ENVIRONMENTAL ASSESSMENT ON PROTECTING WINTER-RUN WILD STEELHEAD FROM PREDATION BY CALIFORNIA SEA LIONS IN THE LAKE WASHINGTON SHIP CANAL, SEATTLE, WASHINGTON

National Marine Fisheries Service
Washington Department of Fish and Wildlife

January 1995

UNITED STATES DEPARTMENT OF COMMERCE
Office of the Under Secretary for
Oceans and Atmosphere
Washington, D.C. 20230

JAN 5 1995

To All Interested Government Agencies and Public Groups:

Pursuant to the National Environmental Policy Act, an environmental review has been performed on the following action:

TITLE: Environmental Assessment on Protecting Winter-Run Wild Steelhead from Predation by California Sea Lions in the Lake Washington Ship Canal, Seattle, Washington.

SUMMARY: The National Marine Fisheries Service in cooperation with the Washington State Department of Fish and Wildlife prepared a joint Environmental Assessment that examines the environmental consequences of a combination of actions including lethal removal as a last resort to protect the depressed Lake Washington winter-run of wild steelhead migrating through the Lake Washington Ship Canal and Ballard Locks from predation by California sea lions. The number of steelhead escaping to spawn has declined from about 2600 fish in the 1983 season to only 70 fish last season. Action to reduce or eliminate predation is necessary because California sea lions have consumed as much as 60 percent of the returning adult wild steelhead as they migrate through the Ballard Locks area and such exploitation rates can have a significant impact on the status or recovery of the Lake Washington winter-run steelhead.

The proposed action is to lethally remove individually identifiable sea lions as a last resort only after non-lethal deterrence in combination with captive holding are not sufficient to remove predatory sea lions from the Locks area. All practicable attempts would be made to capture and successfully place the predatory sea lions in captivity during the duration of the run prior to lethal taking. Lethal taking would be applied only to those few predatory sea lions that have been observed to prey on steelhead. Lethal removal is proposed as a last resort because non-lethal alternatives have been shown to have limited success in reducing predation.

RESPONSIBLE PERSONS:

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The environmental review process led us to conclude that this action will not have a significant effect on the human environment. Therefore, an environmental impact statement will not be prepared. A copy of the finding of no significant impact including the supporting environmental assessment is enclosed for your information. In addition, in accordance with Washington State Environmental Policy Act, the Washington State Department of Fish and Wildlife has made a final determination of non-significance pursuant to Chapter 232-19 of the Washington Administrative Code.

Sincerely,

Donna Wieting

Donna Wieting
Acting Director
Office of Ecology and
Conservation

Enclosure

State of Washington

DEPARTMENT OF FISH AND WILDLIFE

ADOPTION OF EXISTING ENVIRONMENTAL DOCUMENT

DESCRIPTION OF PROPOSAL: To consider the environmental consequences of actions to protect wild winter-run steelhead from predation by California sea lions. Additionally, consider other actions that may be taken in the short or long term to enhance the steelhead run, and other factors that may be affecting the status of wild steelhead.

PROPONENT: Washington Department of Fish and Wildlife, National Marine Fisheries Service

LOCATION OF CURRENT PROPOSAL: Lake Washington Ship Canal from Lake Washington to the seaward side of the Hiram M. Chittenden or "Ballard" Locks facility.

TITLE OF DOCUMENT BEING ADOPTED: Protecting winter-run wild steelhead from predation by California sea lions in the Lake Washington ship canal, Seattle, Washington.

AGENCY THAT PREPARED DOCUMENT BEING ADOPTED: National Marine Fisheries Service and Washington Department of Fish and Wildlife

DATE ADOPTED DOCUMENT WAS PREPARED: December 1994

DESCRIPTION OF DOCUMENT (OR PORTION) BEING ADOPTED: Assessment of the environmental consequences of actions to protect and enhance wild winter-run steelhead in the Lake Washington drainage.

IF THE DOCUMENT BEING ADOPTED HAS BEEN CHALLENGED (197-11-630), PLEASE DESCRIBE:

THE DOCUMENT IS AVAILABLE TO BE READ AT (PLACE/TIME): Washington Department of Fish and Wildlife, Habitat Program, 5th Floor Natural Resources Building, 1111 Washington St, SE, Olympia, WA 98504-3155. Monday - Friday 8am - 5pm.

We have identified and adopted this document as being appropriate for this proposal after independent review. The document meets our environmental review needs for the current proposal and will accompany the proposal to the decisionmaker.

Name of agency adopting the document: Washington Department of Fish and Wildlife

Responsible Official: Gordon Zillges **PHONE:** (206) 902-2528

Position/Title: Regulatory Services Division Manager

Address: 600 Capitol Way North, Olympia, WA 98501-1091

DATE: 1/6/95 **SIGNATURE:** Gordon Zillges

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ENVIRONMENTAL ASSESSMENT ON PROTECTING WINTER-RUN WILD STEELHEAD FROM PREDATION BY CALIFORNIA SEA LIONS IN THE LAKE WASHINGTON SHIP CANAL, SEATTLE, WASHINGTON

Prepared by: National Marine Fisheries Service
Washington Department of Fish and Wildlife

TABLE OF CONTENTS

I. INTRODUCTION 1

II. PURPOSE AND NEED 3
- II.A. Formation of the Task Force 7
- II.B. Task Force Recommendation 7

III. ALTERNATIVES INCLUDING THE PROPOSED ACTION 13
- III.A. No Action Alternative 13
- III.B. Lethal Removal 13
- III.C. Non-Lethal Removal Measures 13
- III.D. Modify the Locks Facility with Barriers or Escape Cover 13
- III.E. Implement Other Fish Passage/Management/Habitat Measures 14
- III.F. Remove the Locks Facility 14
- III.G. Lethal Removal in Combination with Other Measures (Proposed Action) 14

IV. AFFECTED ENVIRONMENT 15
- IV.A. Geographic Location 15
- IV.B. Locks Facility and Fishway 15
- IV.C. California Sea Lions 26
- IV.D. Winter-run Steelhead 37

V. ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION AND ALTERNATIVES 44
- V.A. No Action Alternative 44
- V.B. Lethal Removal 45
- V.C. Non-Lethal Removal 46
  - V.C.1. Deterrence 46
  - V.C.2. Aversive Conditioning 50
  - V.C.3. Acoustic Barrier 52
  - V.C.4. Capture and Removal 58
  - V.C.5. Translocation 62
  - V.C.6. Temporary Captive Holding 65
  - V.C.7. Permanent Captive Holding 72
  - V.C.8. Other Non-Lethal Sea Lion Measures 73
- V.D. Modify the Locks Facility with Barriers or Escape Cover . . 77
  - V.D.1. Physical Barrier 77
  - V.D.2. Escape Cover/Structural Additions 81
  - V.D.3. Electric Barriers 84
- V.E. Implement Other Fish Passage/Management/Habitat Measures . . 84
  - V.E.1. Fish Passage Enhancement 84
  - V.E.2. Fisheries Management 86
  - V.E.3. Habitat Improvement 87
- V.F. Remove the Locks Facility 87
- V.G. Lethal Removal in Combination with Other Measures (Proposed Action) 88

VI. CONSIDERATIONS UNDER SECTION 120(d) OF THE MARINE MAMMAL PROTECTION ACT. 92

VII. FINDING OF NO SIGNIFICANT IMPACT 97

VIII. COORDINATION AND CONSULTATION 100

IX. LIST OF PREPARERS 100

X. REFERENCES 100

APPENDIX A. RESIGHTS OF CALIFORNIA SEA LIONS TAGGED AND BRANDED DURING THE CAPTURE/TRANSLOCATION EFFORTS AT THE LOCKS.

