackish water; (3) fluid dynamics; (4) ecosystem dynamics and food webs in brackish water situations; and (5) the technical operation of the lock complex. The scientific committee will provide recommendations to improve conditions in the LWSC including possible alternative O&M strategies. The COE will obtain funding to implement the scientific committee recommendations. The scientific committee recommendations will be tested via temporary trials before permanent implementation.

Research Studies on Puget Sound Chinook Behavior

The COE has been studying the behavior of juvenile and adult PS Chinook in the LWSC for many years. The primary study objectives are to learn enough about PS Chinook behavior in the LWSC so that changes in O&M and structures within the LWCS can be evaluated and implemented to reduce mortality of emigrants and immigrants. The behavior studies are conducted by tagging individual PS Chinook which are then tracked through time. Three types of tags are generally used: (1) passive integrated transponder (PIT) tags that emit a unique code when the tag passes through a magnetic field, as tagged fish move through various parts of the lock complex where PIT tag detectors are located, the unique signature is recorded along with time and other variables; (2) microacoustic tags allow researchers to follow individually tagged PS Chinook resulting in a data base of location, depth and movement through time; and (3) archival tags continuously record environmental data, including water temperature, in the microhabitat where the fish is located, these data are stored in the tag and recovered when the tag is recovered. From the data collected it is then possible to identify movement through time of both emigrants and immigrants, the environmental conditions they prefer and their preferred locations as they transit the LWSC as well as the environmental conditions in microhabitats within the LWSC. As technology has advanced, allowing for increased miniaturization and increased ranges over which tags can be detected, a better understanding of how PS Chinook respond to various aspects of the LWSC has steady grown. Results of the studies have been applied (smolt slides, slow fill of the large lock, etc.) that have reduced injury to PS Chinook.

Minimization Measures

The following measures, described as part of the proposed action, are intended to reduce or avoid adverse effects on listed species and their habitats. These minimization measures are integral components of the proposed action and the following analysis was completed accordingly.

a. During non-drought years, the COE reduces water use for salinity control and increases flow through the fish passage flumes.

b. During drought years, the COE begins the annual refill of Lake Washington at an earlier date than usual to assure the likelihood of attaining a lake elevation of 22 feet. By beginning the filling process earlier, adequate water flow can be devoted to the fish passage flumes in May and June.

c. Slow valve operation. Currently the east end and center Stony gate valves have been mechanically modified to slow the opening time (increased from 2 minutes 20 seconds to 4 minutes 40 seconds). This modification to the operation has decreased the rate of fill of the lock chambers, effectively minimizing injury to juvenile salmonids. The lower injury rates result from the fact that water flows through the filling culverts at a lower velocity and entrains fewer juvenile salmonids; additionally, the lower velocities result in less severe injury to those fish that are entrained. Additional testing indicates that even slower opening speeds could further reduce injury to juvenile salmonids. The COE is currently developing plans and specifications for a new operating system that will include variable speed motors, providing a broad range of opening rates to further enhance the ability to reduce entrainment. The COE is seeking funding to construct this new operating system and will do so should funding become available.

d. Strobe lights have been installed in the large lock to reduce entrainment of juvenile salmonids in the filling culverts.

e. Barnacles in the filling culverts to the large lock will be removed annually to reduce physical injury to PS Chinook and other juvenile salmonids.

f. Wires (bird netting) were strung over the stilling basin to deter avian predation of salmonid smolts.

g. All in-water work will occur during appropriate work windows in consultation with NMFS and MIT.

h. Replacement of treated wood structures, or other treated wood parts of structures, is and will be done with best management practices as recommended by the Western Wood Preservers Institute (1996) to minimize impacts to sensitive species.

Action Area

Action area means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). For purposes of this consultation, the action area is the LWSC (within the City of Seattle, King County, Washington), which includes the lock complex and all of its components (the saltwater drain, the fish ladder, the smolt passage flumes, the spillway, etc.) and associated structures, the Fremont and Montlake Cuts, the water and land areas immediately adjacent to these facilities that are regulated by the COE, all water encompassed by Shilshole Bay, Salmon Bay, Lake Union, Portage Bay, Union Bay, and Lake Washington, as well as tributary and upland areas immediately adjacent to these waters potentially affected by the lock complex operations.

The action area is used by the PS Chinook and PS steelhead. Emigrating juvenile salmonids (smolts) and returning adults migrate through the area. The action area is also designated as EFH for Pacific Coast groundfish (PFMC 1998a), coastal pelagic species (PFMC 1998b), and Pacific Coast salmon (PFMC 1999), and is in an area where environmental effects of the proposed project may adversely affect EFH for those species, see Table 1 for a complete list of species found in the action area.

ENDANGERED SPECIES ACT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat on which they depend. Section 7(a)(2) of the ESA requires Federal agencies to consult with NMFS on the species within NMFS's jurisdiction to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their critical habitats. Section 7(b)(4) requires NMFS to provide an incidental take statement that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts.

Biological Opinion

This Opinion presents NMFS's review of the status of each listed species of Pacific salmon[2] considered in this consultation, the condition of designated critical habitat, the environmental baseline for the action area, all the effects of the action as proposed, and cumulative effects (50 CFR 402.14(g)). For the jeopardy analysis, NMFS analyzes those combined factors to conclude whether the proposed action is likely to appreciably reduce the likelihood of both the survival and recovery of the affected listed species.

The critical habitat analysis determines whether the proposed action will destroy or adversely modify designated CH for listed species by examining any change in the conservation value of the essential features of that CH. The regulatory definition of "destruction or adverse modification" at 50 CFR 402.02 is not used in this Opinion. Instead, this analysis relies on statutory provisions of the ESA, including those in section 3 that define "critical habitat" and "conservation," in section 4 that describe the designation process, and in section 7 that sets forth the substantive protections and procedural aspects of consultation, and on agency guidance for application of the "destruction or adverse modification" standard.[3]

Status of the Species

NMFS reviews the condition of the listed species affected by the proposed action using criteria that describe a 'viable salmonid population' (VSP) (McElhany et al. 2000). Attributes associated with a viable salmonid population include abundance, productivity, spatial structure, and genetic diversity that maintain its capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout the entire life cycle, which are influenced, in turn, by habitat and other environmental conditions.

Status of Puget Sound Chinook Salmon

Life History. PS Chinook salmon are the largest of the pacific salmon that reside in the Puget Sound basin. Being large, they require deeper water in which to spawn compared with other members of the genera. Spawning grounds are generally located in the mainstem and major tributaries of the larger river systems. An example is the Skagit River which contains six independent spawning populations. Eggs are deposited in well oxygenated gravel in late fall and juveniles emerge in late winter to early spring. The juveniles move downstream, feeding all the while. Entry into estuaries can occur within the first year of emergence (days to months) to one year after emergence. As a result, there are two types of PS Chinook, those that leave the rivers in the first year of life,

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[2] An 'evolutionarily significant unit' (ESU) of Pacific salmon) and a 'distinct population segment' (DPS) of steelhead (final steelhead FR notice) are considered to be 'species,' as defined in Section 3 of the ESA. (Waples 1991)

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

called ocean type; and those that leave the rivers in the second year of life, called stream type (Wydoski and Whitney 2003). The possible number of life history strategies resulting from the variable available habitats and the length of time spent in rivers before emigrating into marine waters is conceivably as large as the number of individuals. However, four dominant life histories have been identified: (1) delta fry; (2) fry migrants; (3) parr migrants; and (4) yearling migrants. The delta fry life history dominates in those river systems with functional delta habitat (K. Fresh, NMFS, Personal communication). The fry migrant life history strategy emigrates rapidly into the nearshore marine waters of Puget Sound where they apparently move into pocket estuaries near their natal rivers. If they don't find pocket estuaries with functional habitat their apparent survival is extremely low (Eric Beamer, Skagit Coop biologist, personal communication).

Once the juvenile smoltify (change their appearance to a silvery sheen and become physiologically adapted to full strength salt water conditions) they emigrate into the marine waters of Puget Sound and expand their habitat range as they grow. By late summer or early fall, the juveniles generally emigrate into the north Pacific Ocean where they reside for one to three years before returning to spawn in their natal rivers (Wydoski and Whitney 2003).

Puget Sound Chinook generally exhibit an ocean-type life history; most migrate to the ocean within their first year of life. Although some populations have a high proportion of yearling migrants, the proportion varies from year to year and appears to be environmentally mediated rather than genetically determined. PS Chinook stocks generally mature at ages three and four and exhibit similar, coastally-oriented, ocean migration patterns.

Distribution and Abundance. The PS Chinook ESU is comprised of 31 historically quasi-independent populations of PS Chinook, of which 22 are believed to be extant (PSTRT 2001; 2002). This ESU encompasses all runs of PS Chinook in the Puget Sound region from the North Fork Nooksack River to the Elwha River on the Olympic Peninsula. The boundaries of the PS Chinook ESU correspond generally with the boundaries of the Puget Lowland Ecoregion.

PS Chinook populations contain natural spawners numbering in the hundreds (median natural escapement is 481, Myers et al. 1998). Six populations had more than 1,000 natural spawners, but only two were thought to have a low fraction of hatchery fish. Estimates of the historical equilibrium abundance, based on pre-European settlement habitat conditions, ranged from 1,700 to 51,000 potential PS Chinook spawners per population. The historical estimates of spawner capacity are several orders of magnitude higher than realized spawner abundances observed throughout the PS Chinook ESU range (Myers et al. 1998).

Previous assessments of stocks within the PS Chinook ESU have identified several stocks as being at risk or of concern. Long-term trends in abundance and median population growth rates for naturally spawning populations of PS Chinook indicate that approximately one-half of the populations are declining and one-half are increasing in abundance over the length of available time series. Eight of 22 populations have declining abundance over the short term, similar to long-term trends that show 11 - 12 populations declining (Myers et al. 1998).

Nehlsen et al. (1991) identified four stocks as extinct, four stocks as possibly extinct, six stocks as at high risk of extinction, one stock at moderate risk, and one stock of special concern. Harvest impacts on PS Chinook populations averaged 75 percent (median is 85 percent; range 31-92 percent) in the earliest five years of data availability and have dropped to an average of 44 percent (median is 45 percent; range 26-63 percent) by the late 1990s.

Overall abundance of the PS Chinook ESU has declined substantially from historical levels, and many populations are small enough that genetic and demographic risks are likely to be relatively high. Both long and short term trends in abundance are predominantly downward, and several populations are exhibiting severe short term declines. Spring-run PS Chinook populations throughout this ESU are all depressed (Nehlsen et al. 1991).

Risk factors. Reasons for decline include anthropogenic activities which have blocked or reduced access to historical spawning grounds and altered downstream flow and thermal conditions. In general, upper river tributaries have sustained impacts from human forest practices while lower river tributaries and mainstems have sustained impacts caused by agriculture and urbanization. Diking for flood control, draining and filling of freshwater and estuarine wetlands, and sedimentation due to forest practices and urban development are cited as problems throughout the ESU (WDF et al. 1993). Blockages by dams, water diversions, and shifts in flow regime due to hydroelectric development and flood control projects are major habitat problems in several basins. Bishop and Morgan (1996) identified a variety of habitat issues for streams in the range of the PS Chinook ESU including: (1) changes in flow regime (all basins); (2) sedimentation (all basins); (3) high temperatures in some streams; (4) stream bed instability; (5) estuarine loss; (6) loss of large woody debris in some streams; (7) loss of pool habitat in some streams; (8) blockage or passage problems associated with dams or other structures; and (9) decreased gravel recruitment. These impacts on the spawning and rearing environment may also have an impact on the expression of many life-history traits and mask or exaggerate the distinctiveness of many stocks. The Puget Sound Salmon Stock Review Group concluded that reductions in habitat capacity and quality have contributed to escapement problems for PS Chinook (PFMC 1997). It cited evidence of direct losses of tributary and mainstem habitat due to: (1) dams; (2) loss of slough and side channel habitat caused by diking, dredging, and hydromodification; and (3) reductions in habitat quality due to land management activities.

The artificial propagation of fall-run stocks is widespread throughout this region. Summer/fall Chinook salmon transfers between watersheds within and outside the region have been commonplace throughout the 20th century; thus, the purity of naturally spawning stocks varies from river to river. Nearly 2 billion hatchery reared Chinook salmon have been released into Puget Sound tributaries since the 1950s. The vast majority of these have been derived from local returning fall-run adults. Returns to hatcheries have accounted for 57 percent of the total spawning escapement, although the hatchery contribution to spawner escapement is probably much higher due to hatchery-derived strays on the spawning grounds. The electrophoretic similarity between Green River fall-run PS Chinook and several other fall-run stocks in Puget Sound suggests that there may have been a significant and lasting effect from some hatchery transplants (Marshall et al. 1995). Overall, the pervasive use of Green River stock throughout much of the extensive hatchery network in the geographic range of this ESU, may reduce the genetic diversity and fitness of naturally spawning populations.

Other concerns noted by the Biological Review Team (BRT) are the concentration of the majority of natural production in just two basins, high levels of hatchery production in many areas of the PS Chinook ESU, and widespread loss of estuary and lower floodplain habitat diversity along with associated life history types. Populations in the PS Chinook ESU have not experienced the sharp increases in the late 1990s seen in many other ESUs, though more populations have increased than decreased since the last BRT assessment. After adjusting for changes in harvest rates, however, trends in productivity are less favorable. Most populations are relatively small, and recent abundance within the PS Chinook ESU is only a small fraction of estimated historic run size.

Status of Puget Sound Chinook Salmon in the Action Area. The Cedar River PS Chinook historically moved through the Cedar-Black-Green-Duwamish rivers sequence for hundreds of generations and thus were adapted to those circumstances. However, separating the Lake Washington drainage basin from the rest of the Green/Duwamish River basin in the early 20th century changed the migration pathway and rearing locations of Cedar River PS Chinook. Prior to the rearrangement of the system, Cedar River PS Chinook migrated from the Cedar River into the Black River, then into the Green/Duwamish River, and then into Elliott Bay (reverse sequence for returning adults). With the rearrangement, Cedar River PS Chinook juveniles were forced to move into Lake Washington where they spend time rearing, then emigrate through the LWSC, the lock complex, and then into Puget Sound (reverse order for returning adults). The Cedar River PS Chinook were forced into the new system almost instantaneously (one year to the next). In addition, most Chinook salmon populations throughout their coast-wide distribution do not move through large lakes between freshwater spawning grounds and saltwater rearing habitat. It seems clear that as a consequence of the reorientation of the migratory pathway, and the existence of a large lake in this new migratory pathway, the Cedar River PS Chinook population was depressed and remained at low levels for many generations.

Another consequence of the drainage system revision on Cedar River PS Chinook survival is the lack of a brackish water transition zone. Both juvenile and adult individuals are forced to move abruptly from one salinity regime to another. The normal state of affairs would be for migrants (juveniles or adults) to spend time in the brackish water interface between salinity regimes (acclimation period) prior to moving from one salinity regime into another. This abrupt change in salinity may contribute to an increase in mortality.

The Lake Washington PS Chinook population has declined since peak returns during the mid-1980s (Weitkamp and Ruggerone 2000). Adult returns have declined more than eight percent per year for each run, with the PS Chinook Cedar River run declining at 10.1 percent per year, the Issaquah Creek run at 8 percent per year, and the North Lake Washington run at 16.6 percent per year. Of the 22 populations of PS Chinook in Puget Sound, the Lake Washington populations were among the five populations showing the steepest declines (greater than five percent per year) (Myers et al. 1998). Spawning escapements of natural Lake Washington PS Chinook were exceptionally low during the years 1996 through 1998 and have continued through 2003. The two tables below summarize escapement data for the north Lake Washington and the Cedar River PS Chinook populations. The Cedar River PS Chinook average escapement was similar pre and post listing. In contrast, the North Lake PS Chinook has shown an increase in escapement abundance after listing. This increase is probably due to an increase in the number of hatchery released PS Chinook juveniles that returned and spawned naturally.

Table 2. Escapement of naturally spawning PS Chinook salmon into the Lake Washington basin.

Puget Sound Chinook before ESA listing

Year	North Lake	Cedar River
1994	436	452
1995	249	681
1996	25	303
1997	67	227
1998	265	432
Total	1,042	2,095
Average	208.4	419

Puget Sound Chinook after ESA listing

Year	North Lake	Cedar River
1999	264	241
2000	264	120
2001	459	810
2002	268	369
2003	212	562
Total	1,466	2,102
Average	293.27	420.4

Two populations of the PS Chinook ESU are present in the Lake Washington Basin, the north Lake Washington spawning population including Issaquah Creek (classified as native/wild), and the Cedar River population (classified as native/wild) (S. Bishop, NMFS, pers. comm., 2004).

The Lake Washington Basin PS Chinook are fall-run stocks and adults first appear at the lock complex in mid-June. In general, peak returns occur in mid- to late-August and the adult run is completed by early October (S. Bishop, NMFS, pers. comm., 2004). Because the hatchery fish were not marked until 2000, it has not been possible to distinguish between stocks as the fish pass the lock complex. Known population sizes, however, show that most returning fish are of hatchery origin (S. Bishop, NMFS, pers. comm., 2004).

Recent tagging studies have shown that significant numbers of PS Chinook migrating upstream hold for an extended period in the area just above the intake to the saltwater drain in the area known as the cool-water refuge. After holding for various periods of time the adults move into the watershed to spawn (Fresh et al. 1999). A study funded by King County and the COE using acoustic tags to track 45 adult PS Chinook migrating upstream in and around the lock complex between July and October 2000 found:

- The average residence time of tagged fish within the hydrophone array immediately upstream of the lock complex was 19 days.

- The earlier a fish entered the system, the longer it remained prior to moving upstream. All tagged fish exited the system (the monitored area) between August 10 and October 2, with a mean departure date of September 4.

- Prominent holding (or residence) areas were:
  (1) Adjacent to the entrance to the saltwater drain intake,
  (2) The small lock, and,
  (3) The large lock.

The majority of PS Chinook that enter the LWSC return to the Issaquah Creek Hatchery, with smaller numbers returning to a facility at the University of Washington. There are also two populations of wild spawning PS Chinook in the system, the north Lake Washington population including Issaquah Creek, and Cedar River populations, recognized by the Technical Review Team (TRT) (Ruckelshaus et al. 2006). Studies on the number of hatchery-produced PS Chinook that stray and subsequently spawn naturally in either river began in 2000. Preliminary data indicate that a high percentage of naturally spawning PS Chinook are hatchery strays.

The PS Chinook populations that originally occupied the Cedar River have largely been extirpated (Ruckelshaus et al. 2006). The Cedar River and north Lake Washington population have been re-established from hatchery strays, and strays originating from other populations outside of the Lake Washington drainage basin. The residual amount of original genetic information carried into the current populations is most likely small.

The contribution of the two Lake Washington populations to the entire ESU is probably small. They are closely related to the Green River population, and with good reason since the hatchery stock is derived from Green River PS Chinook. Since the majority of the PS Chinook adults returning to the Lake Washington system are of hatchery origin and the wild spawners are closely related to the Green River population, these two populations probably contribute little to the overall diversity of the ESU. The annual variation in abundance of returning adults varies greatly (see Table 2, above). However, the overall trend appears to be flat.

Status of Puget Sound Steelhead

Life History. Steelhead are the anadromous version of freshwater rainbow trout. The typical life history involves spending two to three years in freshwater before migrating downstream into marine waters. Once the juveniles emigrate they move rapidly through Puget Sound into the North Pacific Ocean where they reside for several years before returning to spawn in their natal streams. Adults returning to spawn generally arrive in their natal rivers either in the summer or winters months and are referred to as summer or winter populations. Unlike many other members of the *Oncorhynchus* genus, all steelhead do not die after spawning and some undergo multiple spawning cycles (Wydoski and Whitney 2003).

Distribution and Abundance. Puget Sound Steelhead are found in all accessible large tributaries to Puget Sound and the eastern Strait of Juan de Fuca (WDFG 1932). Estimates of their historical abundance in Puget Sound are largely based on catch records. Analysis of the catch records from 1889 to 1920 indicates that the catch peaked at 163,796 individuals in 1895. Assuming a harvest rate of 30-50 percent, Little (1898) estimated that the peak run size ranged from 327,592 to 545,987 fish. By 1898, the run size was depressed by as much as fifty percent of what it was three years previously. Catches continued to decline from 1900 through the 1920s. In 1925, the Washington State Legislature classified steelhead as a game fish (no commercial catch allowed), but only above the mouth of any river or stream (WDFG 1928). Commercial harvest of steelhead in Puget Sound fell to levels generally below 10,000 fish. Total steelhead run size (catch and escapement) for Puget Sound in the early 1980s was calculated from estimates in Light (1987) to be approximately 100,000 winter-run and 20,000 summer-run fish. Light estimated that 70 percent of steelhead in ocean runs were of hatchery origin (combined Puget Sound and coast). The percentage of escapement to spawning grounds was substantially lower due to differential harvest and hatchery rack returns. In the 1990s the total run size for major stocks in this DPS was greater than 45,000, with total natural escapement of about 22,000. Busby et al. (1996) estimated 5-year average natural escapements for streams ranged from fewer than 100 to 7,200 fish, with corresponding total run sizes of 550-19,800 fish.

Nehlsen et al. (1991) identified nine Puget Sound steelhead stocks at some degree of risk or concern. WDF et al. (1993) identified 53 stocks within the DPS, of which 31 were considered to be of native origin and predominantly natural production. They assessed 11 of the 31 stocks to be healthy, 3 to be depressed, 1 critical, and 16 of unknown status. Their assessment of the remaining (not native/natural) stocks was 3 healthy, 11 depressed, and 8 of unknown status. Of the 21 populations in the Puget Sound DPS reviewed by Busby et al. (1996), 17 had declining and 4 increasing trends, with a range from 18 percent annual decline (Lake Washington winter-run steelhead) to 7 percent annual increase (Skykomish River winter-run steelhead).

Since 1992 there has been a general downtrend in steelhead populations in this DPS. Over this period, the number of populations considered to be "healthy" declined from 14 (26 percent of all populations in the DPS) to 5 (9 percent), and the number of populations of "depressed" status increased from 14 (26 percent) to 19 (35 percent). One population (1 percent) remained "critical," but the number of populations of unknown status increased from 24 (45 percent) to 27 (50 percent).

Marked declines in natural run size are evident in all areas of the DPS, a pattern that reflects widespread reduced productivity of natural steelhead. Even sharper declines are observed in southern Puget Sound (Green and Nisqually river winter-runs) and in Hood Canal (Skokomish winter-run). Throughout the ESU, natural steelhead production has shown at best a weak response to reduced harvest since the mid 1990s. Median population growth rates were estimated for several populations in the DPS, using the 4-year running sums method (Holmes 2001, Holmes and Fagan 2002; see also McClure et al. 2003). The estimated growth rate was less than 1, indicating declining population growth, for nearly all populations in the ESU. Exceptions were the Tolt summer-run population in northern Puget Sound and the Dewatto and Hamma Hamma winter-run populations in Hood Canal (Hard et al. 2007).

The PS steelhead DPS is composed primarily of winter-run populations (37 of the 53 populations). 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 concentrated in northern Puget Sound and Hood Canal; only the Elwha River and Canyon Creek support summer-run steelhead in the rest of the DPS. Steelhead are most abundant in northern Puget Sound, with winter-run steelhead in the Skagit and Snohomish rivers supporting the two largest populations (approximately 3,000 and 5,000 respectively). The geometric means of most populations have declined in the last five years; recent mean abundance for many populations is 50-80 percent of the corresponding long-term means.

Risk Factors. Widespread declines in abundance and productivity in most natural populations have been caused by multiple factors: steelhead habitat has been dramatically affected by a number of large dams in the Puget Sound Basin that eliminated accessibility to habitat or degraded habitat by changing river hydrology, temperature profiles, downstream gravel recruitment, and movement of large woody debris. In many of the lower reaches of rivers and their tributaries urban and agricultural development has resulted in the loss of historical land cover in exchange for large areas of impervious surface and open fields (buildings, roads, parking lots, farm crops, etc.). The loss of wetland and riparian habitat has the following impacts:

- The hydrology of many urban streams changed, with increases in flood frequency and peak flow. This has resulted in gravel scour, bank erosion, sediment deposition during storm events, and decreases in groundwater driven summer flows (Moscrip and Montgomery 1997, Booth et al. 2002, May et al. 2003).
- The development of land for agricultural purposes has resulted in reductions in river braiding, sinuosity, and side channels through the construction of dikes,

hardening of banks with riprap, and channelization of the river mainstems. Constriction of the rivers, especially during high flow events increases the likelihood of gravel scour and the dislocation of rearing juveniles. Much of the habitat has been lost, including overwintering habitat and side channel areas that existed before European immigration (Beechie et al. 2001, Collins and Montgomery 2002, Pess et al. 2002).

Previous harvest management practices likely contributed to the historical decline of Puget Sound steelhead, but elimination of direct harvest of wild steelhead in the mid 1990s has largely addressed this threat.

Predation by marine mammals (principally seals and sea lions) and birds may be of concern in some local areas experiencing dwindling steelhead run sizes.

Ocean and climate conditions can have profound impacts on the continued existence of steelhead populations during their ocean dwelling phase and as changing weather patterns affect their natal streams. As snow pack decreases, instream flow is expected to decline during summer and early fall (Battin et al 2007).

The extensive propagation of the Chambers Creek and Skamania Hatchery steelhead stocks has contributed to the observed decline in abundance of native PS steelhead populations (Hard et al. 2007). In contrast to other risks, the effects of artificial propagation can be cumulative. Hard et al. (2007) concluded that all hatchery summer- and winter-run steelhead populations in Puget Sound should be excluded from the ESU.

Status of Puget Sound Steelhead in the Action Area. There are two populations of PS steelhead in the Lake Washington basin. One is the Cedar River population (natural origin); the other is the introduced north Lake Washington population. The Lake Washington and Cedar River winter steelhead have undergone steep declines in abundance. This conclusion is tempered by the uncertainty regarding the degree of interaction between hatchery and natural stocks. The WDFW concludes that there is little overlap in spawning between natural and hatchery stocks of winter steelhead throughout the ESU. This is generally supported by available evidence, but for many basins it is based largely on models and assumptions regarding run timing rather than empirical data. There has been a loss of connectivity between the Duwamish (Green) and Snohomish rivers due to the near extirpation of steelhead in the Lake Washington basin. Studies on the Cedar River and the Lake Washington watersheds (Marshall et al. 2004) indicate that resident *O. mykiss* produce outmigrating smolts in the Lake Washington basin which likely leads to interbreeding between the two life history forms.

Of the 21 populations in the Puget Sound DPS reviewed by Busby et al. (1996), 17 had declining and 4 increasing trends, with Lake Washington winter-run steelhead experiencing a decline of 18 percent. Over recent decades the Cedar River population has shown significantly declining trends in natural escapement (based on catch and escapement data). Abundance trends over the most recent decade were strongly negative and alarmingly low for the Cedar River and Lake Washington populations. Median short-term population growth rate estimates (λ) (and 95 percent confidence intervals) for the Cedar River and Lake Washington populations are 0.808 (0.804-0.811) and 0.802 (0.800-0.803) respectively. Estimates were computed from 10 recent years of data (1995-2004). The sharp reduction in escapement of natural steelhead to the centrally located Lake Washington basin in recent years corresponds to the weakening trends in abundance for populations in neighboring Puget Sound systems (Hard et al. 2007).

There is proposed hatchery program for Lake Washington wild winter-run PS Steelhead that is based on the collection of naturally produced (unmarked) fish returning to the lock complex where broodstock will be collected. No hatchery winter-run steelhead have been released into the Lake Washington system since 1993 (HSRG 2003) because broodstock collection criteria have not been met in recent years. Seventy five adults must return through the lock complex before broodstock can be collected for the program. There has been a substantial loss of returning steelhead adults through the lock complex as a result of California sea lion (*Zalophus californianus*) predation, but this has been largely addressed through harassment and deportation of individual offending animals.

Phelps et al. (1997) reported that Cedar River winter-run steelhead were distinct from Chambers Creek hatchery populations. Similarly, Marshall et al. (2004) found genetic differences between winter-run steelhead captured at the lock complex and Chambers Creek fish.

Status of Critical Habitat

NMFS reviews the status of designated CH affected by the proposed action by examining the condition and trends of primary constituent elements (PCEs) throughout the designated area. The PCEs consist of the physical and biological features identified as essential to the conservation of the listed species in the documents that designate CH (table 3). Presently, Critical Habitat is designated only for Puget Sound Chinook. Designation of Puget Sound Steelhead Critical Habitat is not yet complete.

Table 3. Types of sites and essential physical and biological features named as PCEs in the Lake Washington basin.

Site	Essential Physical and Biological Features	Species Life Stage
Freshwater spawning	Water quality, water quantity, and substrate	Spawning, incubation, and larval development
Freshwater rearing	Water quantity and floodplain connectivity	Juvenile growth and mobility
	Water quality and forage	Juvenile development
	Natural cover [a]	Juvenile mobility and survival
Freshwater migration	Free of artificial obstructions, water quality and quantity, and natural cover[b]	Juvenile and adult mobility and survival
Estuarine areas	Free of obstruction, water quality and quantity, and salinity	Juvenile and adult physiological transitions between salt and freshwater
	Natural cover,[a] forage,[b] and water quantity	Growth and maturation
Nearshore marine areas	Free of obstruction, water quality and quantity, natural cover,[a] and forage [b]	Growth and maturation, survival
Offshore marine areas	Water quality and forage [b]	Growth and maturation

[a] Natural cover includes shade, large wood, log jams, beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
[b] Forage includes aquatic invertebrate and fish species that support growth and maturation.

Four of the PCEs listed in Table 3 are affected by the continuing operation of the LWSC. These PCEs, numbered two through five are: freshwater rearing, freshwater migration, estuarine areas, and nearshore marine areas. Starting with the PCE 2 (freshwater rearing) that is used by the youngest individuals and then progressing downstream each PCE will be discussed in sequence.