I. INTRODUCTION

This Environmental Assessment (EA) was prepared by the National Marine Fisheries Service (NMFS) in accordance with the National Environmental Policy Act and by the Washington State Department of Fish and Wildlife (WDFW) in accordance with Washington State Environmental Policy Act. This EA considers the environmental consequences of actions to protect wild winter-run steelhead from predation by California sea lions. This EA also addresses other actions that may be taken in the short and long term to enhance the steelhead run, and other factors that may be affecting the status of the wild steelhead. Prior EAs on actions to address the sea lion/steelhead conflict and the status of the steelhead run were prepared by NMFS and WDFW in 1989, 1992 and March, 1994.

Activities conducted in past years were undertaken under the authority of Section 109 of the Marine Mammal Protection Act (MMPA). Section 109(h)(1)(C) of the MMPA (16 U.S.C. 1361 et seq.) authorizes the non-lethal removal of nuisance marine mammals by NMFS and WDFW, and this authority was used for the purpose of protecting the declining wild winter-run of Lake Washington steelhead. NMFS has determined that California sea lions in the Lake Washington Ship Canal are a "nuisance" because of the vulnerability of the fish to predation at this location and scientific information demonstrating that these sea lions are negatively affecting the wild steelhead through predation and obstruction to fish passage (NMFS and WDW 1989).

In 1994, Congress amended the MMPA and added a new section - Section 120 to the MMPA, which sets forth a process for consideration of intentional lethal taking of individually identifiable pinnipeds which are having a significant negative impact on salmonids that are either listed or approaching listing under the Endangered Species Act or migrate through the Ballard Locks in Seattle. The process is initiated by a State submitting an application for lethal removal, requires the establishment of a Task Force, and leaves the final decision on approval of lethal removal with the Secretary of Commerce (delegated to NMFS). The specifics of Section 120(a) are as follows:

> *(a) PINNIPED REMOVAL AUTHORITY. Notwithstanding any other provision of this title, the Secretary may permit the intentional lethal taking of pinnipeds in accordance with this section.*
>
> *(b) APPLICATION.*
>
> *(1) A State may apply to the Secretary to authorize the intentional lethal taking of individually identifiable pinnipeds which are having a significant negative impact on the decline or recovery of salmonid fishery stocks which*
>
> *(A) have been listed under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.);*

(B) the Secretary finds are approaching threatened species or endangered species status (as those terms are defined in that Act); or

(C) migrate through the Ballard Locks at Seattle, Washington.

(2) Any such application shall include a means of identifying the individual pinniped or pinnipeds, and shall include a detailed description of the problem interaction and expected benefits of the taking.

(c) ACTIONS IN RESPONSE TO APPLICATION.

(1) Within 15 days of receiving an application, the Secretary shall determine whether the application has produced sufficient evidence to warrant establishing a Pinniped-Fishery Interaction Task Force to address the situation described in the application. If the Secretary determines sufficient evidence has been provided, the Secretary shall establish a Pinniped-Fishery Interaction Task Force and publish a notice in the Federal Register requesting public comment on the application.

(2) The Pinniped-Fishery Interaction Task Force established under paragraph (1) shall consist of designated employees of the Department of Commerce, scientists who are knowledgeable about the pinniped interaction that the application addresses, representatives of affected conservation and fishing community organizations, treaty Indian tribes, the States, and such other organizations as the Secretary deems appropriate.

(3) Within 60 days after establishment, and after reviewing public comments in response to the Federal Register notice under paragraph (1), the Pinniped-Fishery Interaction Task Force shall

(A) recommend to the Secretary whether to approve or deny the proposed intentional lethal taking of the pinniped or pinnipeds, including along with the recommendation a description of the specific pinniped individual or individuals, the proposed location, time, and method of such taking, criteria for evaluating the success of the action, and the duration of the intentional lethal taking authority; and

(B) suggest nonlethal alternatives, if available and practicable, including a recommended course of action.

(4) Within 30 days after receipt of recommendations from the Pinniped-Fishery Interaction Task Force, the Secretary shall either approve or deny the application. If such application is approved, the Secretary shall immediately take steps to implement the intentional lethal taking, which shall be performed by Federal or State agencies, or qualified individuals under contract to such agencies.

(5) After implementation of an approved application, the Pinniped-Fishery Interaction Task Force shall evaluate the effectiveness of the permitted intentional lethal taking or alternative actions implemented. If implementation was ineffective in eliminating the problem interaction, the Task Force shall recommend additional actions. If the implementation was effective, the Task Force shall so advise the Secretary, and the Secretary shall disband the Task Force.

(d) CONSIDERATIONS. In considering whether an application should be approved or denied, the Pinniped-Fishery Interaction Task Force and the Secretary shall consider

(1) population trends, feeding habits, the location of the pinniped interaction, how and when the interaction occurs, and how many individual pinnipeds are involved;

(2) past efforts to non-lethally deter such pinnipeds, and whether the applicant has demonstrated that no feasible and prudent alternatives exist and that the applicant has taken all reasonable nonlethal steps without success;

(3) the extent to which such pinnipeds are causing undue injury or impact to, or imbalance with, other species in the ecosystem, including fish populations; and

(4) the extent to which such pinnipeds are exhibiting behavior that presents an ongoing threat to public safety.

(e) LIMITATION. The Secretary shall not approve the intentional lethal taking of any pinniped from a species or stock that is

(1) listed under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.);

(2) designated as depleted under the MMPA; or

(3) designated a strategic stock.

As described herein, the State of Washington did submit an application for consideration of lethal removal of California sea lions at the Ballard Locks. A Pinniped-Fishery Interaction Task Force was formed and recommended approval of lethal removal with conditions.

II. PURPOSE AND NEED

The purpose of this EA is to assess actions to protect the depressed and declining Lake Washington basin population of wild winter-run steelhead from predation by California sea lions. Extensive studies since 1985 have documented that predation by California sea lions is a principal factor affecting the spawning escapement of returning adult wild winter-run steelhead in the Lake Washington basin. Because of the small size of the total wild run, which historically averaged about 2,500 fish each year, sea lion predation, by itself, has been documented to have prevented achievement of the wild steelhead spawning escapement goal of 1,600 fish in the Lake Washington basin in five of six years between 1985 and 1990, when total wild run size was otherwise large enough to assure attainment of the escapement goal (see Table 1). Although other factors such as freshwater and ocean survival may be contributing to the overall status of the wild steelhead population, sea lion predation is a significant factor affecting the adult spawners that have

survived and returned to the Lake Washington Ship Canal. The wild winter-run steelhead spawning escapement in 1993/94 was only 70 fish and the 1994/95 run is predicted to be within the range of 60 to 371; therefore, unabated sea lion predation on the adult spawners in 1995 may have a significant impact on the status or recovery of this steelhead population. Further background and details on the sea lion/steelhead conflict and efforts to address the conflict, as well as efforts on wild steelhead run enhancement, are described in detail in three Environmental Assessments prepared by NMFS and WDW (1989, 1992 and 1994), and in Scordino and Pfeifer (1993), Fraker (1994), Gearin et al. (1986, 1988a, 1989), Jeffries et al. (1989), Pfeifer (1987, 1988, 1989, 1991a, 1991b, 1994a, 1994c, 1994d), Pfeifer et al. (1989), Norberg (1990), NMFS (1992) and GAO (1993).

Table 1. Lake Washington Wild Steelhead Escapement And Predation By California Sea Lions

Run Year	Run Size Estimate Preseason	Run Size Estimate Post-season	Steelhead Escapement	Escapement Goal	% Of Goal	Steelhead Consumed	% Of Post-season Estimated Run Consumed by Sea Lions
1982/83	----	----	2575	1600	161%	---	--
1983/84	----	2166	1250	1600	78%	---	--
1984/85	----	2527	474	1600	30%	(1500)	(59%)[1/]
1985/86	----	2261	1816	1600	114%	329	15%
1986/87	2965	2997	1172	1600	73%	1254	42%
1987/88	2635	2274	858	1600	54%	1178	52%
1988/89	1655	1973	686	1600	43%	1287	65%
1989/90	2093	1806	714	1600	45%	1065	59%
1990/91	2355	1520	621	1600	39%	899	59%
1991/92	1442	----	599	1600	37%	---	--
1992/93	1611	----	184	1600	12%	---	--
1993/94	1159	76	70	1600	4%	6	8%
1994/95	60 - 371			1600			

[1/] Predation not monitored; based on estimate.