Puget Sound Chinook juveniles spend several months rearing in Lake Washington prior to moving into Puget Sound. Few, if any, stocks of PS Chinook have a large lake in their migratory path between the spawning grounds and the marine environment. Prior to the construction of the lock complex that separates Salmon Bay from Shilshole Bay, Lake Washington flowed out through what is now its inlet which in turn flowed into the Cedar River which became the Black River (which no longer exists), which joined the Green River which in its lower reaches became the Duwamish River. To construct the lock complex and the LWSC, it was necessary to dig two channels (cuts): one through the Montlake area called the Montlake Cut, the other through the Fremont area called the Fremont Cut. This created a new waterway between Lake Washington and Puget Sound. In the process the Lake Washington water level was lowered about nine feet (about 3 meters). The Cedar River was diverted into Lake Washington via its old outlet. The outlet of the Lake Washington system became the LWSC and the lock complex. The lock complex became the controlling point for water level in Lake Washington. Before the river diversion the Cedar River was one of several rivers used by PS Chinook for spawning as part of the Duwamish River drainage basin. The Cedar River PS Chinook stock probably did not use Lake Washington for either rearing, or spawning in its many small tributaries. When the Cedar River was diverted into Lake Washington those PS Chinook juveniles that emerged from redds in the Cedar River were then forced to move through Lake Washington to reach Puget Sound. The Cedar River PS Chinook were not adapted to this new set of circumstances. Instead of a natural riverine system, the PS Chinook were forced to cope with slack water, managed shorelines, piers and floats, high and increasing water temperatures, and predators under circumstances of insufficient refuge from predation. Additional stress occurs when the juveniles leave the LWSC through the lock complex moving from fresh water to salt water almost instantaneously (from zero parts per thousand to 28 parts per thousand in minutes or less, with a temperature difference that can exceeds 10 degrees centigrade) without benefit of a brackish water transition zone for physiological adaptation. This set of circumstances is encountered in reverse order for returning adults.

Juvenile rearing (PCE 2) occurs in the Lake Washington portion of the system. Some juveniles reside for several months in the lake where they feed and grow. The juvenile PS Chinook appear to behave as though they are in the estuarine or nearshore areas of Puget Sound. The small juvenile PS Chinook probably rear in the nearshore areas of Lake Washington and expand their habitat preference out from the shore as they grow and age. Within Lake Washington, the shoreline and nearshore are important habitat. The shoreline is highly managed with little shallow water, wetland, and shallow, gently sloped, shoreline. Much of the shore is armored (vertical bulkheads and riprap) creating shoreline water depths of several feet. There is little native emergent vegetation, but large amounts of non-native milfoil. Both of these circumstances provide minimal habitat quality. The deep water along the shore results in greater opportunities for piscivorous fish to feed on juvenile PS Chinook than shallow water habitat would. The lack of native emergent vegetation results in fewer complex habitat types where refuge and feeding opportunities are located. Milfoil is a non-native plant that can be so dense the DO of the water within a patch can approach zero. The riparian zone along the shore is highly urbanized with almost no native riparian vegetation. The surface water temperatures of Lake Washington approach the high end of the tolerable temperature range for PS Chinook especially during late summer and early fall (Quinn et al. 2002). One positive attribute of PCE 2 in Lake Washington is the abundant food supply. Overall, this PCE is compromised.

Fresh water migration for both juveniles and adults (PCE 3) occurs in the freshwater portion of the LWSC. Almost the entire length of the LWSC shoreline is managed. There are small patches of native habitat, but they are rare and isolated from each other. Most of the shoreline is developed for commercial establishments and private homes. There are long stretches of the shore with vertical bulkheads along both the Fremont and Montlake cuts and much of Lake Union. Protruding into the LWSC are numerous facilities for vessel moorage, vessel building and repair, and boat houses including some with basements. There is an almost total lack of native riparian vegetation. Exceptions are found in a few isolated locations in Lake Union, Portage Bay and Union Bay. The LWSC is a highly developed waterway that was constructed without any thought of the consequences for the aquatic environment. The result is compromised water quality, especially temperature during late summer and early fall, contamination from various sources (contaminated stormwater, bilge water, vessel hull and antifouling paint, petroleum spills, etc.), and numerous obstructions to salmonid migration along the shore (piers with skirts, large vessels, etc.). There is no connection to floodplains and natural cover is limited. Predation by piscivorous fish is a major source of mortality in the LWSC and without adequate refuge the juvenile PS Chinook are subject to greater mortality than they would be in a natural riverine system. The forage in terms of food supply is probably adequate. In summary this PCE is highly compromised. Adults moving into the fresh water portion of the LWSC find themselves in water quality circumstances that approach lethal, primarily due to high water temperatures. These water temperatures have been increasing for at least three decades (Quinn et al. 2002). Tagging studies have shown that many of the adults hold in the area of the salt water drain (Eric Warner, MIT biologist, personal communication). This holding behavior near the salt water drain probably has to do with high surface water temperatures and lack of brackish water for a transition when moving from salt water to fresh water.

The lock complex presents a barrier to migration for both emigrating juveniles and immigrating adults. The barrier is both physical (the physical structures of the lock complex) and the abrupt change in salinity between the fresh and salt water portions of the LWSC. Overall this PCE is degraded.

Once juvenile PS Chinook move through the lock complex into the salt water portion of the LWSC they enter PCEs 4 and 5. Estuarine areas, (PCE 4) are characterized by substantial brackish water, which is almost totally lacking below the lock complex. There is a small shallow layer of fresh water atop a vastly larger salt water body. The small amount of fresh water compared to the amount of salt water results in almost no discernable brackish water estuarine habitat. Most of the shoreline is developed and, with the exception of the two COE-owned parcels, almost no native riparian vegetation is present. There is little to no natural cover. However, there is probably an adequate food supply primarily coming from the LWCS above the lock complex. The water quantity and quality are probably adequate, at least in terms toxicants. In contrast, the lack of brackish water means there is no transition area for juveniles moving from freshwater to salt water, or adults moving the other way. Overall, this PCE is highly degraded.

As the juveniles move into PCE 5, nearshore areas of Puget Sound, they find better circumstances, at least as compared with the three previous PCEs. Water quality and quantity in terms of salinity and lack of contaminants is good. Natural cover is lacking, but forage is most likely sufficient and not limiting. There are few obstructions to movement in the action area. However the nearshore areas in the action area are degraded from the stand point of the natural processes that support a dynamic nearshore ecosystem. Most of the shoreline is armored and the adjacent beaches are mostly exposed rock with very little soft substrate. Soft substrate provides habitat for many of the prey items preferred by juvenile PS Chinook. Overall, this PCE is only somewhat degraded and improvements are possible.

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 informal Section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). For projects that are ongoing actions, the effects of future actions over which the Federal agency has discretionary involvement or control will be analyzed as 'effects of the action.'

The Lake Washington Hydrology, Shoreline, and Riparian Zone

The Lake Washington Basin has been dramatically altered from its pre-settlement conditions primarily due to the creation of the LWSC and urban development. The result is possibly the most modified water body on the West Coast of North America. The Cedar River is now the major source of freshwater to Lake Washington, providing about 50 percent (663 cubic feet per second) of the mean annual flow entering the lake. The Cedar River drainage area is approximately 184 square miles (476 square kilometers), which represents about 30 percent of the watershed area of the Lake Washington Basin. The Sammamish River provides about 25 percent (307 cubic feet per second) of the mean freshwater flow into Lake Washington. The Sammamish River has a drainage area of about 240 square miles (622 square kilometers) and represents about 40 percent of the Lake Washington Basin. Tributaries to the Sammamish River include Swamp, North, Bear, and Little Bear creeks, as well as the surface waters of Lake Sammamish. The remainder of freshwater flow into Lake Washington originates from a variety of small creeks located primarily along the northern and eastern shores. Other smaller tributaries and subbasins in the Lake Washington system include Thornton Creek, McAleer, Forbes, Juanita, Kelsey, Coal, and May creeks, and Mercer Slough.

Within Lake Washington, the natural hydrologic cycle has been temporally shifted. Historically, lake elevations peaked in winter and declined in summer. Today, Lake Washington elevation peaks in spring and begins to decline in summer during the drawdown period, reaching its lowest level at the minimum elevation of 20 feet (6.1 meters) where it is maintained until late winter or spring when Lake Washington is allowed to refill to its highest level of 22 feet. Changes to the Lake Washington Basin have substantially altered the frequency and magnitude of flood events in Lake Washington and its tributary rivers and streams. In the past, Lake Washington=s surface elevation was nearly 9 feet (2.7 meters) higher than it is today and the seasonal fluctuations further increased that elevation by as much as 7 feet (2.1 meters) annually (Williams 2000). In 1903, the average lake elevation was recorded at approximately 32 feet (9.8 meters).

Development and urbanization have also decreased base flow in many of the tributary systems (Horner and May 1998). Increases in impervious and semi-impervious surfaces (e.g., lawns) reduce infiltration thus reduce groundwater discharge into streams and rivers. A substantial amount of surface water and groundwater also infiltrate into the

City of Seattle and King County wastewater treatment system and is eventually discharged to Puget Sound. The frequency and magnitude of flooding in tributary rivers and streams (with the exception of the dam-controlled Cedar River) have increased largely because of the extensive development that has occurred within the basin over the last several decades (Moscrip and Montgomery 1997). Simultaneously the water temperatures have been increasing for at least the past three decades. This is especially true for summer and early fall surface temperatures (Newell and Quinn 2005, Quinn et al. 2002, King County 2007, Goetz et al. 2006).

The shoreline riparian and littoral zones of Lake Washington have undergone considerable change since pre-settlement times. The lowering of Lake Washington exposed 1,334 acres (540 hectares) of what was shallow water habitat and is now upland, reducing the lake surface area by seven percent, and decreasing the shoreline by 10.5 miles (16.9 kilometers) (a 12.8 percent reduction) (Chrzastowski 1981). The most extensive changes occurred in the sloughs, delta areas, and shallows of the lake.

The area of freshwater marshes decreased from an estimated 1,136 acres (460 hectares), prior to construction of the lock complex, to 74 acres (30 hectares) by the early 1980s (Chrzastowski 1981). The mouths of tributaries entering the lake have moved some distance to the new lake shoreline, often across what had previously been a relatively shallow sloped alluvial delta (Warner and Fresh 1999). Historically, the mouths of the tributaries often presented fish passage problems due to depth and some of these areas (i.e., May Creek, Thornton Creek) continue to present fish passage problems today. New wetlands and riparian zones have developed in Union Bay, Portage Bay, Juanita Bay, and Mercer Slough since the LWSC was completed (Dillon et al. 2000).

Shoreline vegetation has changed dramatically from a dense undergrowth of small trees, brush, and Tule grass to landscaped residential properties with bulkheads where most natural vegetation has been removed. An estimated 81 percent of the shoreline east of the Montlake Cut has bulkheads and over 2,700 residential piers exist (Warner and Fresh 1999). Vegetation in the shallow-water habitat along the shoreline is dominated by Eurasian water-milfoil (*Myriophyllum spicatum*), a non-native invasive aquatic plant introduced into the lake in the 1970s. Milfoil has replaced the native aquatic vegetation and altered the substrate characteristics of much of the littoral zone of the lake (Patmont et al. 1981).

The LWSC and Lake Union Hydrology, Shoreline, and Riparian Zone

From the east end of the LWSC to Lake Union, there are only a limited number of short segments (most less than 100 feet (30.5 meters)) of open shoreline (City of Seattle 1999). Portage Bay and Lake Union have extensive amounts of over-water structure for both private and commercial uses while the LWSC has concrete bulkheads through the Montlake Cut and is heavily riprapped at the foot of the walls through the Fremont Cut. Areas west of the Fremont Cut have several commercial shipyards and large vessel moorage. Shorelines are heavily armored and bulkheaded (Weitkamp and Ruggerine 2000). Areas that have some amount of undeveloped shoreline include Gas Works Park, the area south of SR-520 (in Lake Union and Portage Bay), and a protected cove west of Navy Pier at the south end of Lake Union. Vegetation within these areas is limited, with the area south of SR-520 possessing the highest abundance of natural vegetation, consisting primarily of cattails (*Typha* spp.) and small trees (Weitkamp and Ruggerine 2000). Gas Works Park shoreline is primarily grass.

Downstream of the lock complex (from its western end at Shilshole Bay), the canal is a saltwater channel dredged to an authorized depth of 34 feet (10.3 meters) MLLW. The canal is about 300 feet (91 meters) wide and 5,500 feet (1,676 meters) long. There are numerous bulkheads and ship-holding areas along this section of the canal, and the intertidal habitat has been substantially reduced and degraded. The riparian zone has largely been developed and urbanized. Minimal natural vegetation remains.

Just upstream of the lock complex, the authorized depth of the canal is 30 feet (9.1 meters), with a variable width ranging from 100 to 200 feet (about 31 to 62 meters). The section of the canal closest to the lock complex is Salmon Bay. Before construction of the lock complex this area was tidally influenced and navigable only by shallow-draft vessels at high tide. Historically, Salmon Bay was a saltwater inlet (at least during high tide). At low tide, it was practically dry. The water level dropped nearly 20 feet (19.3 feet of 5.8 meters) between extreme high and low tides (Williams 2000). The lock complex raised and stabilized the water level and converted this section of the canal from an estuarine to freshwater/pseudo-estuarine environment and connected Salmon Bay to Lake Union via the lock complex and the Fremont Cut.

The mean water level elevation in Lake Union was not changed by construction of the LWSC, although the range of water levels has been reduced since the construction of the LWSC. Lake Union accommodates a large variety of commercial and industrial facilities along its shoreline, including ship repair and scrapping yards, marinas, and office buildings. Eighty percent or more of the shoreline has been developed and modified by bulkheads or other forms of bank stabilization. Little of the Lake Union shoreline and riparian zone retains natural vegetation (City of Seattle 2000). Eurasian water-milfoil is present in Lake Union. This species contributes a large amount of organic material to Lake Union, which can affect DO levels (Washington Department of Natural Resources (WDNR) 1999).

Lake Union has an arm extending eastward known as Portage Bay. Portage Bay is lined by University of Washington facilities, commercial facilities, and houseboats. The southeastern portion of Portage Bay has an area of freshwater marsh habitat. The remainder of the shoreline has been developed and several marinas are located in the bay. Aside from the aforementioned marsh, little natural vegetation remains in the riparian zone.

The Montlake Cut connects Portage Bay and Union Bay (which is part of Lake Washington). The Montlake Cut was dredged to an authorized depth of 30 feet (9.1 meters) and has a channel width of 100 feet (31 meters).

The LWSC extends eastward through Union Bay and terminates at Webster Point beyond which is the main body of Lake Washington. Prior to construction of the LWSC, Union Bay consisted of open water with the shoreline extending north to 45th Street. After construction, Union Bay water level was lowered along with the Lake Washington water level creating a marsh in the northern portion of the bay. Much of the marsh that was created after construction has since been filled, leaving only the fringe marsh on the southern end (Jones and Jones 1975). The southern limits of the marsh consist of remnant cattail marshes that still exist at the southern edge of this area today. Union Bay has several areas of freshwater marsh, milfoil, and associated fauna. The south side of the bay is bordered by the Arboretum and traversed by the Evergreen Point Bridge, creating a network of smaller embayments and canals with marsh habitats. The north side of Union Bay contains a marshy area previously filled with landfill material that is owned by the University of Washington. Numerous private residences with landscaped waterfronts and dock facilities dominate the remainder of the shoreline.