Data source: WDFW Winter-run Steelhead Inventory Tables.

The sea lion/steelhead conflict first came to the attention of the public in 1980 when one or two sea lions were observed preying on steelhead on a periodic basis at the entrance to the fish ladder at the Hiram M. Chittenden Locks facility (also known as the Ballard Locks). Prior to 1980, sea lion presence at the Locks was infrequent or rare with the first known incident of predation occurring in 1970. The occurrence of California sea lions preying on steelhead at the Locks was not viewed as a resource issue until 1985, when serious declines in the wild winter-run steelhead were noted. Subsequent studies documented that the sea lions were removing significant numbers of adult fish that were returning to spawn. A chronology of sea lion observations at the Locks since 1970 and measures undertaken to enhance the wild steelhead run are described in Scordino and Pfeifer (1993).

This sea lion/steelhead conflict is often referred to as the "Herschel" problem because of the nickname, "Herschel", given to a large sea lion present in earlier years. The Herschel problem now receives considerable media and public attention both regionally and nationally each year, resulting in an extremely sensitive situation. This public attention, as well as concerns for the declining status of the wild steelhead, resulted in implementation of an interagency program to enhance steelhead escapement and reduce sea lion predation. In 1985, NMFS began working cooperatively with WDFW, the Army Corps of Engineers - Seattle District (Corps), and the Muckleshoot and Suquamish Indian Tribes in an interagency program to enhance the wild steelhead run, increase wild steelhead escapement and control sea lion predation. This cooperative relationship was affirmed in 1988 by a U.S. District Court stipulation that the state, federal and tribal parties must work together to address all aspects of the wild steelhead decline problem. Predation reduction efforts have included harassment using underwater firecrackers, chaser boats, acoustic harassment devices, taste aversion conditioning, experimental barrier nets, trapping and relocation of sea lions to the outer coast of Washington and to their breeding grounds off southern California, and use of acoustic deterrence devices to create an acoustic barrier.

Efforts to increase wild steelhead spawning escapement have included restrictions and closures of the sport fisheries; restrictions and closures of treaty Indian fisheries; modified flow patterns at the spillway to improve passage into the fish ladder; collection and spawning of broodstock at the fishway and rearing their progeny to fry for planting in the upper Cedar River; and collection of adult steelhead below Landsburg Dam for transport above the dam (upper Cedar River) for spawning in otherwise unavailable habitat. In addition, NMFS, WDFW and the Tribes have been working with Seattle City Light (Landsburg Dam operators) on design of permanent adult and juvenile fish passage

facilities at Landsburg Dam to increase spawning habitat.

Past sea lion control programs and steelhead enhancement efforts have not been adequate to prevent declines in spawning escapement. The proportion of the total run consumed by sea lions increased between 1986 and 1989 from 42 percent to 65 percent. During this same period, the wild steelhead run decreased by 61 percent. Steelhead escapement goals have not been met for the Lake Washington basin for the past 8 years as shown in Table 1. The 1993/94 wild winter-run steelhead spawning escapement of 70 fish is the lowest on record (Figure 1). Continued shortfalls in achieving the spawning escapement goal, by as much as 96 percent experienced in 1993/94, will result in unrecoverable damage to this run.

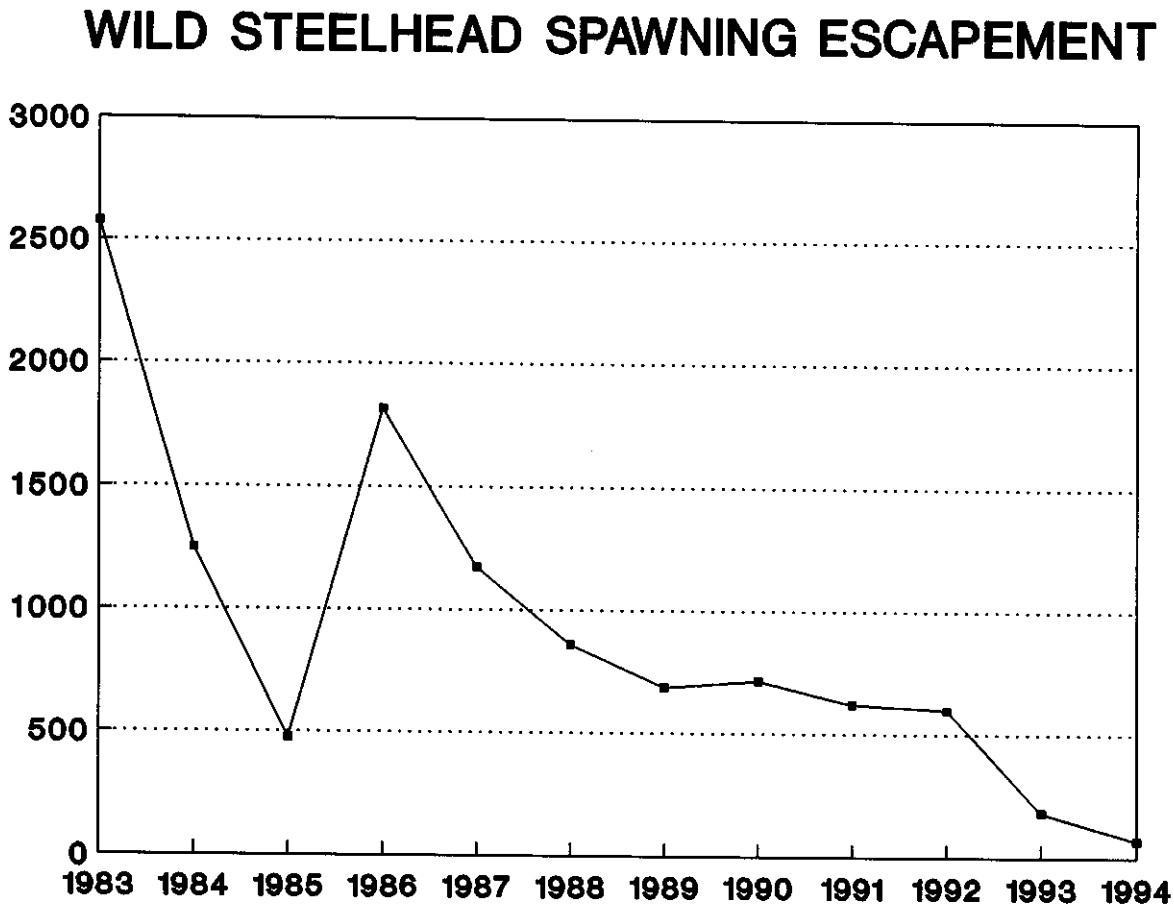

Figure 1. Lake Washington basin wild winter-run steelhead spawning escapement counts.

In view of the declining status of the wild winter-run steelhead in the Lake Washington basin (Figure 1) and the lack of

successful actions in the past in controlling sea lion predation on these fish, the State of Washington sent a letter (application) to the Secretary of Commerce on June 30, 1994 requesting that the process set forth in Section 120 of the MMPA be initiated immediately to consider authorizing the intentional lethal taking of California sea lions that prey on wild winter-run steelhead that migrate through the Ballard Locks in Seattle, Washington from January through May each year.

II.A. Formation of the Task Force

In July 1994, NMFS determined the State's application under Section 120 of the MMPA was sufficient to warrant formation of a Task Force because all of the necessary determinations and required information were in the application or in the documents referenced in the application. Notice of receipt and acceptance of the State's application was published in the Federal Register on August 2, 1994 (59 FR 39325) with a request for public comments. The public comment period closed on September 10, 1994 and copies of the comments were provided to the Task Force.