Water and Sediment Quality

The water and sediment quality in the Lake Washington Basin has been, and continues to be, degraded from a variety of point and non-point sources of pollutants. Historically, Lake Washington, Lake Union, and the LWSC were the receiving waters for municipal sewage. Out-falls were located at numerous locations along the shorelines that discharged limited or non treated sewage. Efforts in the 1960s and 1970s to clean up Lake Washington and other Seattle area waterways led to the expansion of wastewater treatment efforts and the elimination of most discharges of untreated effluent into Lake Washington.

Although raw sewage can no longer be discharged directly into Lake Washington, Lake Union, and the LWSC, untreated discharges occasionally still enter these waterways during periods of high precipitation through discharge from combined sewer overflows.

Historical discharges and past dumping practices continue to impact the Lake Washington system. In historical industrial areas such as Lake Union and southern Lake Washington, sediments have been contaminated by persistent toxins, such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and heavy metals (King County 1995).

In addition to point sources of pollutants, a variety of non-point sources contribute to the degradation of water and sediment quality. Non-point sources include stormwater and subsurface runoff containing pollutants from road runoff, failing septic systems, underground storage tanks containing fluids such as gasoline and diesel oil, gravel pits/quarries, landfills and solid waste management facilities, sites with improper hazardous waste storage, and commercial and residential sites treated with fertilizers and pesticides. As urbanization has expanded, sediment input into the Lake Washington system has also increased.

The ecology of Lake Washington has undergone substantial changes since the drainage system was modified in the early part of the 20th century. Many (at least 20) non-native fish and plant species have been introduced into Lake Washington and years of sewage discharge into the lake increased phosphorus concentration and subsequently led to eutrophication. Bluegreen algae dominated the phytoplankton community, and production of some species of zooplankton was suppressed. In the mid 1960s, water quality improved dramatically as sewage was diverted from Lake Washington to Puget Sound. Dominance by blue-green algae subsided and zooplankton populations rebounded. However, around this same time period (1970s), Eurasian water-milfoil was introduced into Lake Washington.

Milfoil can cause localized water quality problems when it grows in dense clumps and/or when it forms dense floating mats that can contain other plant material. Within the clumps, the DO can be reduced below five parts per million. In the lower layers of the mats the plants die and decompose, increasing biological oxygen demand reducing DO and pH. On occasion, conditions in the clumps and mats can become anoxic. Furthermore, substrates rapidly change from sand or gravel to mud because of the large amount of organic deposition and decomposition that occurs. Milfoil has established itself in much of the shallow shoreline habitat (less than 33 feet (10 meters) deep) of Lake Washington, Lake Sammamish, Lake Union, Portage Bay and the LWSC.

Operation of the large and small locks for vessels allows saltwater to intrude into Lake Union during the summer when seasonal freshwater flow decreases and boat use increases. This intrusion creates a seasonally fluctuating saltwater layer in Salmon Bay, the Fremont Cut, and Lake Union. This system is dramatically different from the typical saltwater/freshwater interface seen in most estuarine systems of the Pacific Northwest because there is no natural tidal mixing of these layers east of the lock complex that creates a typical brackish water estuary.

The sediments of Lake Union are very soft, deep, and contain a large amount of organic material from milfoil and other macrophytes. As microorganisms in the sediment break down this material, they consume much of the oxygen in the lower part of the lake. By the end of summer, concentrations of DO in the hypolimnion of Lake Union are near zero (WDNR 1999).

Today, the mile-long waterway between the lock complex and Shilshole Bay serves as the estuarine/marine area, as the result of the lock complex creating an abrupt transition between fresh and marine waters. From the lock complex to the upstream extent of salinity intrusion is considered the pseudo-estuarine area. Usually this pseudo-estuarine area extends to the east end of Lake Union but can extend as far as the University Bridge in a dry summer. Although it is possible for saltwater to reach the University Bridge, this phenomenon is considered a rare event and salinity never exceeds one ppt at the University Bridge. The estuary and pseudo-estuary are not formed by river action, but is primarily a human made construct. Consequently, this area lacks the diversity of habitats and brackish water refuges characteristic of other (unaltered) river estuaries.

Freshwater enters the saltwater below the lock complex primarily over the spillways, through the fish ladder, or in a series of pulses during lock operation. Additionally, brackish water is returned to the estuary below the lock complex from the saltwater drain or via the fish ladder. During summer months, the amount of freshwater flowing over the spillway is limited and a freshwater lens is not maintained below the lock complex. The extent to which saltwater travels up the LWSC and into Lake Union is primarily controlled by outflow at the lock complex and the frequency of large and small lock operations.

A surface lens comprised of water with relatively low salinity (less than 20 ppt in concentration) may occur in the area immediately downstream from the lock complex, however most of the water in the stilling basin has higher salinity. The low salinity lens at high volumes (250 to 400 cubic feet per second) may extend beyond the railroad bridge, depending on the level of discharge at the lock complex and tidal conditions. During periods of low freshwater flow, the salinity gradient becomes stronger and, as mentioned previously, little or no freshwater lens is formed.

A similar effect can be seen with regard to water temperature. Water temperature changes dramatically from above to below the lock complex. Summertime differences can be as high as 16° F (8.8° C). The thermal stratification of Lake Union results in surface temperatures regularly exceeding 68° F (20° C) for extended periods during the summer. The average temperature of Puget Sound (below the lock complex) is 52 to 57° F (11 to 14° C) during this period. Because of the minimal mixing of freshwater and saltwater through the lock complex the large temperature gradient is maintained.

An additional consideration is the increasing trend in water temperature, especially in summer and early fall. There are ups and downs in individual years, but overall the trend is a general increase in temperature (Goetz et al. 2006, Newell and Quinn 2005, Quinn et al. 2002, and King County 2007). If these circumstances continue, at some moment in time the water temperature, it is primarily the surface water temperature, will exceed the lethal threshold for returning adult PS Chinook.

Fish and Fish Predators in the Lake Washington Ship Canal

Adult and juvenile PS Chinook and PS steelhead migrating between the Lake Washington drainage and Puget Sound must pass through the LWSC and the lock complex. As noted above, this migratory route is considerably different than the migratory route that these populations were adapted to prior to the separation of the Lake Washington and Duwamish River drainage basins.

Observed and potential migratory pathways for juvenile PS Chinook and PS steelhead to pass through the lock complex are: (1) fish ladder, (2) spillway gates, (3) smolt passage flumes, (4) old saltwater drain, (5) saltwater drain through the fish ladder auxiliary water supply, (6) entrainment into the small lock culvert intakes, (7) volitional migration through the small lock miter gates, (8) entrainment into the small culverts (2 by 4 feet (0.6 by 1.2 meter) side portals) during down lockages in the small lock, (9) entrainment into the large lock culvert intakes into the upper large lock chamber, (10) entrainment into the large lock culvert intakes for the full lock chamber, (11) entrainment into the small (2 by 4 feet (0.6 by 1.2 meters)) culverts during down lockages (of the upper or full lock), and (12) volitional migration through the large lock miter gates (COE 2000b). Monitoring of fish passage has occurred for routes 1, 2, 3, 4, 5 (at intake), 9, and 10.

Although there are 12 possible routes, monitoring indicates that migrating juvenile salmon typically pass through the lock complex by one of three main routes: the spillway (smolt passage flumes, spillway gates), large lock miter gates, or the filling culverts. Smolt migratory behavior through the project is based on four years of monitoring smolt passage at the lock complex and information from other water control projects in the Pacific Northwest (COE 1999a, Williams 2000).

Predation of salmon is often greatest at bottleneck areas where fish aggregate. Within the LWSC juvenile PS Chinook and steelhead may be vulnerable to predation as they migrate from Lake Washington through the LWSC east of the lock complex. Areas of predation include: (1) as they pass through the primary outlets of the lock complex; (2) as they aggregate below the spillway and lock complex; and (3) as they pass through the estuary below the lock complex.

The primary freshwater predators of PS Chinook are non-native fish species, smallmouth bass (*Micropterus dolomieui*) and largemouth bass (*Micropterus salmoides*). Another fish predator, northern pikeminnow (*Ptychocheilus oregonensis*) appears to be an important predator but little data are available on their abundance. There are an estimated 3,400 smallmouth and 2,500 largemouth bass in the LWSC (Tabor et al. 2000). The smallest number of smallmouth is at the west end of the LWSC in Salmon Bay (approximately 3 percent of the population) while the highest number is at the east end at Portage Bay (approximately 60 percent of the population). Few if any freshwater fish predators have been captured within the immediate vicinity of the lock complex. Smallmouth bass consumed almost twice as many PS Chinook smolts per fish compared to largemouth bass (500 smolts versus 280 smolts, respectively) with PS Chinook making up 50 percent of identified smolts. Consumption of PS Chinook smolts occurred primarily from mid-May to the end of July, bracketing their documented migration period. Salmon smolts represented 50 to 70 percent of the diet of smallmouth bass during this time period (Tabor et al. 2000). Northern pikeminnow and cutthroat trout (*O. clarki clarki*) are the principle fish predators of PS steelhead, with bass contributing to some predation. The incidence of freshwater predation by fish in the LWSC may be increasing due to increasing water temperatures. There has been a long-term trend of increasing water temperatures in the LWSC which may result in increased energy demands and higher predation rates from native and non-native predators on later migrating PS Chinook smolts (Schindler 2000).

The primary known avian and mammalian predators on juvenile PS Chinook are glaucous-winged gulls (*Larus glaucescens* and others), harbor seals (*Phoca vitulina*), and California sea lions (*Zalophus californianus*) (most of these predators also prey on PS steelhead). Gull predation in the lock chamber has virtually been eliminated since implementation of the slow fill procedures in 1999. Prior to 1999, up to one of every eight smolts entrained in the large lock conduits were eaten by gulls (WDFW 1996). In 2000, anecdotal information has indicated there were only isolated periods when gulls may be preying on sockeye salmon smolts passing through the smolt flumes. One or two noted periods of predation included extreme low tides during the highest smolt passage day(s).

In 2000, the MIT conducted pilot predation studies of juvenile PS Chinook below the lock complex (Footen 2000). The most abundant predators were sea-run cutthroat trout (*Salmo clarki clarki*) and staghorn sculpin (*Leptocottus armatus*) and farther away the key predators were staghorn sculpin and resident PS Chinook (blackmouth). Another important predator is bull trout.

Puget Sound Chinook made up 12 percent of the cutthroat trout diet, 34 percent were other species smolts, mostly chum. Bull trout diet consisted of 27 percent PS Chinook and 12 percent other salmonids. Fifty percent of the sculpin diet was PS Chinook, but this estimate was influenced by one sample.

In related monitoring of Passive Integrated Transponder (PIT) tagged PS Chinook, a large fraction of the tagged fish were caught in saltwater within a few days of detection in the smolt flumes, suggesting a rapid osmotic transition. The PIT tag data suggest that the captured PS Chinook emigrants spent relatively little time in the lower salinity lens below the lock complex before making the transition to higher salinity water. Puget Sound steelhead smolts probably undergo a similar migratory behavior below the lock complex. Those smolts not ready to transition to more saline water may swim back upstream through the large and/or small locks and be detected multiple times (R2 Resource Consultants 2001). What remains unknown is whether PS Chinook and PS steelhead that are ready to make the transition are susceptible to avian or other forms of predation during that short period while they are confined to the small freshwater area below the lock complex, or how necessary the freshwater lens is to less developed smolts for additional time and space to complete smoltification.

The abundance of harbor seals and California sea lions in Puget Sound has increased significantly in recent decades. Between 1985 and 1995, significant numbers of adult steelhead were consumed by sea lions. In 1996, NMFS authorized removal of several nuisance sea lions and subsequent sea lion predation rates declined to two percent of the adult steelhead run. Concurrent with removal of the animals, NMFS has been running an acoustic deterrent device (also known as an acoustic harassment device) in areas near the lock complex. The acoustic deterrent device acts as a behavioral barrier to sea lions, emitting sounds in the range of 10 to 15 kHz, a frequency range that appears to exclude most animals from the area below the lock complex (NMFS 1996). Sea lions have not been observed preying on juvenile salmonids near the lock complex since 1999. The acoustic deterrent device has been tested on PS Chinook as they migrate through the fish ladder. No difference in behavior of PS Chinook, with or without the acoustic deterrent devise operating, was observed (Brent Norberg, NMFS, pers. comm. 2005).

Harbor seals are present in Puget Sound year-round and are more abundant than sea lions. They commonly prey on salmon, but predation by harbor seals at the lock complex has been observed infrequently. Although one or more adults can be seen on an irregular basis by the fish ladder, the number of juvenile PS Chinook or PS steelhead taken by harbor seals is believed to be a small percentage of the run (COE 2001).

Effects of the Action

Effects of the action means 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). Effects of the action that reduce the ability of a listed species to meet its biological requirements may increase the likelihood that the proposed action will result in jeopardy to that listed species or in destruction or adverse modification of a designated critical habitat.

Effects on Listed Species

NMFS has analyzed the effects of the following activities associated with the O&M of the LWSC and have determined that they have insignificant or discountable effects and are not likely to result in take of PS Chinook or PS steelhead. Therefore, the activities will not be further analyzed in this Opinion. See the Description of the Proposed Action section for a complete description of these projects:

1) Dolphin replacement
2) Annual maintenance of the large and small locks
3) Special operations
4) Pier maintenance
5) Facilities maintenance
6) Gallery drains
7) Channel tidelands
8) Guide pier

NMFS expects the effects of these projects to be discountable because: 1) the activities will be conducted when the lock chambers have been emptied of water (effects of dewatering are described below) or on uplands which will not impact the aquatic resources or listed species; 2) activities conducted above or on the water will have no effect to PS Chinook or PS steelhead; and 3) other activities are inside buildings located upland.

Effects from Spills of toxic or hazardous material (spill response plan) and the Use of fire suppressants are not evaluated in this Opinion because these actions are not reasonably likely to occur. If these actions do occur they will be in response to an emergency that will require an After-the-Fact consultation in which the specific action can be evaluated. Similarly, any actions in the Lake Washington general investigation study will have an individual Section 7 consultation prior to implementation.

Wounding of Puget Sound Chinook and PS steelhead as they pass through the Locks

Operation and maintenance of the lock facility can lead to physical contact between fish and lock complex structures and vessels during normal cycling operations. Fish may experience abrasion and strikes injuring body tissues, as well as disorientation and other sublethal injury when exposed to rapid water velocity and pressure changes causing shearing and turbulence. Furthermore, normal lockage operations will expose fish to a high density of motor-powered watercraft that may lead to injury or death from propeller strikes. The mere experience of transiting the lock complex can also lead to longer-term injuries that occur after fish leave the lock filling conduit outlets.

Wounding from abrasive impact would occur when fish contact physical structures such as concrete walls or barnacles covering the walls within the lock complex conduits during operations. Historically, abrasion suffered in the large lock may have been the primary injury suffered by juvenile salmonids passing through the lock complex conduits. These abrasive impacts can cause scale loss. The potential effects of scale loss for juvenile salmonids include complications in osmoregulation leading to dehydration, gut stasis (lack of movement of intestinal contents), and increased susceptibility to disease and predation (Schreck 1982). The actual level of mortality from descaling has not been determined and PS Chinook and PS steelhead are known to survive even after significant descaling injuries. Modifications of lock filling procedures and yearly barnacle removal since 1999 have resulted in significant reductions in descaling and other mechanical injuries.