A Pinniped-Fishery Interaction Task Force on the sea lion/steelhead conflict at the Ballard Locks was established on September 30, the date of its first public meeting. Notice of establishment of the Task Force and its meeting was published in Federal Register on September 27, 1994 (59 FR 49234). Subsequent meetings were announced through NOAA Press Releases and reported in local media. The Task Force held a total of eight days of meetings (which were open to the public) to consider pertinent data on California sea lions, winter-run steelhead, the nature and extent of the interaction at the Locks, the design and operation of the Locks/fishway facility, and past measures and considerations for reducing or eliminating the sea lion/steelhead interaction. The 21-member Task Force consisted of scientists who are knowledgeable about the pinniped interaction that the application addresses; representatives of affected conservation and fishing community organizations; and representatives of WDFW, Tribes, U.S. Fish and Wildlife Service, Army Corps of Engineers, and NMFS.

II.B. Task Force Recommendation

The Task Force recommendations were submitted to NMFS on November 23, 1994 and a minority report was submitted on December 5, 1994. The number one priority recommendation of the Task Force was to make all practicable attempts to remove all identified predatory sea lions and temporarily hold them in captivity through the end of the steelhead run. The Task Force acknowledged that some incidental mortality may occur during capture and holding. The Task Force further recommended that if complications in captivity occur, the care of the sea lions be referred to an Animal Care

Committee (ACC), with the ACC having the flexibility to recommend euthanasia if, in its opinion, it is necessary. The ACC also should be utilized to determine humane holding standards for temporary captivity.

In regard to lethal removal, the Task Force recommended that approval of lethal removal of individually identifiable predatory California sea lions be allowed only if:

1) All practicable attempts are made to capture and place identified predatory sea lions in captivity during the duration of the run. Lethal removal is to occur only if adequate holding facilities are unavailable.

2) The sea lion predation rate exceeds 10 percent in any consecutive 7-day period after January 1, 1995. If, after the initiation of lethal removals, the predation rate equals or falls below 10 percent, for 14 consecutive days when steelhead have been recorded passing through the fish ladder (i.e., omitting those days on which no steelhead are recorded passing through the fish ladder), removals of newly identified predatory sea lions will cease until the predation rate again exceeds 10 percent for any consecutive 7-day period. However, predatory sea lions identified prior to the end of a 14-day "reduced predation" period are to be removed.

3) Captured sea lions to be lethally removed will be euthanized humanely using protocols developed by the ACC.

4) The Corps provides a report to NMFS on an Interagency Working Group (convened by the Corps) recommendations on the following six issues identified by the Task Force as needing immediate assessment and modification, if warranted.

    a) Maintain head at the fish ladder entrance. Ensure velocities exiting the fish ladder meet the best available fish attraction criteria, as determined by the Interagency Working Group, across all tidal levels.

    b) Spill protocol. Review procedures and if indicated, modify spillage at the two gates nearest the fish ladder entrance (spillgates 5 and 6), to guide fish toward the fish ladder entrance. Evaluate the flow pattern at the fish ladder entrance during times of low spill, so as to maximize fish attraction.

    c) Assess fallback of steelhead from fish ladder. Assess fallback (fish entering and subsequently

leaving the first gate of the fish ladder), using information from the 1993-94 and 1994-95 steelhead sonic tagging studies and design and implement solutions if fallback is significant.

d) Water spray at ladder entrance. Create a surface disturbance and evaluate the ability of water spray to attract and hold adult steelhead near the entrance to the fish ladder.

e) Lighting adjustments at fish ladder. Evaluate shading the area inside the fish ladder entrance, during daylight hours, and illuminating at least the first two steps of the fish ladder at night.

f) Decrease salinity in attraction flow. Decrease the salinity of the attraction flow at the fish ladder entrance.

5) NMFS and WDFW investigate the potential benefits and feasibility of expanding or modifying the frequency and the area of coverage of the acoustical devices employed near the Locks, in conjunction with other methods of deterrence.

6) Up to 40 individually identified predatory sea lions are to be removed (either non-lethally and/or lethally) with the caveat that if the number removed reaches 20, the Task Force be immediately reconvened to evaluate removals. In addition, if as many as 15 sea lions are lethally removed, lethal removal should be stopped and the Task Force immediately convened to evaluate available results and options and provide further recommendations to NMFS. Allowed capture methods should include floating traps, submerged traps, tangle nets and other measures deemed appropriate by WDFW and NMFS.

For the purpose of its recommendations on removal to captivity or lethal removal, the Task Force intends the following definitions apply:

<u>Predatory sea lion</u> is an individually identified sea lion (i.e., one bearing brands, tags, natural marks, etc.) observed by NMFS or WDFW personnel or contract personnel, either this year or in past years, killing or eating at least one steelhead in any waters of the Lake Washington basin east of a line projected from the southern end of the Shilshole Bay Marina breakwater, due south to landfall.

<u>Predation rate</u> is the estimated predation, divided by the steelhead index, multiplied by 100 percent. Where the

estimated predation is a statistically reliable estimated total number of wild and/or hatchery steelhead killed within the observation area as described in Pfeifer et. al. (1989). The steelhead index is the number of steelhead estimated to have passed through the fish ladder counter, plus the estimated predation.

The Task Force also recommended, separate from the lethal removal recommendation, that agencies and groups involved with activities at the Locks immediately address the following recommendations that involve attempting a number of non-lethal measures.

1. Sea Lion Barrier. Assess all viable non-net options for the possible installation of a sea lion barrier from the area below the fish ladder entrance across the entire spillway, and implement any feasible options.

2. Steelhead Refuge. Assess and implement options that have merit for application. These include, but are not limited to a "pipe forest", a flexible "plastic kelp forest" and a fabric or plastic cover on the surface of the water.

3. Sea Lion Deterrence. Investigate the feasibility of expanding or modifying the area of coverage of the acoustical devices employed at the Locks, as well as investigating the use of other frequencies. Implement and evaluate other methods of deterrence in conjunction with other recommended activities.

The Task Force also included several interim evaluation points within its recommendations and requested that NMFS notify it when any of those are reached. Regardless of the effectiveness of, or the implementation of, any of the above recommendations, the Task Force requests that the NMFS provide to the Task Force by January 7, 1995, preliminary estimates of daily predation rates. The Task Force believes that the following information is essential to evaluate the effectiveness of actions taken to control predation.

1. Annual predation rate - the estimated total number of steelhead killed by sea lions divided by the total reconstructed run size.

2. Spawning escapement - the estimated total number of steelhead that reach the spawning grounds.

3. Replacement rate of sea lions - the rate at which new predatory sea lions enter the Ship Canal project area after identified predatory sea lions are removed.

4. Residency time - the amount of time (e.g. sea lion hours) that sea lions spend at or in the Ship Canal.

Additional recommendations of the Task Force under three areas of concern are as follows.

1) Recovery Plan. The Task Force recommends that WDFW, the Tribes and federal managers immediately begin development of, and subsequent implementation of, a recovery plan for Lake Washington wild steelhead. The Task Force recommends that the Corps undertake an evaluation of long-term measures to improve fish passage at the Locks facility. Such work should include a comprehensive evaluation of fish passage design and capability to optimize adult fish passage at the existing ladder and installation of additional fish passage capability (e.g., a second fish ladder). The Task Force recognized that such work may take several years to complete, but it would like to see the assessment begin as soon as possible.

2) Habitat. The Task Force determined that habitat improvement and protection is vital to the recovery and subsequent sustainment of Lake Washington's steelhead population. Due to their nearly two year freshwater residency, steelhead are particularly sensitive to changes in habitat conditions. The Task Force recommended that the following actions in the Lake Washington ecosystem begin immediately.

a) Conduct tributary habitat surveys. Evaluate current anadromous habitat, with priority given to tributary index sections and Cedar River mainstem.

b) Increase effectiveness of present state authority/ enforcement for habitat protection. Accomplish present mandates in the Lake Washington ecosystem as well as throughout Washington to prevent continued habitat degradation and loss.

c) Purchase/rezone critical watershed shoreline habitat. The purpose of this action is to arrest continued habitat loss due to urbanization. Follow-up with variable habitat monitoring is also recommended.

d) Develop integrated Cedar River Water Management Plan below Seattle Water Department and Seattle City Light Projects to accommodate needs of steelhead. Integrate water plan prioritizing steelhead needs within the system by optimizing and restoring areas of steelhead production in Cedar River. This would be done by stabilizing flows, optimizing adult and smolt passage, and enhancing fry/smolt passage in diversions.

e) Review Metro or other available water quality data to identify potential problems; relate back to and/or correlate to fish passage and/or correlate to fish passage and/or rearing. The purpose of this action is to identify potential fish production limitations.