In 2001, the COE studied juvenile coho and PS Chinook injuries from passage through a narrow high velocity jet (80 feet per second) into contact with surfaces of varying roughness. Death and injury from descaling increased with increasing roughness (COE 2001). The results of this study probably apply to PS steelhead. In the same study, the COE reported that barnacles removed from the conduits in 1999, resulted in a 75 percent reduction in the number of heavily injured smolts entrained within the conduits (COE 2001). Therefore, the COE will continue annual barnacle removal as a part of the proposed action to minimize abrasion related injury and death.

Short-term delayed injuries and modified fish behavior would result from rapid water velocity and changes in water pressures. Fish typically experience water turbulence after passing through the lock complex (i.e. through a spillway or lock conduit) in the outlet area. The extent of behavioral disruption is related to the extent of area affected by increased turbulence (a function of discharge as well as the energy dissipation characteristics of the spillway or conduit outlet). Since 1999, the COE has implemented a “slow fill” process for large lock cycling operations to minimize the rapid, extreme variation of water flow and the effects of such conditions on fish. At the time of this consultation neither the COE nor NMFS has data on short-term delayed injury of fish passage through the spillway gates or conduits of the large lock chamber. This type of injury is difficult to isolate from other types of injury (such as that occurring during passage through the conduits proper) making it difficult to study (R2 Resource

Consultants 1998). Despite the lack of clear data on injury, highly turbulent conditions might be minimized in stilling basins minimizing the effects of these water conditions on fish (COE 2001). Furthermore, conditions can be made more functional for fish passage by continuing implementation of slow fill procedures, as proposed. The current method of slow fill is meant to delay or slow the fill rate, reducing fish entrainment in the lock complex filling culverts and minimizing turbulence at the water surface in the lock chamber. The initial objective of eliminating turbulence was to eliminate gull predation of up-welled smolts, but the subsequent effect may have also resulted in reduced short-term delayed injuries.

The COE operates the lock complex to enable transit of watercraft in both directions between Puget Sound and Lake Washington. Thus, during each lock cycle, adult fish are exposed to propeller driven watercraft in a confined area. Adult sockeye salmon are injured or killed when struck by propellers (COE 2001). There have been no observations of adult PS Chinook injuries from propeller strikes although this is probably because the sockeye occur in the Lake Washington system in much greater numbers than PS Chinook, thus the probability of a strike to PS Chinook is much lower compared with strikes to sockeye. Because sockeye salmon injuries have been observed, and PS Chinook and PS steelhead are exposed to the same conditions, NMFS assumes these conditions kill or injure PS Chinook and PS steelhead, although probably in much lower numbers than have been observed for sockeye.

Finally, the mere passage of these fish through the lock complex exposes them to longer term, delayed injury, or death. Such injury or death is attributable to physical impacts and behavioral modification occurring from the conditions within the lock complex described above. For example, wounded fish are more susceptible to disease, disorientation of juvenile fish during emigration, and changes in behavior that may increase susceptibility to predation. However, just as the minimization measures described above (barnacle removal and slow fill) have been effective in minimizing the immediate effects of lock complex transit, so they are likely to minimize disorientation, and susceptibility to disease and predation (COE 2001).

Migration

The presence of the lock complex and its continuing O&M will cause the continued disruption of fish migration. The facilities create a physical barrier that alters stream flow and consequently fish passage, despite the presence of fish passage facilities.

The spillway gates at the lock complex do not appear to injure or kill PS Chinook or PS steelhead. The spillway crest has a smooth surface, without protrusions from the crest or tailrace that would result in mechanical injury or mortality (R2 Resource Consultants 1998). The gate opening has a low head (8.0 to 9.0 feet (2.4 to 2.7 meters)), and the average flow through the spillway gate opening is between 12 and 15 cubic feet per second, well below flows reported as causing injuries to fish. As a result, the spillway does not expose juvenile fish to injury or death by the means described above or inhibit migration.

However, when flow volume is insufficient to operate the spillway gates, PS Chinook and PS steelhead behavior can be impaired, forcing juvenile PS Chinook and PS steelhead to seek other routes through the lock complex, increasing their exposure to the injuries described above. Since 2000, smolt passage flumes that minimize the amount of water needed for safe passage have allowed for safe passage later into the migration season, including periods of low stream flow.

Prior to 1999, climate variability and continuing development within the Lake Washington basin may have reduced base-flows (Horner and May 1998) thereby resulting in less late spring and early summer inflow to the Lake Washington system (Houck 2000). When low flow conditions arise, the closing of all spillway gates is the first measure enacted to maintain mandated lake elevations. Juveniles are then forced to travel through one of the other routes, and such diversions can lead to injury. Under the proposed action, the COE will continue to operate the smolt passage flume to minimize the effects of the loss of passage through the spillway.

The following sections describe the effects of operating the smolt passage flumes, fish ladder, and saltwater drain.

Smolt Passage Flumes. In 2000, the COE installed the smolt passage flumes to provide a means of controlling discharge flows as well as allowing emigrating juvenile salmonids to avoid other, potentially harmful routes through the lock complex. As such, the operation of the smolt flumes results in a reduction of potential injuries to juvenile PS Chinook and PS steelhead. Because the COE must maintain specific lake levels, the amount of available water dictates the duration of smolt flume operation. If available water volume is not sufficient to operate the flumes through the emigration period, the emigrants may be forced to transit less fish-friendly routes and increased injury could result. The smolt passage flumes typically do not operate during summer months past June, especially in dry years, because of the low water volume in Lake Washington and the requirement to maintain the lake level at 20 feet (6.1 meters). This factor is particularly important for juvenile PS Chinook, whose emigration period extends through early July.

When the smolt passage flume operation ceases, PS Chinook and other late emigrating smolts are forced to travel through one of the following routes: (1) the fish ladder; (2) the saltwater drain; (3) lock-filling culverts; or (4) one of the two locks. These routes expose emigrant fish to the types of injuries discussed above. There are other routes, but these are the dominant ones used by emigrating smolts when the smolt flumes are taken out of operation. To minimize the need to shut down the smolt flumes, the COE intends to seek modification from Ecology to the amount of saltwater that is allowed to pass upstream of the University Bridge, approximately four miles upstream of the lock complex. This would provide more water for the smolt passage flumes since less water would need to be released from above the lock complex to keep the saltwater from intruding into the freshwater portion of the LWSC. This modification would enable smolt flumes to operate for a longer period of time into the summer, which would benefit emigrant PS Chinook and other salmonid smolts.

Fish Ladder. The fish ladder provides an upstream migration route for adult PS Chinook and PS steelhead returning to the Lake Washington basin. The COE modified the fish ladder in 1976. The rehabilitated fish ladder was designed to reduce migration delay and facilitate upstream migration, based on the best information available at that time (COE 2000a). Fish do not appear to receive physical injuries from passage through the fish ladder. However, the fish ladder entrance is narrow, creating a bottleneck for the fish moving upstream. There is some evidence that the large adult female PS Chinook use the lock chambers in greater frequency than their proportion in the population would indicate. One explanation for this is the large females may be deterred from using the fish ladder because of the small entrance (Eric Warner, MIT biologist, personal communication). This bottleneck can increase predation and delay migration. Additionally, a 16° F (8.9° C) temperature differential exists between the entrance and exit of the ladder. A similar situation exists for salinity where the change is from about 28 parts per thousand to near zero salinity in the LWSC. This differential, occurring in such a short distance, can stress fish, impairing normal migration behavior. Research indicates that as many as 30 percent of adult PS Chinook salmon that passed through the fish ladder move back downstream below the lock complex to return to the cooler, higher salinity water (Fresh et al. 1999). It is unlikely that returning to the marine side of the locks has an adverse effect on adult Chinook.

Saltwater Drain. Entrainment of smolts into the saltwater drain is not considered to be a serious concern because velocities are low (five to eight feet per second), and the pipes are straight and smooth (no barnacles, no sharp turns). Discharge into salt water is unlikely to result in any injuries or mortalities. Discharge via the diffuser well under the fish ladder may be a problem because there is no unobstructed outlet for emigrant smolts to pass directly into Puget Sound from the diffuser well. Emigrant smolts might pass from the well through the fiberglass grates (3 inch by 3 inch openings) at the base of five pools through which the salt water drain water upwells, or they may remain in the diffuser well. During annual dewatering of the fish ladder in late May, few smolts have been observed (COE 2001).

Direct observations and continuous monitoring indicate that few smolts go through the saltwater drain (BioSonics 2001). Although the saltwater drain cannot be eliminated as a pathway for emigrant smolts under current operating conditions, even during periods of little or no spill, the saltwater drain intake is less likely to be a major pathway for juvenile PS Chinook and PS steelhead than the large lock culvert intakes for the following reasons:

(1) The drain intake is at a greater depth (50 feet (15.2 meters) average versus 33 feet (10.0 meters) for lock culvert intake).

(2) Velocities into the intake (0.5 to 1.0 feet/second) are much lower than velocities typically encountered and selected by smolts passing through either the flumes or the culvert intakes (three to five feet/second).

(3) Poor water quality conditions (low DO) (less than 5.0 milligrams/liter) near the drain may exist for sustained periods. This analysis is supported by fish passage research and environmental conditions at the drain intake.

(4) Adult PS Chinook may enter the intake of the saltwater drain in the forebay of the lock complex. The intake was initially screened in the 1970s, but accumulation of debris required that the screen be removed. Salmonids entering the drain should be able to swim out of the 6 feet (1.8 meters) diameter pipe since velocities are not high (5.6 feet/second). Numbers of PS Chinook entering the intake and time spent in the drain pipe is currently under investigation by tracking movements of PS Chinook adults in the forebay.

A short-term modification of the salinity standard may allow increased use of the smolt passage flumes and thereby reduced use of the saltwater drain.

Migration Delay

Delayed migration leads to increased energy expenditure, stress, susceptibility to disease and predation, and altered spawning timing. If an adult PS Chinook or PS steelhead does not arrive on the spawning grounds when others of its species are present then it will not be able to spawn successfully. An important concern is the extent to which the lock complex delays upstream migration of PS Chinook from Shilshole Bay to the forebay of the lock complex.

Water discharge through the fish ladder may affect the time it takes fish to pass through the vicinity of the lock complex. Studies at dams indicate increased rates of fish passage through fish ladders and other fish passage structures when even a small amount of water is spilled to attract fish (Junge and Carnegie 1973). Proposed operations would continue the 200 cubic feet per second of water released from Spillway Gate 5 nearest to the fish ladder from January 1 through March 31 (to attract winter steelhead). Spill water may also be released (when sufficient water is available) near the fish ladder from May through October in an attempt to attract adult PS Chinook. However, low water availability prevents spill of additional attraction water after early June of most years. Since 1995, spill through Gate 5 has been replaced by flow through the smolt passage flume, which may also serve to attract adult PS Chinook to the fish ladder. Low water availability can result in migration delay for both adult and juvenile PS Chinook and PS steelhead, thus increasing the risk of mortality due to stress, energy expenditure, or disease susceptibility.

Water Quality

In general, PS Chinook and PS steelhead encounter an abrupt change in temperature and salinity as they pass from the warm (~59 to 70° F (15 to 21° C)), less saline waters (0 to 0.3 ppt) upstream of the lock complex to the cool (54 to 61° F (12 to 16° C)), saline (15 to 29.7 ppt) waters of Shilshole Bay (the actual conditions depend on the spill volume) and vice versa. In contrast, PS Chinook and PS steelhead in a natural estuary would be free to move up and down the channel selecting preferred temperature and salinity. While the frequency and magnitude of injury to emigrant salmonid smolts at the lock complex has been significantly reduced (as discussed previously), the rapid transition from the warm fresh-waters of the LWSC into cold, marine waters of Shilshole Bay (Puget Sound) will persist as long as the lock complex is present and operational.

Salinity. For most Puget Sound salmonid stocks, emigration is followed by an extended period of estuarine residence (not the case for PS steelhead). The estuarine environment provides intermediate and varied salinity regimes that aid in the physiological transition of salmon from freshwater to saltwater habitats. In the Lake Washington system, the estuarine environment has been dramatically altered by the creation of the LWSC, the lock complex, and the diversion of the Cedar River into Lake Washington. The presence of the lock complex creates a sharp salinity transition for adult and juvenile PS Chinook and PS steelhead migrating in both directions between Lake Washington and Puget Sound (COE 2001).

In a natural setting where a river (or stream) meets saltwater the two salinity regimes create a transition zone, or brackish water estuary. At the upstream end of the transition zone the salt water content is almost zero. At the downstream end of the transition zone the salt water content is almost full strength seawater. The transition zone is thus a region where salinity varies from almost zero to nearly 30 ppt (approximate Puget Sound water salinity). This zone can be critical to physiological adaptation for either juvenile or adult salmonids when they move between fresh- and salt-water environments (Healey 1991). Without the transition zone, salmonids may well find themselves subjected to increased stress as they attempt to undergo the physiological changes necessary to osmoregulate in different salinity regimes. In the freshwater environment the individual is required to actively remove freshwater from its body, while in the saltwater environment the individual is required to ingest saltwater and remove salt. Both of these activities require the expenditure of energy. Movement of salmonids from the LWSC directly into saltwater is stressful and probably results in delayed mortality that would not be seen in natural circumstances where they can adapt more gradually to changing salinity conditions (COE 2001).

Recently emerged fry have been shown to tolerate high salinity. However, most PS Chinook fry are not fully adapted to osmoregulate in saltwater, as evidenced by their elevated blood chloride levels (Wagner et al. 1969). Clarke et al. (1989) suggested that ocean-type PS Chinook fry may be able to exploit estuarine areas by seeking out lower salinity habitats rather than by physiological change to greater salinity tolerance. Larger and older PS Chinook fry and fingerlings have greater tolerance to saltwater transition than smaller and younger fish. Furthermore, faster growing fish of any length exhibit greater saltwater tolerance than slower growing fish, indicating the importance of growth rate. As such, juvenile PS Chinook will spend time in brackish water habitat to allow for physiological acclimatization when moving from freshwater to marine conditions. In contrast PS steelhead appear to move rapidly through Puget Sound into the north Pacific Ocean (Melnychuk et al. 2007, Welch et al. 2004). In addition, PS steelhead remain in freshwater for two or more years prior to emigrating (Wydoski and Whitney 2003), are consequently larger than most emigrant PS Chinook, and apparently need little time for acclimation to marine conditions.

Salinity tolerance increases rapidly once PS Chinook fingerlings reach a size greater than 2.2 inches (55 millimeters) and even direct transfer to seawater results in low mortality (Wagner et al. 1969). Based on physiological studies, ocean-type PS Chinook are usually fully smolted at a length of 2.6 to 2.8 inches (65 to 70 millimeters). At the lock complex, the point of physical separation between freshwater and saltwater, PS Chinook smolts have historically (1967), and more recently (1998), been caught at sizes much greater than those in other river systems. The mean size was 4.3 inches (110 millimeters) (range 3.2 to 5.4 inches, or 82 to 137 millimeters) in 1967 (COE 1999a) and 4.1 inches (105 millimeters) in 1998 (Warner and Fresh 1999). Fish of this size are thought to be fully capable of rapid transition to saltwater (Allen and Hassler 1986, Ewing, et al. 1980, Hoar 1976, Wagner et al. 1969). However, the specific effects of the transition from the freshwater above the lock complex to marine waters below the lock complex have not been studied.