3) Fishery Management. The Task Force recognized that improvement in fisheries management is important to the recovery and subsequent sustainment of Lake Washington's steelhead trout populations. The Task Force recommended that the following actions to improve fisheries management of steelhead in the Lake Washington ecosystem begin immediately:

a) Explore methods and develop inseason run size estimate of wild steelhead abundance in the Lake Washington Ship Canal. Methods should include hydro-acoustic technology, fish counters, and tagging studies.

b) Determine smolt production of tributaries including potential impacts of previous supplementation. The purpose of this action is to prioritize tributaries for future recovery efforts, as a component of a comprehensive steelhead production analysis.

c) Develop reliable wild steelhead run size predictive tool. The purpose is to enumerate spawners and outmigrant smolts and relate them to total run size (including marine mammal predation).

d) Identify sources and location of smolt mortality. Determine freshwater survival between streams and Shilshole Bay to identify critical and correctable smolt mortality through tagging and tracking studies.

e) Implement short term supplementation of wild steelhead. Use limited wild broodstock for supplementation to augment critically low wild run size.

f) Increase enforcement and emphasis on patrols to protect spawners from poaching.

Additional details of the Task Force recommendations including minority views on the lethal removal recommendation are in the Task Force report (Task Force 1994).

NMFS has taken the Task Force recommendations into consideration in deciding whether to approve lethal removal. The Task Force

recommendations including minority views and comments from the public are included in the proposed action and alternatives herein. This EA also provides the pertinent information taken into consideration by NMFS in accordance with Section 120(d) of the MMPA in assessing the Task Force recommendation and other alternatives.

III. ALTERNATIVES INCLUDING THE PROPOSED ACTION

III.A. No Action Alternative

This alternative is to take no action to repel or remove California sea lions from the Lake Washington Ship Canal. The no action alternative is not preferred because it will not reduce the steelhead mortalities caused by sea lions at the Locks. No action could result in the eventual loss of a wild run of steelhead in the Lake Washington basin.

III.B. Lethal Removal

This alternative is to kill all California sea lions that prey on steelhead in the Lake Washington Ship Canal. This alternative, by itself, is not preferred. Lethal removal should be combined with initial use of non-lethal measures and considered only as a last resort if feasible, practical, non-lethal control efforts fail to reduce/eliminate sea lion predation.

III.C. Non-Lethal Removal Measures

This alternative is to continue the past years' non-lethal removal efforts. This alternative, by itself, is not preferred. Past efforts indicate that non-lethal efforts alone are unlikely to be effective on all predatory sea lions and that the few animals that are oblivious to or able to avoid non-lethal measures are likely to account for most of the predation on the wild steelhead that can be as high as 65 percent of the returning adult spawners. Some non-lethal measures such as the acoustic barrier appear to have some effects on some animals while others are not practical or have no likelihood of success in deterring/removing sea lions. The non-lethal measures considered are described in Section V.C. of this document.

III.D. Modify the Locks Facility with Barriers or Escape Cover

This alternative is to modify the Locks facility and install downstream structures to separate sea lions from steelhead. Such modifications would have to be accomplished by the Corps, the responsible federal agency. The Corps would have to consider

impacts of structures on operation, safety and maintenance of the Locks for the authorized purpose of providing a navigable waterway between Puget Sound and Lake Washington; potential impairment of the release or retention of water necessary for regulation of lake levels; and passage of other salmonid runs. Feasibility and physical model studies as well as hydraulic implications of any possible modifications would likely be necessary prior to Corps consideration. Because of this and other factors described in more detail in Section V.D. of this document, implementation of this alternative cannot occur in sufficient time to protect the 1994/95 winter-run.

III.E. Implement Other Fish Passage/Management/Habitat Measures

This alternative is to implement fish passage improvements, fisheries management modifications and habitat improvements to enhance the status of the winter-run wild steelhead. Fishery closures and some fish passage enhancements have occurred in past but have not resulted in increased spawning escapement. This alternative, by itself, is not preferred. Nonetheless, steelhead fishery closures in the Lake Washington drainage will reduce mortality on the returning 1994/95 winter-run wild steelhead. Other measures, described in more detail in Section V.E. of this document, would have no effect on the returning 1994/95 winter-run, but could improve overall status of the population. Most of these measures however cannot be implemented in sufficient time to enhance the 1994/95 winter-run and would require involvement of other agencies.

III.F. Remove the Locks Facility

This alternative is to remove the Locks facility to eliminate steelhead vulnerability to predation at this site. This is not a viable alternative as described in Section V.F. of this document. Even if it were viable, it could not be accomplished in time to protect the 1994/95 winter-run steelhead.

III.G. Lethal Removal in Combination with Other Measures (Proposed Action)

This is the preferred alternative to implement the Task Force recommendation to allow lethal removal of individually identifiable predatory California sea lions only under certain conditions. The proposed action is a combination of non-lethal deterrence with acoustic devices, capture and removal to captivity, and lethal removal as a last resort. These actions would be implemented on a phased approach with the deterrence measures as the first approach to prevent most animals from accessing the areas of high predation (i.e., area in front of

fishway). Only the predatory sea lions that prey on steelhead would be targeted for removal to captivity or lethal taking. The acoustic barrier is intended to "screen-out" naive animals that have not preyed on steelhead at this site. This approach will minimize the possibility of replacement of the predatory animals by new entrants. Efforts would be made to place the removed "problem" animals in captivity first and lethal taking would occur only if adequate holding facilities are unavailable. The proposed action is described in more detail in Section V.G. of this document,

IV. AFFECTED ENVIRONMENT

IV.A. Geographic Location

The problem area is located in the Lake Washington Ship Canal from Lake Washington to the seaward side of the Hiram M. Chittenden or "Ballard" Locks facility (hereinafter referred to as the Locks) out into Shilshole Bay (Figure 2). The sea lion/steelhead conflict was initially located primarily in the spillway area of the Locks facility near the entrance to the fish ladder; but as the numbers of sea lions in the area increased, so did the occurrence of substantial predation in other areas such as in front of the lock doors and downstream out to Shilshole Bay. Sea lions have also been observed preying on winter-run steelhead upstream of the Locks in freshwater. In 1987/88, one California sea lion was observed pursuing and eating free-swimming steelhead in Lake Washington at Sand Point. However, the downstream area of the Locks remains the principal area of concern. Because of the location of the Locks at the convergence of freshwater and saltwater, steelhead are especially vulnerable to sea lion predation because the fish will mill in the downstream area while making physiological adjustments for freshwater migration.