Saltwater preference testing has suggested that the state of smoltification in PS Chinook juveniles determines their salinity preference. The likelihood that PS Chinook juveniles will voluntarily enter saltwater is directly related to their state of smoltification (Schreck and Stahl 2000). Those smolts not ready to transition to marine conditions may swim back upstream through the large or small lock as suggested by the data collected on individual fish that were detected twice in the smolt flumes (R2 Resource Consultants 2001). Migration delay may have a negative affect on PS Chinook smolts because freshwater temperatures increase through the emigration period, sometimes approaching the high end of their tolerance range. These conditions could ultimately cause mortality due to osmoregulatory stress.

Data gaps exist on whether PS Chinook and PS steelhead smolts that emigrate through the lock complex are susceptible to avian or other forms of predation during the time they are adjusting to the high salinity marine conditions. Additionally, studies have not been conducted to determine if emigrants remain in or near the freshwater lens just below the lock complex and how necessary the freshwater lens is to less developed PS Chinook smolts in providing additional time and space to complete the smoltification process. The COE is attempting to obtain funding to conduct studies to determine the susceptibility of PS Chinook smolts to osmoregulatory stress and predation because of rapid salinity change. If the COE obtains the proposed salinity waiver from Ecology, the salinity gradient should moderate near the lock complex and improve estuarine water conditions for PS Chinook smolts still undergoing smoltification.

Salinity in the fish ladder lower entry pool has been identified as a factor affecting attraction of adult salmonids to the ladder. Maintaining cues, such as freshwater, for homing PS Chinook and PS steelhead is an important function of the fish ladder.

Temperature. A temperature differential exists between the freshwater above, and the saltwater below the lock complex. The temperature gradient is strongest during late summer when the surface layers of the LWSC have reached their highest temperature and when water is not spilled over the spillway. The trend in water temperature has been on the rise for more than three decades. This increasing trend most likely complicates the movement of adults into freshwater and juveniles into salt water.

Elevated temperatures are probably not a limiting factor for emigrating juveniles. Studies indicate that surface layer temperatures above the lock complex were approximately 63.5° F (17.5° C) in June, increasing to 66° F (19° C) in July. By July, the majority of PS Chinook smolts have passed through the lock complex. However, any juvenile PS Chinook that have not emigrated by July will encounter detrimental conditions emigrating later in the summer. Additionally, temperatures above the lock complex at a depth of 46 feet (14 meters) were approximately 7° to 9° F (4° to 5° C) cooler than surface temperatures (Hansen et al. 1994).

The temperature differential above and below the lock complex is probably the most important variable for returning adult PS Chinook immigrating into Lake Washington. These fish encounter surface water temperatures above the lock complex of between 68 and 72° F (20° and 22° C) in August and September. Tracking studies indicate that adult PS Chinook may hold (stay) for up to 19 days in the cooler, more saline water located near the saltwater drain entrance just upstream of the large lock prior to continuing their upstream migration. The DO content of the water near the saltwater drain is relatively low (5.3 to 6.5 milligrams/liter) and may be stressful for adult PS Chinook. In contrast, adult PS steelhead immigrate into the Lake Washington system in winter when the temperature differential is not detrimental to them.

Peak immigration of adult PS Chinook occurs in mid-August and 80 percent of the return typically passes through the large lock between July 25 and September 12, corresponding to the period of highest Lake Washington surface water temperatures. As immigrant adult PS Chinook swim toward the lock complex from Shilshole Bay, they are found in less saline, warmer surface waters (to a depth of 7.5 feet (2.3 meters) or less) during the night and morning hours. During mid afternoon the PS Chinook adults below the lock complex move into deeper waters, where they encounter both cooler temperature and greater salinity (COE 1999a).

Tracking studies indicate that adult PS Chinook immigration through the LWSC did not occur until surface water temperatures fell below 72° F (22° C), leading Fresh et al. (1999) to hypothesize that the warm surface waters of the LWSC inhibited adult PS Chinook immigration. Other studies have indicated temperatures exceeding 70° F (21° C) can block the migration of PS Chinook (McCullough 1999). With the trend of increasing surface water temperatures, adults may, in the future, be delayed from moving upstream even longer than the current delay.

During the adult immigration time period the temperatures in the LWSC above the lock complex are near the PS Chinook thermal limit. For example, Coutant (1970) reported that after PS Chinook jacks (small young males) had acclimated to Columbia River temperatures of 66° F (19° C), if they were then subjected to temperatures near 72° F (22° C) they would begin dying after seven days. Acclimation to high temperature is important because an abrupt increase in temperature can lead to mortality at otherwise sublethal temperatures. Water temperatures believed to be suitable for migrating fall PS Chinook are 51 to 67° F (10.6 to 19.4° C) (Reiser and Bjornn 1979). During the record high temperatures in 1998, dead pre-spawned PS Chinook were observed in the LWSC and the Sammamish Slough (Fresh et al. 1999). The number of dead PS Chinook could not be determined due to the relatively deep, turbid waters.

The spawning migration is generally a stressful period and high temperatures can exacerbate stress levels, increase susceptibility to disease, and kill fish before spawning (Gilhousen 1990). In the Nechako River, British Columbia, where Chinook salmon experience 66° F (19° C) (mean) water on the spawning grounds, pre-spawning deaths were estimated at less than 6 percent (Jaremovic and Rowland 1988). In contrast, during 1998, Lake Washington PS Chinook returning to Bear Creek and the Sammamish Slough experienced relatively higher pre-spawning mortality (K. Fresh, NMFS biologist, personal communication, 1999).

Even so, Healey (1991) notes that Chinook salmon typically encounter warm water during spawning migrations and that high temperature has rarely been implicated in mortality during egg incubation. In contrast, other evidence suggests that warm water temperatures encountered by adults prior to spawning may reduce the viability of their eggs (McCullough 1999; Smith et al. 1983). Following the warm waters of 1998, the Issaquah Hatchery reported higher PS Chinook egg mortality (20 percent) than usual (Kurt Fresh personal communication, 1999). Preliminary analysis by Houck (2000) suggests warm water temperature during the PS Chinook spawning immigration may lead to reduced survival of their offspring. Temperature records collected in the Lake Washington drainage basin indicate water temperatures were exceptionally warm and increasing during the 1990s compared with earlier decades.

High, and increasing, water temperatures may negatively affect adult PS Chinook by delaying migration and may possibly decrease egg viability. The COE is considering alternative designs for the fish passage facilities to decrease the temperature gradient in the vicinity of the lock complex. This work is being conducted under the GI Study.

Dissolved Oxygen. Low DO concentrations occur in the seasonal saline layer at the bottom of Lake Union and the LWSC because of biochemical oxygen demand of the sediment. Saltwater intrusion upstream of the lock complex occurs during lock operations and eventually reaches Lake Union. Operation of the saltwater drain is regulated to ensure that the saltwater concentration does not exceed one ppt at the

University Bridge (downstream of the Montlake Cut) any time during the year as mandated by Ecology. An anoxic layer and thermocline are created in the water column of Lake Union as a result of salt water intrusion. These conditions typically break up in the fall with the return of high freshwater flows.

As noted above, adult PS Chinook that have transited the fish ladder and are holding in the forebay must choose between the cooler, less oxygenated water near the bottom or the warmer, more oxygenated mid-waters. Bottom waters upstream of the lock complex and in Lake Union become anoxic during summer but become oxygenated during fall with the return of high freshwater flows. Investigations of adult PS Chinook immigrating through estuaries indicate low DO can block upstream migration. Alabaster (1989) reported that Chinook salmon immigration (Willamette and San Joaquin Rivers) was blocked at DO concentrations of 3.5 milligrams/liter at 70° F (21° C) or 3.9 milligrams/liter at 72° F (22.4° C). A 75 percent migration failure rate was observed at a DO concentration of 4.7 milligrams/liter at 70° F (21° C). During an extensive review of salmon oxygen requirements, Davis (1975), cited in (Weitkamp and Ruggerone 2000) recommended DO concentrations of 7.25 milligrams/liter to protect all individuals of a population, and noted that at 5.25 milligrams/liter, the average individual in a population would begin to exhibit symptoms of stress. When immigrating through the LWSC, PS Chinook were found near water depths of 20 feet (6.1 meters) (Fresh et al. 1999). Based on estimates of 5.4 to 7.5 milligrams/liter DO at 18 feet (5.5 meters) and higher concentrations near the surface upstream of the saltwater drain, oxygen levels alone probably would not have inhibited adult PS Chinook migration. However, DO concentration at mid-depths may change from year to year, and the combined effect of moderately low DO concentrations at mid-depths and high water temperatures may contribute to the holding behavior exhibited by adult PS Chinook in the lock complex forebay. However, studies on the behavior of PS Chinook in other estuaries have indicated that some adult PS Chinook have a holding period prior to moving upstream. Such study results indicate that holding near the forebay may not be entirely related to water quality.

Dissolved Oxygen levels near the saltwater drain (less than 26 feet (7.9 meters) depth), where most PS Chinook hold, were generally below the 7.25 milligrams/liter needed to protect all individuals (Van Rijn 2001). Minimum DO levels near the holding area (approximately 5.5 milligrams/liter) were well above levels that would cause mortality. Most adult PS Chinook holding near the saltwater drain exhibited little movement during August 2000, possibly a response to the moderate DO levels near the cooler water.

Low DO levels at the bottom of Lake Union could negatively affect the organisms that inhabit benthic sediments. However, studies in Lake Union indicate that the benthic macroinvertebrate community is typical of those found in deep water lakes. These communities are characterized by hardy species, such as Chironomids (important prey of PS Chinook juveniles), oligochaete worms, and several clam species that tolerate low oxygen levels (Dillon 1993). Lake productivity does not appear to be a limiting factor for juvenile salmonids, including PS Chinook (COE 2001).

Export of Nutrients and Food

As previously discussed, the lock complex creates a physical barrier blocking the free exchange of marine/estuarine and fresh waters. The result is a decrease in the exchange of nutrients and food within the vicinity of the lock complex. Potential adverse effects include an overall reduction in the export of nutrients and food from above to below the lock complex. Studies indicate that *Daphnia* comprise 90 percent of the diet of juvenile PS Chinook sampled in the inner (eastern) portion of Shilshole Bay, while in those sampled in the outer portions of Shilshole Bay feed primarily on smaller fish, polychaete worms, amphipods, and other benthic/epibenthic crustaceans. Since the lock complex blocks the movement of nutrients and food into Shilshole Bay, a smaller average PS Chinook size or growth rate could result, which would make this population more susceptible to predation. Simenstad et al. (1999) found poor feeding success, or behavioral disruption of feeding, in juvenile PS Chinook immediately below the lock complex.

Lake Level Effects

Operation of the lock complex requires that the level of Lake Washington be maintained between approximately 20 and 22 feet (6.1 and 6.7 meters) elevation. Dillon et al. (2000) measured the water depths at the mouths of tributaries entering Lake Washington to determine whether access to spawning grounds may be inhibited during low-flow conditions. Juanita and Coal Creeks have access problems before the lake level drops to 20 feet (Weitkamp and Ruggerone 2000). In contrast, the channel depth of the Cedar River, Sammamish River, and May, McCleer, and Thornton creeks where they enter Lake Washington was greater than 1.5 feet (0.5 meters) when the lake level was at 20 feet (6.1 meters), indicating PS Chinook and PS steelhead would not have difficulty gaining access to these waterways.

Although completion of the lock complex and the LWSC in 1916 led to a significant lowering of the water level in Lake Washington and would have initially affected access of salmon to spawning streams, the continued operation of the lake level within the present restricted range probably enhances access during low water years. In pristine lakes, salmon can experience difficulty entering smaller tributaries during years of low lake level and stream flow (COE 2001). Since the COE does not allow the lake water level to go below 20 feet (6.1 meters), there are no extreme low water events from the perspective of immigrant adult PS Chinook and PS steelhead returning to Lake Washington tributaries.

Riparian and Bank Maintenance

Maintenance and landscaping occurs periodically along both shores of the LWSC. The Programmatic Agreement for stewardship of the LWSC National Historic District requires retention and preservation of the terrain and any significant landscape features. Vegetation and landscaping (e.g., the Lombardy poplar colonnade) are considered significant features and therefore need to be maintained to preserve the historical integrity of the LWSC National Historic District.

The riparian vegetation consists of a medley of native and non-native plants. Where possible, landscape maintenance will plant native shrubs and groundcover to reduce erosion potential along the shoreline. However, certain elements, such as the colonnade of Lombardy poplars along the Fremont Cut that are nearing the end of their life expectancy, will be replanted with the same or similar species of Poplar as needed, to maintain safety for navigation and pedestrians. The Fremont Cut Vegetation Rehabilitation Plan will guide COE restoration efforts for the next 40 years.

Similarly, Large Woody Debris (LWD) is removed from the LWSC when it poses a risk to navigation. The role of LWD in this highly modified environment has not been established and would differ from the function it provides in natural environments (refugia, pool formation, and prey habitat). Large woody debris would provide some benefits to the system (such as refugia). However, because of the armored shoreline and deep channelized nature of the LWSC, LWD typically moves through the system and accumulates at the lock complex. Therefore, the benefits to salmonids of LWD in this setting, is probably limited.

The LWSC is a highly modified channel with numerous concrete and wooden bulkheads, steeply inclined rubble shore, and revetments. In the Fremont Cut, the bulkheads are heavily riprapped. The concrete and wooden bulkheads, steeply inclined shore, revetments and riprap are repaired or replaced as needed. Measures that stabilize river banks typically adversely affect the natural form and function of the river, thus affecting fish and their associated habitats. In general, bank stabilization tends to physically stabilize river banks or divert flow from one bank to another. This change increases river flow velocities, exacerbating downstream bank erosion, leading to river bed degradation and lowering of river stages. However, in a highly developed and modified channel like the LWSC, riprapped banks can result in increased biological interactions. Interstitial spaces in riprap can affect emigrant PS Chinook because predators can find cover between the rocks. Increased interstitial space size increases non-salmonids use (e.g. squawfish (*Ptychocheilus oregonensis*) and sculpins (*Cottus asper*)), causing increased competition and predation on juvenile PS Chinook.

Fish Handling during Lock Maintenance

The COE annually dewaters the large and small lock chambers, and the fish ladder for maintenance. To avoid and minimize the stranding of fish leading to their injury or death, the COE proposes to capture and handle listed fish during the dewatering events. While fish handling is almost always incorporated into proposed actions for the purpose of minimizing the effects of other proposed activities, fish handling can cause adverse effects, some leading to injury or death. Mortality may be immediate or delayed. Under the techniques used during this action, injury and death from handling stress is expected to be rare.

During the dewatering events, fish will be captured using seines and dip nets. All fish will be removed and placed on the saltwater side of the lock complex. All fish will be transported in large buckets (minimum 5 gallon) filled with stream water. The fish and water temperature will be monitored to ensure the health and condition of the fish until they are released. Given the low impact of these capture and relocation techniques, the likelihood of injury to PS Chinook is expected to be low.

Puget Sound Chinook and PS steelhead normal behavior will be temporarily disrupted during the capture and relocation activities. The trapping and movement of these fish will be conducted by qualified personnel and is not expected to result in injury or death in most cases. Handling of fish increases their stress levels and can cause a variety of injurious conditions, including reduced disease resistance, osmoregulatory problems, decreased reproductive capacity, and increased mortality (Kelsch and Shields 1996). NMFS anticipates that the handled fish will be released shortly after their capture, minimizing stress to PS Chinook and PS steelhead juveniles. Depending on the number of PS Chinook and PS steelhead that need to be relocated during the dewatering events, some deaths may occur during the handling and transfer process.