IV.B. Locks Facility and Fishway

Construction of the Lake Washington Ship Canal project commenced in 1911. The Locks and dam were built in 1916 to control the water level in Lake Washington and provide ship and barge traffic between Lake Washington, Lake Union and Puget Sound. The original construction included a fish ladder at the site of the present structure. Adjustments were made to the original fish ladder in 1948/49 that reduced the height of the weirs from 26 inches to 16 inches. By the late 1960s, studies were underway to replace the existing fish ladder. The impetus was the observation that the existing ladder seriously impacted upstream migrating fish. Resource agencies identified serious passage problems such as poor entrance conditions, heavy spillway flow coupled with poor entrance conditions, predation (by seals), and

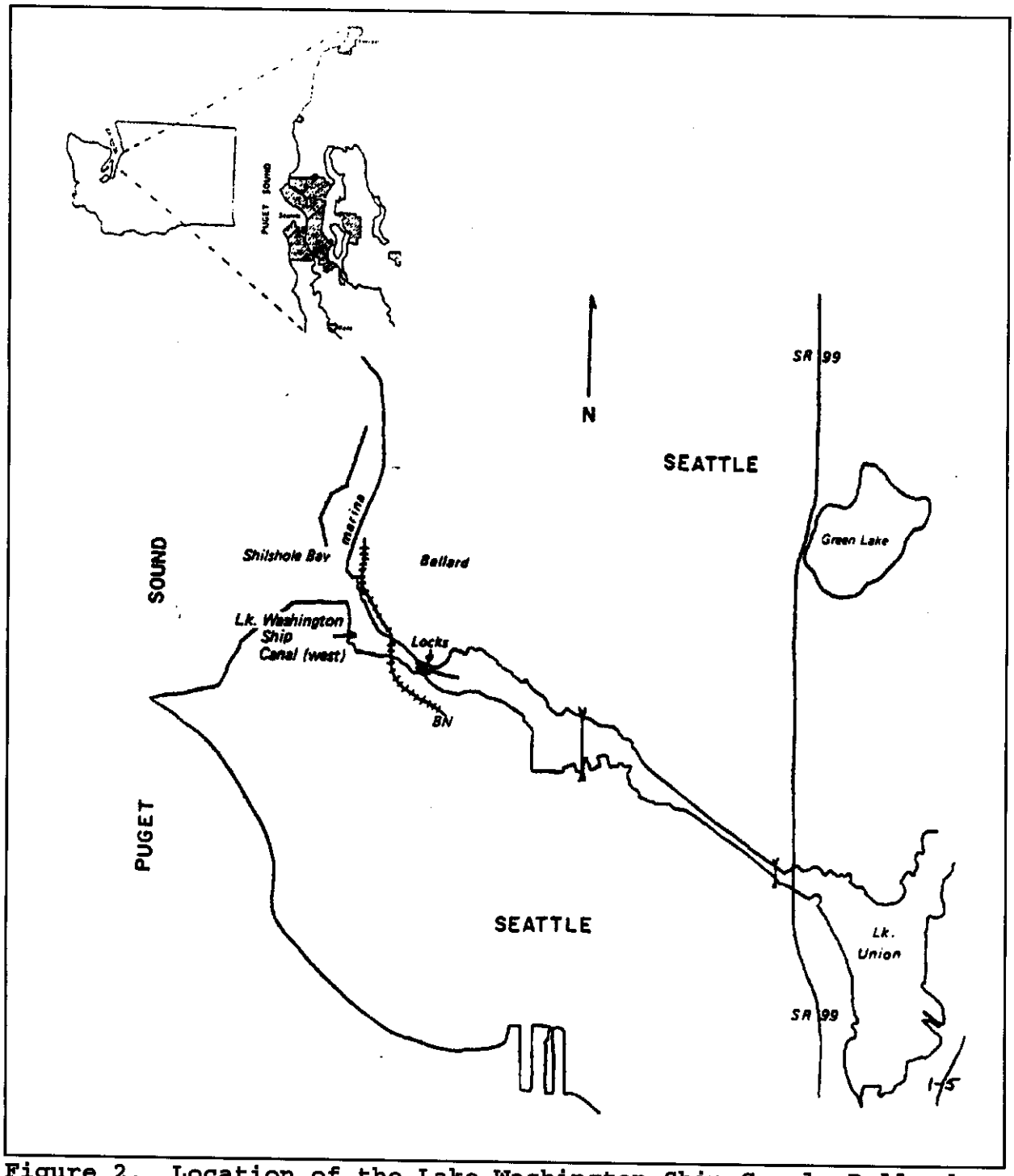

Figure 2. Location of the Lake Washington Ship Canal, Ballard Locks, Shilshole Bay area.

the effect of boat and barge traffic on fish passing the Locks facility. In 1971, escapement of upstream migrating anadromous fish in the Lake Washington basin was estimated at 300,000 fish (180,000 sockeye, 80,000 coho, 10,000 chinook, and 7,000

steelhead). Improved fish facilities were required because losses due to passage problems at the Locks were estimated to be as high as 20 percent of the combined sockeye and chinook populations.

Prior to rehabilitation, fishway criteria were developed and coordinated with WDFW and NMFS. These fishway criteria included 1) fishway entrance velocities of 5 - 8 feet per second (fps); 2) minimum transportation velocity of 2 fps; 3) water surface drop over fixed weirs from a minimum of 0.8 ft to a maximum of 1.0 ft.; 4) minimum depth of water in entrance slots of 4.0 ft; and 5) more gradual slope. These criteria were intended to overcome the following deficiencies in the old ladder: 1) insufficient attraction water flows from the ladder entrance; 2) difficulty or inability of fish to enter the fish ladder at lower tidal stages; 3) improper elevations between ladder pools; 4) absence of submerged orifices in the ladder pool weirs except at the fish ladder entrance and exit; 5) need for frequent manual flow regulation for optimum flows in the ladder; 6) false attraction of fish to the saltwater drain; and, 7) steep gradient.

Construction of the rehabilitated fish ladder was completed in 1975. The fish ladder consists of a series of pools at different levels, or steps, that provide passage for migrating fish from Puget Sound to the Lake Washington basin. The pools in the fish ladder are separated one from the other by dams, called weirs, that allow fish to swim from pool to pool either over the weir or under the weir through an orifice.

Adequate fish flow conditions from the uppermost weir (the fish ladder exit) down to weir no. 9 are maintained by providing a flow of about 20 cubic feet per second (cfs) from the surface water of the Lake Washington Ship Canal. Below weir no. 9, the varying elevation of the tide in Shilshole Bay can flood the fish ladder and inhibit adequate fish flow conditions. Therefore, adequate fish flow conditions in the pools below weir no. 9 are provided by the diversion of mixed freshwater and saltwater, being returned from just upstream of the Locks via the saltwater drain, to a distribution area within the fish ladder. This area, called a diffuser, is designed to distribute flow to the lower pools of the fish ladder based upon the elevation of the tide. At the lowest design tide (-0.5 ft MLLW), the diffuser distributes flow to the entrance pool (below no. 18) and to the pool below weir no. 17. At the highest design tide (12.0 ft MLLW), the diffuser distributes flow to all of the pools below weir no. 9. The flow through the diffuser to meet minimum transportation velocity criteria is about 160 cfs.

Other important features of the fish ladder are that it has two entrances: 1) a side entrance that is a one-foot wide ungated slot; and 2) a downstream entrance that is gated, such that the width of the entrance can be varied from a minimum of just under

one foot to a maximum of almost four feet. It is the setting of the downstream entrance gate that controls the entrance flow conditions to meet design criteria. A six-foot diameter butterfly valve controls the flow from the saltwater drain through the diffuser supply pipe to the distribution well. A fish ladder control system automatically adjusts the entrance gate setting based on the tide elevation. The control system is also capable of automatically adjusting the butterfly valve to maintain a nearly constant design flow of 160 cfs to the diffuser. Automatic control of the butterfly valve is necessary in low water years to conserve water in the Lake Washington basin. Otherwise, the butterfly valve can be (and has been) set manually to achieve better than minimum fish flow conditions.

Table 2. Pertinent Data for the Lake Washington Ship Canal and Hiram M. Chittenden Locks facility.