Interdependent and Interrelated Actions

Continued O&M of the LWSC allows continued commercial, industrial, and recreational usage in the action area. Water-dependent development is likely to continue because of the access provided by the LWSC. However, the scale of this development is primarily dependent on outside market forces and not on O&M of the LWSC. Many of the current commercial and industrial users along this waterway have experienced a sharp economic downward trend in the past several decades (e.g., fishing, timber export) reducing the number of large ships that utilize the locks. Recreational use, on the other hand, has probably increased. Although we cannot quantify the effects of commercial or recreational vessels on salmonids in the Lake Washington system, the effects are expected to be minor and unaffected by this consultation.

Sustained water-dependent development in the Lake Washington Basin will continue to affect salmonid populations. Most of the land areas surrounding the LWSC action area are fully developed. Fully developed does not mean that no further development will occur, it simply implies future development will most likely involve changes in how the existing infrastructure is used.

Synthesis of the Analysis

The LWSC is an artificial structure, maintained for human use and provides little functional aquatic habitat for PS Chinook and PS steelhead. Both juvenile and adult salmon and steelhead are adversely affected by the continued O&M of the LWSC. The effects of O&M include physical injury from abrasion and propeller contact, migration delay resulting from blockages of free movement of stream flow (and fish passage through the LWSC), stress caused by large gradients in water quality parameters (salinity, water temperature, DO), reduced availability of estuarine prey caused by low export of nutrients and food. Finally, some become trapped in the stilling well beneath the fish ladder, entering this area via attraction to the saltwater drain. As the COE acquires new information from the scientific committee work and LWGI study efforts, it will be able to improve O&M activities in terms of their effects on salmon and steelhead, leading to proportionally decreased incidence of injury and death in the future.

Effects on Fish. There are short-and long-term impacts associated with the existing O&M of the LWSC. The continued O&M of the LWSC is not expected to change any of these impacts. The exceptions to this are when the COE commissions studies to investigate fish injury and death. If study results show that injury and death can be reduced by taking a specific action, then the COE will apply those findings to its O&M as funding becomes available.

While the continued O&M has adverse effects on both PS Chinook and PS steelhead, it will not reduce the likelihood of survival and recovery of either. Major changes to the Lake Washington drainage occurred early in the twentieth century and Chinook and steelhead populations continued to thrive for decades afterwards. Recently, The COE has changed O&M to decrease the potential take. NMFS anticipates that COE will continue to modify their O&M to reduce take as new information becomes available. Specific practices that will reduce the effects on the Lake Washington populations of PS Chinook and PS steelhead include:

1. The installation of smolt slides to assist emigrant smolts in their passage from freshwater into saltwater, this has reduced mortality of juveniles compared with conditions prior to the advent of smolt slide.

2. The installation and operation of strobe lights at the entrance of the intake (fill) galleries causes the emigrant smolts to avoid the fill gallery entrances.

3. The diversion of saltwater from the saltwater drain into the fish ladder has increased the fraction of adults that use the fish ladder in contrast to using the lock chambers where they may be injured by physical contact with spinning vessel propellers.

4. Annual cleaning to remove barnacles and other items that roughen the walls of the lock complex passage ways reduces mortality or harm to emigrant smolts that pass through the culverts.

5. Implementation of in-water work windows for any in-water work conducted as part of O&M reduces the likelihood of affecting individual fish.

6. Slow fill of the lock chambers to reduce turbulence.

7. The number of PS Chinook and PS steelhead exposed to the effects of the action is low. Only two of 22 PS Chinook and two of 53 PS steelhead populations (north Lake Washington and the Cedar River populations) are directly affected by the proposed action. The abundance of the Lake

Washington populations is currently small compared to most other populations in the ESU and the watershed is one of the most degraded, by urban and suburban development, of any in the Puget Sound. The adverse effects of the project will not impact the distribution or preclude long-term survival and recovery of the PS Chinook or PS steelhead. The continued O&M of the LWSC will not appreciably reduce the breeding, feeding and reproduction of the PS Chinook or PS steelhead.

Effects on Puget Sound Chinook Critical Habitat. Puget Sound aquatic habitat has been dramatically altered in the past century. The Lake Washington watershed is a prominent example of such modification. The diversion of the Cedar River into Lake Washington and the creation of the Montlake and Fremont cuts resulted in the creation of a Lake Washington drainage basin separate from the Green/Duwamish drainage system. This drainage system was, and continues to be, artificially managed. The portion of the system from Lake Washington to Shilshole Bay (the LWSC) is more like a water flume than a natural river. The hydrology, water quality, shoreline, and riparian conditions of the LWSC have been degraded due to urban, industrial, commercial, and residential development. The LWSC lacks a brackish water estuary, is almost totally devoid of native riparian vegetation, and has little shallow water habitat. Available habitat is concentrated in a few locations resulting in insufficient refuge habitat throughout most of its length. In addition, the presence of the lock complex near the LWSC terminus with Puget Sound, presents challenges to emigrating and immigrating PS Chinook as well as other fish species.

The LWSC is armored with riprap and concrete throughout most of its freshwater length. It contains hundreds of docks and piers, as well as numerous boat houses, and many hundreds of moored vessels. The shoreline of a natural system would be populated with vegetation ranging from large trees to low scrubs with eroding banks. A great deal of the shoreline of the LWSC is populated with human made structures including homes, industrial facilities, boat repair facilities, boat manufacture facilities and many other (primarily water oriented) businesses, and some open park-like spaces. However, despite the lack of natural habitat, PS Chinook must travel through the LWSC during emigration and immigration from and to spawning areas. The lock complex is an artificial structure that was designed for use of vessels transiting between the LWSC and Puget Sound.

As a result of these large-scale historic modifications, the LWSC functions inefficiently as a migration corridor for PS Chinook. It contains the PCEs for freshwater migration and rearing, but they function poorly in that regard, again because of the highly modified nature of the corridor and system function. The proposed action will perpetuate some of the dysfunction in the system. However, effects are expected to be reduced as the results of the science committee and LWGI study work are used to address specific ecological deficiencies related specifically to the O&M, and generally to the larger systemic issues.

Thus, the continued O&M of the LWSC will not alter the existing conservation value of critical habitat for Puget Sound Chinook as it will not reduce the existing function of the PCEs of CH present in the action area. Specifically:

1. The available forage base (food supply) is not limiting and is in excess in PCE 2 and PCE 3. Thus, there is sufficient forage base for growth and survival.

2. COE changes to the operation and physical structure of the lock complex has reduced migration barriers. Examples include removal of dangerous roughness in filling culverts and reduced flow velocities. Thus reducing passage obstructions in PCE 3.

3. The COE improvements to riparian habitat on land owned by the COE in PCE 5. This includes establishing native vegetation in the riparian area and controlling damage to habitat from human intervention, thus improving natural cover in PCE 5.

Although improvements have reduced impacts to CH as demonstrated by reduced mortality to emigrant PS Chinook, further improvements are unlikely to be made without additional funding.

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). Cumulative effects that reduce the ability of a listed species to meet its biological requirements may increase the likelihood that the proposed action will result in jeopardy to that listed species or in destruction or adverse modification of a designated critical habitat.

Between 1990 and 2000, the population of King County increased by 15.2 percent[4], and 3.3 percent between 2000 and 2005. Thus, NMFS assumes that future private and state actions will continue within the action area, increasing as population density rises. As the human population in the action area continues to grow, demand for agricultural, commercial, water dependent development, or residential development is also likely to grow. The effects of new development caused by that demand are likely to reduce the conservation value of the habitat within the action area. However, NMFS is not aware of any specific future non-Federal activities within the action area that would cause greater effects to a listed species or a designated critical habitat than presently occur.

[4] U.S. Census Bureau, State and County Quickfacts, King County. Available at http://quickfacts.census.gov/qfd/

Conclusion

After reviewing the status of PS Chinook and PS steelhead, and PS Chinook CH, the environmental baseline for the action area, the effects of the proposed action, and cumulative effects, NMFS concludes that the proposed action is not likely to reduce the likelihood of survival and recovery of PS Chinook or PS steelhead. Therefore, the proposed action will not jeopardize the continued existence of PS Chinook or PS steelhead. In addition, NMFS determined that the proposed action will not reduce the conservation value of critical habitat designated for PS Chinook and therefore will not adversely modify or destroy PS Chinook critical habitat.

Conservation Recommendations

Section 7 (a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. The following recommendations are discretionary measures that NMFS believes are consistent with this obligation and therefore should be carried out by the COE:

1. NMFS recommends that the COE seek funding to continue to improve runoff forecasting abilities. Such improvements would assist the COE in real-time operation of the fish passage flumes.

2. NMFS recommends that the COE institute an adaptive management plan (plan) that incorporates lessons learned from current and future monitoring and fish behavior studies. The plan should be developed in coordination with NMFS and use current and future monitoring of PS Chinook behavior studies to improve habitat and passage conditions. The plan should include the following:

    a. An explanation of the sequence of how annual research, monitoring, and evaluation actions will be utilized to review changes in habitat, LWSC O&M, and PS Chinook and PS steelhead behavior in and around the lock complex and LWSC.

    b. Elements and goals needed for implementation, recovery, process and participation; assumptions and uncertainties about key habitat and species factors related to the goals; hypotheses about contributions of actions to goals; performance measures to assess effectiveness of the actions, including decision points; data collection, analysis and evaluation supporting measures to assess effectiveness.

    c. A systematic process for improving future management actions by learning from the outcomes of pilot or implemented actions.

    d. An evaluation of all monitoring and research data to determine future actions. These actions will be based on the best scientific information.

When uncertainty exists, the plan should provide the support to continue the research and monitor the results to reduce uncertainties.

e. Coordination with local resource agencies.

f. A decision-making structure defining roles and responsibilities, including commitments to implementing the plan and actions.

g. Preparation of annual progress reports to document implemented activities, and estimates of progress towards performance targets.

h. Preparation of a comprehensive programmatic evaluation of progress every three years. The programmatic evaluations reports would serve as checkpoints to provide a detailed evaluation of whether actions implemented are meeting the goals of the plan. These checkpoint reports would also serve as the annual progress reports.

i. NMFS should receive a copy of all progress and evaluation reports within 30 days of finalization.

3. NMFS recommends the COE improve migration of PS Chinook and PS steelhead through the LWSC by conducting the following:

   a. Describe and evaluate PS Chinook and PS steelhead use of aquatic habitats above and below the lock complex.

   b. Complete the design of a new entrance to the existing fish ladder.

   c. Construct a new fish ladder entrance and associated structures.

   d. Seek funding to conduct biological and physical studies, as needed, and develop models to:

      i. Study (model) the effects of building an entirely new fish ladder, a trap and haul system, or a by-pass facility to improve survival of PS Chinook and PS steelhead.

      ii. If the modeling studies show inconclusive results or increased mortality from any of the above systems, then no further action would be taken on those options that showed increased mortality or inconclusive results.

      iii. If more than one option is beneficial, then the one that shows the greatest increase in survival rate should be chosen for a pilot or feasibility study (in the case of a trap and haul effort, a pilot study to show the efficacy of such an operation would be initiated; in the case of a new fish ladder design or bypass system, a feasibility study of design and construction would be initiated).

iv. If feasibility studies for a new fish ladder or bypass design show that one or both are infeasible, then no further action would be required for the infeasible option(s).

v. If the pilot study for a trap and haul operation shows inconclusive or decreased survival, then no further action is required.

vi. If the pilot study for a trap and haul operation of adult PS Chinook shows that survival is improved, the COE should seek funding to study the feasibility (conceptual framework) of a trap and haul system to move PS Chinook from the western- to the eastern-end of the LWSC.

vii. If the results of the feasibility study are positive, then the COE should obtain funding to institute a trial trap and haul program of sufficient duration to test the concept.

viii. If the trial program shows increased survival of PS Chinook, the COE should institute the program on a permanent basis.

ix. The COE should partner with other local entities to research, monitor, evaluate and model the factors that result in significant delay (greater than two weeks) and/or pre-spawn mortality of adult PS Chinook within the action area.

4. NMFS recommends that the COE reduce the interaction of PS Chinook and PS steelhead with boats in the large lock chamber by partnering with one or more local entities (Tribal, State, County, City, University, or Federal agencies) to seek funding to study the interaction of PS Chinook and PS steelhead with vessels in the large lock.

    a) If the results of the study indicate that vessels cause significant physical injury, then the COE should either institute management practices, or seek funding to physically modify the large lock, to minimize the interaction of vessels and adult salmonids.

    b) If results of the study show inconclusive results, then no further action would be needed.

5. NMFS recommends the COE improve water management at the lock complex by evaluating drought conservation plans to ensure the priority of water saving actions that would result in minimizing mortality of PS Chinook passing through the lock complex by placing fish ladder and smolt passage flumes as a high priority for continued operation.

Please notify NMFS if the COE carries out any of these recommendations so that we will be kept informed of actions that minimize or avoid adverse effects and those that benefit listed species or their designated critical habitats.

Reinitiation of Consultation

Reinitiation of formal consultation is required and shall be requested by the Federal agency or by NMFS 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 incidental take statement is exceeded; (b) if new information reveals effects of the action that may affect listed species or designated critical habitat 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 on the listed species or designated critical habitat that was not considered in the biological opinion; or (d) if a new species is listed or critical habitat is designated that may be affected by the identified action (50 CFR 402.16).

To reinitiate consultation, contact the Washington State Habitat Office of NMFS and refer to the NMFS tracking number assigned to this consultation.

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(o)(2) exempts any taking that meets the terms and conditions of a written incidental take statement from the taking prohibition.

Presently, NMFS is preparing the ESA section 4(d) rulemaking prohibiting take of threatened Puget Sound steelhead, and that rulemaking should be completed in the near future. While take is not yet prohibited, the following section assesses the amount or extent of take of Puget Sound steelhead. Should the action agency retain discretion over the proposed action after NMFS completes the rulemaking prohibiting take, the exemption from the prohibition will become effective for Puget Sound steelhead, concurrent with the publication of the final rule prohibiting their take.

Amount or Extent of Anticipated Incidental Take

Puget Sound Chinook and PS steelhead transit the LWSC as both emigrant juveniles and immigrant adults each year. As such they are exposed and respond to the effects of the O&M of the LWSC. Effects of the action include wounding, capture, and harm where exposure to habitat modified by the proposed action disrupts normal behaviors resulting in injury or death. Therefore, incidental take of PS Chinook and PS Steelhead is reasonably certain to occur.

The amount of take in terms of the number of captured fish anticipated can be quantified, and is reported below. This statement exempts that amount of take from the prohibition against take in accord with the provisions of ESA section 7(o).

The proposed action also perpetuates the operational circumstances that wound and harm PS Chinook. The number of animals wounded or harmed is impossible to quantify. The impossibility stems from the fact that while all fish that transit the LWSC are exposed to mechanisms that wound fish, not all fish will be wounded. Similarly, while all fish that transit the LWSC are exposed to habitat modified by operations and maintenance, not all will respond to exposure to the extent they are killed, or even injured. Furthermore, the populations of PS Chinook that migrate through the LWSC are exposed to a drastically modified and degraded environmental baseline that is not the result of the proposed action, and the extent of exposure from the proposed action cannot be separately or discretely identified against the background of the environmental baseline. Finally, the number of PS Chinook discretely affected by the proposed action will fluctuate annually depending on the number of emigrant and immigrant individuals that move through the LWSC.

In addition to the factors mentioned above, NMFS's ability to quantify the amount take from either wounding or harm is impossible because actually finding dead or injured fish is difficult (rare for adults and impossible for juveniles) such that an accurate sample is difficult to obtain. Factors complicating the location of injured and dead fish include the likelihood that: 1) some percentage of affected fish will die well outside of the action area from injuries suffered in the action area, 2) the dead fish are likely to rapidly decompose, outside of the action area, and 3) scavengers will remove carcasses before the carcasses can be identified.

Because of the factors mentioned above, NMFS quantifies take as an extent of exposed fish, as follows:

1. Wounding. Adults and juveniles are wounded traversing the lock complex and LWSC. Juveniles are descaled when they pass through various passages associated with filling the lock chambers. The fraction of juveniles descaled (wounded) reaches as high as five percent depending on the speed at which the lock chambers are filled. Therefore NMFS anticipates up to five percent of the emigrated juveniles will be wounded. Adults can become trapped in the diffuser well under the fish ladder. The number trapped may be as high as 1.5 percent of

the total adult run. Some of the trapped adults are removed from the diffuser well and allowed to continue their migration while others will die. Therefore NMFS anticipates up to 1.5 percent of the adult run will be either wounded or killed. Because of current, ongoing, efforts at reducing descaling and keeping adults out of the diffuser well, NMFS exempts take for each incidence so long as the Terms and Conditions presented below are implemented.

2. Harm. Most, if not all of the PS Chinook than traverse the LWSC will be exposed to modified habitat. Specifically, temperatures near the high end of their tolerance range, no brackish water transition zone, and no shallow water shoreline or shallow water side channels for feeding and refuge from predation. All of the PS Chinook that originate in the Lake Washington basin are exposed to these conditions. These conditions likely result in a reduction in the probability of survival. NMFS anticipates that all members of this population will be subject to harm, that is, a small reduction in the survival rate. Because the COE has implemented measures to minimize the longstanding effects of the operation of the LWSC and the lock complex, NMFS exempts each instance of harm so long as the Terms and Conditions presented below are implemented.

3. Capture. To conduct the research studies considered during this consultation, COE will capture 300 adult PS Chinook (of which approximately 30 will be wild PS Chinook) annually for continued scientific studies of the behavior of adult PS Chinook that transit the LWSC for the duration of this Opinion.

The take exempted in this incidental take statement is extended only to actions under the jurisdiction of the COE and defined within the Opinion. The incidental take is exempted for a five-year period from the date the Opinion is signed. The COE should reinitiate consultation on the O&M of the LWSC with NMFS prior to the fifth year of this Opinion, so the take exemption does not lapse.

<u>Reasonable and Prudent Measures</u>

Reasonable and prudent measures are nondiscretionary measures to avoid or minimize take that must be carried out by cooperators for the exemption in section 7(o)(2) to apply. The COE has the continuing duty to regulate the activities covered in this incidental take statement where discretionary Federal involvement or control over the action has been retained or is authorized by law. The protective coverage of section 7(o)(2) will lapse if the COE fails to exercise its discretion to require adherence to terms and conditions of the incidental take statement, or to exercise that discretion as necessary to retain the oversight to ensure compliance with these terms and conditions. Similarly, if any applicant fails to act in accordance with the terms and conditions of the incidental take statement, protective coverage will lapse.

NMFS believes that full application of conservation measures included as part of the proposed action, together with use of the RPMs and Terms and Conditions described below, are necessary and appropriate to minimize the likelihood of incidental take of listed species due to continuance of the proposed action.

NMFS recognizes the COE will not be able to apply all of the RPMs at the same time. Some are by their nature contradictory or several may result in similar improvements to survival. In these instances the COE shall consult with NMFS to evaluate the situation(s) and implement an RPM or subset of RPMs that have the greatest probability of improving survival of listed fish. NMFS has coordinated with the COE in the development of the RPMs and Terms and Conditions.

The COE shall:

1. Minimize the incidental take associated with migration of PS Chinook through the LWSC.

2. Minimize the incidental take associated with entrainment of PS Chinook in the saltwater drain system.

3. Minimize the incidental take associated with riprap bulkhead habitat in the LWSC.

4. Minimize the incidental take associated with annual maintenance impacts to PS Chinook during dewatering of the fish ladder, and the large and small locks.

5. Ensure completion of a monitoring and reporting program to confirm that the Terms and Conditions in this Incidental Take Statement are effective in avoiding and minimizing incidental take from permitted activities.

<u>Terms and conditions</u>

To be exempt from the prohibitions of section 9 of the ESA, the COE and its cooperators, if any, must fully comply with conservation measures described as part of the proposed action and the following terms and conditions that implement the reasonable and prudent measures described above. Partial compliance with these terms and conditions may invalidate this take exemption, result in more take than anticipated, and lead NMFS to a different conclusion regarding whether the proposed action will result in jeopardy or the destruction or adverse modification of designated critical habitat.

1. To implement RPM number 1, the COE shall insure that:

    - The COE currently allows the maximum amount of salt water into the LWSC that does not exceed the limit imposed by Ecology at the University Bridge. If the Ecology standard is modified, the COE shall increase the amount of salt water in the LWSC to the maximum allowed, east of the lock complex, and simultaneously meet the modified saltwater standard at the University Bridge in late summer and early fall.

- The smolt passage flumes shall be installed and operational by mid-April each year.

- The smolt passage flumes are operated during the identified (from COE PIT-tag data) PS Chinook juvenile emigration period (generally from April 15 to July 31).

- The smolt flumes shall continue operating after July 31, due to the variable nature of smolt emigration timing, as long as water is available.

- The smolt flumes are inspected on a daily basis to identify and remove debris that may block the intakes or become lodged on the dewatering plates.

- Barnacles are removed each year (during large lock annual maintenance) from all the conduits, culvert intakes, and culvert outlets (portals) in the large lock chamber, both upper and lower to reduce injury of juvenile PS Chinook entrained into the large lock conduits.

- The strobe lights in the entrance to the large lock conduits are operating at an effective level during the juvenile PS Chinook emigration period, approximately April 15-July 31.

- The strobe lights effective level will be determined by COE biologists in coordination with NMFS and be maintained at the effective performance level which shall entail replacement of all non-functioning lights during large lock annual maintenance, the COE shall also evaluate whether the existing system is adequate for long-term operation or whether another system will provide greater reliability. Should the COE find that the strobe light system is ineffective, the COE shall seek funding to replace the system with a more reliable system.

- The large lock will be filled at the slowest feasible rate with the existing system of valves to reduce entrainment during the juvenile PS Chinook emigration period.

- Funding is sought to finish replacement of the Stony Gate Valves (design has been completed) in the large lock chamber.

- During the spring, summer and fall months, when the availability of freshwater is limited, the lock complex shall be operated in a manner to conserve as much water as possible for fish passage flume operation such that they can be operated as often and as late in the year as possible (past July 31).

- Determine the time, or times, of the day when emigrant PS Chinook juveniles will most likely use the fish passage flumes and only operate the smolt flumes during those times in a further effort to save water and extend their temporal operation.

- Evaluate the effectiveness of operating the flumes each time the large lock is filled to determine of this action will direct emigrating smolts away from the large lock filling culverts toward the flumes.

- The large lock is operated at night as much as possible (depending on staffing availability) during the adult PS Chinook immigration period to allow more cold saltwater to flow into the area where the adults hold adjacent to the east side of the lock complex.

2. To implement RPM number 2, the COE shall ensure that:

    - Fish are kept out of the system leading to the diffuser well, or a route that will allow fish to escape the diffuser well is constructed.

3. To implement RPM number 3, the COE shall ensure that:

    - Small rock (rat-rock) is placed in the interstices of large riprap (large boulders) as maintenance occurs on existing riprap that makes up the current bulkheads of the LWSC. This should be done in a way that minimizes refuge opportunities for predators and maximizes the amount of shallow water habitat for juvenile PS Chinook.

4. To implement RPM number 4, the COE shall ensure that:

    - Behavioral exclusion methods are utilized (e.g., seal bombs) in the large lock to evacuate as many fish as possible prior to operating pumps to dewater the lock.

    - All pumps used for dewatering will be screened to prevent impingement, entrapment, and/or injury to PS Chinook.

    - All capture, retention, and handling methods will be implemented at times that will avoid temperature stress of PS Chinook being caught and handled.

    - All captured live PS Chinook are released as soon as possible, and as close as possible to the point of capture.

    - Captured PS Chinook are anesthetized for a minimal amount of time. The number of PS Chinook anesthetized (if this technique is used) at one time should be no more than that which can be processed within several minutes.

- A healthy environment is created and maintained for any PS Chinook that are held, and holding time is minimized, water to water transfers, the use of shaded, dark containers, and supplemental oxygen will all be considered in designing fish handling operations.

- Large PS Chinook will be kept separately from any juvenile salmonids to prevent predation on juveniles.

- Workers hands are free of sunscreen and other lotions, and insect repellent prior to conducting activities that may involve the handling of PS Chinook.

5. To implement RPM number 5, the COE shall ensure that:

   - Annual progress reports will be submitted to NMFS describing the implementation and effectiveness of each RPM. Included in the report, in part, will be a comprehensive evaluation of PS Chinook passage at the LWSC and measures put in-place, and future changes, to minimize and reduce injury and mortality.

NOTICE: If a sick, injured or dead specimen of a threatened or endangered species is found in the project area, the finder must notify NMFS through the contact person identified in the transmittal letter for this Opinion, or through the NMFS Office of Law Enforcement at 1-800-853-1964, and follow any instructions. If the proposed action may worsen the fish's condition before NMFS can be contacted, the finder should attempt to move the fish to a suitable location near the capture site while keeping the fish in the water and reducing its stress as much as possible. Do not disturb the fish after it has been moved. If the fish is dead, or dies while being captured or moved, report the following information: (1) NMFS consultation number; (2) the date, time, and location of discovery; (3) a brief description of circumstances and any information that may show the cause of death; and (4) photographs of the fish and where it was found. NMFS also suggests that the finder coordinate with local biologists to recover any tags or other relevant research information. If the specimen is not needed by local biologists for tag recovery or by NMFS for analysis, the specimen should be returned to the water in which it was found, or otherwise discarded.

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 1998a), coastal pelagic species (PFMC 1998b), 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 46 species of Pacific Coast groundfish (PFMC 1998a), four coastal pelagic species (PFMC 1998b), and three Pacific Coast salmon (PFMC 1999). The entire list is shown in Table 1 (attached) of this document.

Based on information provided in the BA, and the analysis of effects presented in the ESA portion of this document, NMFS concludes that the proposed action will have the following adverse effects on EFH designated for Pacific Coast salmon: (1) the proposed action may result in detrimental short- and long-term impacts to a variety of habitat parameters, but most likely water quality; and (2) the operation of the lock complex can have a detrimental affect on water quality east of the lock complex.

EFH Conservation Recommendations

NMFS believes that the following conservation measures are necessary to avoid, mitigate, or offset the impact of the proposed action on EFH. These Conservation Recommendations are a non-identical set of the ESA Terms and Conditions. NMFS believes that the following conservation measures are necessary to avoid, mitigate, or offset the impact that the proposed action has on EFH.

1. To minimize the adverse effects to water quality, the COE should perform sufficiently frequent lockages to minimize the probability of the saline water layer becoming anaerobic.

2. The COE should monitor and model potential impacts of increased salinity in the LWSC.

3. The COE should coordinate with the Washington Department of Ecology to maximize saltwater intrusion, and therefore provide more cold, high DO, water into the LWSC east of the lock complex, and simultaneously meet the Ecology imposed saltwater standard at the University Bridge in August and September, without causing the highly saline layer to become anaerobic.

Statutory Response Requirement

Federal agencies are required to provide a detailed written response to NMFS's EFH conservation recommendations within 30 days of receipt of these recommendations [50 CFR 600.920(j) (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, in your statutory reply to the EFH portion of this consultation, we ask that you clearly identify the number of conservation recommendations accepted.

Supplemental Consultation

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

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.

This ESA consultation concludes that the proposed action will not jeopardize the affected listed species. Therefore, the COE can fund and carry out this action in accordance with its authority under the Rivers and Harbors Act of 1910. The intended user is the COE and a variety of interests including NMFS, the MIT, the State of Washington, King County, the City of Seattle, and the Port of Seattle. These consultations help fulfill multiple legal obligations of these agencies. The information is also useful and of interest to the general public as it describes the manner in which public trust resources are being managed and conserved.

Individual copies were provided to the above-listed entities. This consultation will be posted on NMFS's 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

<u>Information Product Category</u>

Natural Resource Plan.

<u>Standards</u>

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 NMFS's 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.

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Table 1. Species of fishes with designated EFH occurring in Puget Sound.

Groundfish Species	redstripe rockfish *S. proriger*	Dover sole *Microstomus pacificus*
spiny dogfish *Squalus acanthias*	rosethorn rockfish *S. helvomaculatus*	English sole *Parophrys vetulus*
big skate *Raja binoculata*	rosy rockfish *S. rosaceus*	flathead sole *Hippoglossoides elassodon*
California skate *Raja inornata*	rougheye rockfish *S. aleutianus*	petrale sole *Eopsetta jordani*
longnose skate *Raja rhina*	sharpchin rockfish *S. zacentrus*	rex sole *Glyptocephalus zachirus*
Ratfish *Hydrolagus colliei*	splitnose rockfish *S. diploproa*	rock sole *Lepidopsetta bilineata*
Pacific cod *Gadus macrocephalus*	striptail rockfish *S. saxicola*	sand sole *Psettichthys melanostictus*
Pacific whiting (hake) *Merluccius productus*	tiger rockfish *S. nigrocinctus*	starry flounder *Platichthys stellatus*
black rockfish *Sebastes melanops*	vermilion rockfish *S. miniatus*	arrowtooth flounder *Atheresthes stomias*
Bocaccio *S. paucispinis*	yelloweye rockfish *S. ruberrimus*	
brown rockfish *S. auriculatus*	yellowtail rockfish *S. flavidus*	Coastal Pelagic Species
canary rockfish *S. pinniger*	shortspine thornyhead *Sebastolobus alascanus*	anchovy *Engraulis mordax*
China rockfish *S. nebulosus*	cabezon *Scorpaenichthys marmoratus*	Pacific sardine *Sardinops sagax*
copper rockfish *S. caurinus*	lingcod *Ophiodon elongatus*	Pacific mackerel *Scomber japonicus*
darkblotch rockfish *S. crameri*	kelp greenling *Hexagrammos decagrammus*	market squid *Loligo opalescens*
greenstriped rockfish *S. elongates*	sablefish *Anoplopoma fimbria*	Pacific Salmon Species
Pacific ocean perch *S. alutus*	Pacific sanddab *Citharichthys sordidus*	chinook salmon *Oncorhynchus tshawytscha*
quillback rockfish *S. maliger*	butter sole *Isopsetta isolepis*	coho salmon *O. kisutch*
redbanded rockfish *S. babcocki*	curlfin sole *Pleuronichthys decurrens*	Puget Sound pink salmon *O. gorbuscha*