LOCATION	Seattle, Washington
DRAINAGE AREA	607 Square miles
PROJECT LENGTH	8 miles
RESERVOIR (Lake Union & Lake Washington)	
Normal High, pool elevation	+22 feet
Normal Low, pool elevation	+20 feet
Storage (EL. +20 to EL. +22)	48,000 Acre-feet
SPILLWAY DAM	
Length	235 feet
Height	63 feet
Number of bays	6
Bay width	32 feet
Tainter gates (6)	32 x 12 feet
Pier width	4 feet
Crest elevation	+13.75 feet
Bridge elevation	+26 feet
NAVIGATION LOCKS	
Main Lock	
Available Length (for square end vessels)	760 feet
Available Length-east chamber	385 feet
Available Length-west chamber	327 feet
Clear width	80 feet
Depth on lower miter sill	29 feet
Depth on upper miter sill	36 feet
Small Lock	
Available Length(for square end vessels)	123 feet
Clear width	28 feet
Depth on lower miter sill	16 feet
Depth on upper miter sill	16 feet
Number of lockages (1984-1993)	about 17,000 to 29,000 per year
Channel from deepwater in Puget Sound to Burlington Northern Railway Bridge	
Depth	34 feet
Width	300 feet
Length	5,500 feet
Depth (passing basin)	34 feet
Depth (log basin)	8 feet

Channel from Burlington Northern Railway Bridge to Locks
- Depth 34 feet
- Width 150-200 feet
- Length 900 feet

SALTWATER DRAIN (SWD)
- Conduit length 700 feet
- Conduit area 30 square feet
- SWD discharge gate
  - Width 7 feet
  - Height 5 feet
  - Crest elevation 10.0 feet

FISH LADDER
- Width 8 feet
- Slope 1 on 8
- Weir height 8 feet
- Number of fixed weirs 18
- Number of adjustable weirs 3
  (Regulation or pool fluctuation)
- Ladder flow (above tidal range) 18.6 to 23 cfs
- Fishway entrance gates (Regulation for tidal fluctuation)
- Number of Gates
  - Downstream gate (double) 3.8 foot max
  - Width of opening 0.94 min
  - Height 22 feet
- Side slot
  - Width of opening 1.0 foot maximum, 0.0 foot min
  - Height 22 feet
- Exit orifice
  - Length 10 feet
  - Height 5.5 feet
  - Invert elevation +14.5 feet

DIFFUSER SYSTEM
- Normal flow 160 cfs
- Number of diffusers 6
- Velocity through grating (gross area) 1 fps

ATTRACTION WATER SYSTEM
- Source of attraction water - Discharge of saltwater drain
- Attraction water conduit (Diffuser supply pipe)
  - Inside diameter 6 feet
  - Length 210 feet
- Valve (Butterfly valve located at fish ladder)
  - Valve size 6 foot diameter

Tribal Usual and Accustomed Fishing Area

The Lake Washington Ship Canal is within the usual and accustomed fishing areas of the Muckleshoot and Suquamish Tribes as adjudicated in United States v. Washington. These tribes have treaty fishing rights to the salmonid runs that enter the Lake Washington basin.

Fish Passage Issues

All Lake Washington anadromous fish stocks, whether wild or hatchery origin, must pass through and are affected by conditions they encounter in the Ship Canal and at the Locks facility. It is therefore important that upstream and downstream migrants move

through the Locks facility as safely and efficiently as possible. Pfeifer (1994a) estimated that about 60 to 70 percent of the returning steelhead use the fish ladder to access freshwater, the remainder pass through the locks during vessel passage.

In 1990, NMFS, WDFW and the Corps formed an Ad Hoc Technical Committee of engineers and fish passage experts to review existing information on all facets of fish passage and fish vulnerability to sea lion predation at the Locks facility. Facility operation, predation observations, steelhead biology, fish ladder design and physical environmental factors were considered by the Committee in determining whether structural modifications might be feasible in resolving some or all of the predation problem. The Committee identified operational aspects that needed to be examined or modified to enhance fish passage (Norberg 1990). One operational aspect noted by the Committee was that the pattern of water releases from the spillgates may contribute to passage delays by distracting fish away from the fishway. A revised spill protocol was developed and implemented to reduce distraction of returning spawners from the fishway when surplus water was being released from the dam. The protocol has been in use by the Corps since 1990 as a result of the Committee's recommendations. In regard to potential structural modifications, the Committee concluded that insufficient information about the behavior and movement patterns of returning steelhead precluded further analysis of possible structural alternatives and recommended further studies on steelhead passage and behavior in the Ship Canal (Norberg 1990). Thus, the Committee recommended three specific studies that would provide needed information: 1) a sonic tracking study on Lake Washington basin steelhead to better understand fish behavior and movements in the Ship Canal especially their reaction to the presence of predators; 2) a fishway illumination study; and, 3) a study on the salinity gradient between the fishway attraction water and the ambient water in the spilling basin in front of the fishway. Results from the tracking study could be used for further consideration of structural modifications or additions to Locks facility or Ship Canal for the enhancement of passage or the protection of fish. The fish tracking study was initiated in 1994 and is currently underway (Tabor et al. 1994).

The fishway illumination studies were conducted during the 1990/91 season (Pfeifer 1991b) and during the 1991/92 season (Pfeifer 1994a). Although questions remain regarding the lighting design, it does not appear that lighting the fishway at night produced a significant improvement in fish passage. Illumination of the fishway at night failed to demonstrate a clear increase in nighttime use by steelhead (Infometrix 1994; Pfeifer 1994a). The proportion of steelhead passages occurring at night when the fishway was unlit was almost exactly the same as the proportion that passed at night when it was lit during the study period (Pfeifer 1994a). It is possible that the lighting

design and layout used during the experiment may not have adequately addressed the presence of excessive light gradients (i.e., sharp shadows, or rapid transitions between dark and light areas) which appear to be important in fishway use (Bob Pearce, NMFS fish passage engineer, pers. comm.). However, lighting the vicinity outside of the fishway entrances to reduce the light gradient between the fishway and tailrace to encourage passage may be counter productive. Increasing light levels near the fishway at night may increase the likelihood of predation during hours of darkness. The effects of fishway lighting to reduce internal shadowing during the day was not tested during the experiment.

The collection of salinity data recommended by the Committee commenced in 1991. The data was analyzed in 1994 by Pfeifer (1994a) and Infometrix (1994), and the analyses were expanded to include a number of environmental factors. The salinity study stems from the fact that the main source of water for operating the fish ladder is the saltwater return system used to reduce saltwater intrusion into Lake Washington. The analysis of the effects of environmental variables by Pfeifer (1994) included the following: fishway salinity; salinity gradient; fishway temperature; temperature difference between the fishway and the tailrace; spill flows; tide height; degree of tidal change; time of day; and moon phase. The analyses were complicated by the low abundance of steelhead. The analyses did not yield any clear predictive correlates with steelhead passage, however, steelhead do tend to enter the fishway on flood tides, particularly in the morning to mid-day. In addition, preliminary analysis indicated that it may be necessary to keep the fishway entrance pool head within a given range to optimize passage.

Since about 1987 or 1988, escapement of sockeye and chinook in the Lake Washington basin has declined by about one-third. Populations of coho and steelhead have declined even more dramatically. However, the sockeye run was up in 1994. As a result, fish passage at the Locks facility is currently being re-examined. In 1994, the Corps has organized an Interagency Working Group of fishery biologists and fish passage experts from NMFS, WDFW, USFWS, tribes and Corps to review an array of issues on fish passage at the facility for both returning adults and outmigrating juvenile salmonids (smolts). A report of this Group's recommendations is expected in late December 1994. Although the discussions included concerns for all anadromous fish, the structural and operational issues that may have direct applicability to wild winter-run steelhead and sea lion predation were of primary concern because of the continuing decline and critically low numbers of steelhead. In order to focus the fish passage discussions and assist with the development of recommendations for improvement, several aspects of the Locks facility and operations were reviewed by the Working Group with regard to possible effects on both returning adult fish and

smolts. The aspects include the design and operation of the fishway, the configuration and operation of the spillgates, the structure and operation of the locks themselves, the use of the saltwater drain, and the interactions of all fishery resources with these facilities.

A number of variables may affect the operational efficiency of the fish ladder. As described above, the effects on fish passage of using water from the saltwater return system are not fully understood. The operation of entrance control structures, gate geometry, and interactions with tidal stage combine at times to cause the entrance pool head to be either minimal or excessive resulting in attraction flows that are not within design specifications (i.e., less than 5 ft/sec during high tides, or greater than 8 ft/sec during low tides). In addition, spill configuration or operations might be changed to enhance fishway attraction. Defining specific water use needs also will assist in allocation of available water to maximize fishway attraction. Resolution of these concerns is an integral part of reducing sea lion predation at the Locks facility by achieving maximum adult passage efficiency and minimizing delay. However, it is important to recognize that optimization of fishway operation, by itself, is not likely to eliminate sea lion predation on adult fish. Steelhead are likely to mill for some period below the Locks and spillway before entering freshwater, even if the fish ladder were working perfectly. Improving passage rates to the maximum extent possible, however, could lower the vulnerability of fish by reducing the time they spend in the primary predation zones near the fishway.

Two sources of water are utilized for fishway operation. Fresh lake surface water (about 20 cfs) is introduced through the fishway exit into the upper ladder with water surface elevation controlled by three adjustable weirs. Variably brackish water (about 160 cfs) from the saltwater drain sump is introduced into the lower fishway through conduits and a diffuser well. The salinity in the lower fishway is therefore variable and is strongly influenced by the salinity of water in the saltwater drain. Some mixing of freshwater in the lake and saltwater from upstream lockages occurs in the saltwater drain sump; therefore, it is unlikely that fishway salinity would be higher than tailrace salinity with a few short term exceptions. Based on analyses of the salinity measurements in the fishway and tailrace collected during the 1991/92 and 1992/93 steelhead runs, Pfeifer (1994a) and Infometrix (1994) found that in general the salinity in the fishway entrance pool ranges from zero to 5 ppt for the majority of the steelhead run period (about 82 percent in 1991/92 and 57 percent in 1992/93) (Pfeifer 1994a). Salinity in the range of 5 to 10 ppt occurred with less frequency (about 18 percent in 1991/92 and 38 percent in 1992/93). In one year (1992/93), entrance pool salinity reached 25 ppt for a brief period (about two hours), and exceeded 9 ppt about 4 percent of

the time. Infometrix (1994) found that the tailrace salinity is higher, to varying degrees, than fishway salinity (up to 29 ppt in 1991/92) and that the salinity gradient is positive, i.e., no cases were noted where the tailrace was less saline than in the fishway entrance pool. The mean gradient between the fishway and tailrace was approximately 15 ppt in 1991/92. Large spills over the dam tended to decrease the salinity in the tailrace; however, the lower salinity water below the dam would then be captured during lockages and subsequently enter the fishway via the saltwater drain (thereby reducing fishway salinity). Analyses by Infometrix (1994) indicate that steelhead appear to prefer conditions of stronger salinity gradients for passage. Pfeifer (1994a) noted that fish tended to move through the ladder when the salinity was low, but the incidence of higher salinity in the fish ladder was relatively rare and the number of fish passing the facility was so low that findings were not conclusive. Both reports point to the need to keep fishway salinity low in order to maximize the difference between the fishway attraction water and water in the tailrace to optimize fish attraction to the fishway.

In regard to overall fish passage, NMFS and WDFW have provided a number of recommended actions for fishway improvements to the Corps. The Corps is acting on some of the recommendations and evaluating others. More detailed information on Corps activities in response to the recommendations is discussed in Section V.E. of this document. The fishway recommendations include: 1) ensure that the fishway controller is operating effectively to integrate entrance gate operation with attraction water supply to optimize ladder entrance attraction flow; 2) evaluate the installation of a closeable entrance gate on the north entry slot to provide a less labor intensive means of closing off this entrance during periods of increased spill as indicated in the original design specifications for the fish ladder; 3) review the effects on fish passage of using the saltwater drain as the main water supply for the fishway and determine the feasibility of modifying the water supply to allow experimentation with lower salinity attraction flows; 4) evaluate the feasibility of creating a sea lion exclusion area near the fishway entrance; and, 5) begin a comprehensive evaluation to identify and describe all factors affecting adult fish passage efficiency through the Locks facility, and design and implement feasible solutions. In addition, the Corps has been asked to evaluate the installation of a second fishway to increase passage capability and modify the downstream (west) entrance gate to meet modern fishway design standards. This would involve designing a moveable sill entrance gate that is three to four feet wide and would provide 1 to 1.5 feet of entrance head for the entire operational range. This would also entail re-plumbing the auxiliary water system to provide adequate flow for these conditions.

The Corps is pursuing repairs and upgrades to the existing

fishway controller to ensure that it is operating effectively. The Corps has also indicated its general willingness to evaluate detailed proposals on sea lion exclusion barriers for possible hydraulic effects and other permitting criteria. In the absence of compelling data or analysis of the impacts on the Locks facility, however, the Corps has indicated that the scope or design of further modifications to the facility remain unclear. Specifically, the Corps has advised that actions to reduce fishway salinity will require better rationale and further evaluation before the Corps will consider whether to proceed. The Corps also has indicated that it is not pursuing the addition of another fishway, and that modification of the existing fishway entrances is undecided.

The design and operation of the spillgates can affect both adult (upstream) migrants and juvenile (downstream) migrants. Spill patterns influence fishway attraction for adults. The frequency and depth of spillgate openings and spill volume influence the attractiveness of the spillway as a path of egress for smolts. At present, this egress path is not properly configured for optimum smolt outmigration efficiency or safety. The submerged gate openings do not maximize smolt attraction and narrow gate openings create abrupt velocity gradients and disorienting conditions leading to smolt predation and injury. Several approaches have been recommended: attract smolts away from the lock chambers; improve passage safety and efficiency; increase flexibility to manipulate spill patterns to increase fishway attraction for returning adults; and improve water use efficiency.

The spillway recommendations include: 1) continue to operate the spillgates according to the protocol developed jointly by NMFS and the Corps in 1990, and verify that the minimum gate opening criteria and the objective to maximize fishway attraction are being met; 2) install protective birdlines across the tailrace to protect smolts below the dam; and, 3) develop a means to provide surface spill and a pathway for safe smolt egress to the tailrace.

The lock chambers are an important route for both upstream and downstream migrants. Pfeifer (1994) estimated that roughly 30 to 40 percent of returning adult steelhead use the lock chambers (rather than the fish ladder) as their pathway to Lake Washington. Normal locking procedures, and "mini-flushing" to reduce salinity above the dam, create strong turbulence downstream of the large lock chambers leading to elevated smolt predation by birds. There may also be other sources of smolt injury associated with locking procedures which have yet to be documented. Slower filling and draining procedures which have been tested in the large lock, appeared to have provided some relief for smolts during the locking procedure. Subsequent examination of the locks valve mechanisms revealed that

significant wear damage resulted from the partial openings used and therefore it appears that further implementation of the "slow locking" procedure will not be possible without some modification to the valve system. Several recommendations have been developed for reducing smolt mortality and increasing lock operation efficiency.

The lock operation and structural recommendations include: 1) develop a standard operating procedure for slow locking and mini-flushing which includes specifications for tide height, daily and seasonal timing, and frequency; 2) continue to deploy and evaluate water spray as an avian predator deterrent; 3) evaluate the potential for injury of downstream migrants as they pass through the lock chamber manifolds and conduits, and assess the feasibility of structural changes to reduce identified sources of injury; and 4) evaluate the design of the lock chamber manifolds, conduits and outlets to reduce or eliminate turbulent upwelling, reduce the need for slow locking, increase water use efficiency, and enable mini-flushing as needed.

The saltwater drain consists of an intake located at the upstream end of the large lock, delivery conduits to the fishway, and a main line discharge at the north end of the dam. The drain functions to collect saltwater, introduced during east bound lockages, and route it back to the tailrace through the conduits. This is part of a necessary system used to protect water quality in the Ship Canal. As a water conservation measure, roughly half of the water budgeted for saltwater return is used to provide the majority of the water supply to the fishway. As required, the remainder is discharged through the north drain exit. When the north drain exit is in operation it becomes an attractant for returning adult migrants which can enter the drain conduit, primarily during high tide. Once inside the conduit, fish can either continue on to the lake via the drain intake, or may become trapped in the diffuser well at the fish ladder. To eliminate adult entry, the drain exit was fitted with a removable screen. The screen was recently observed to be a source of mortality for downstream migrants. Accordingly, the screen was removed as a protective measure for juvenile fish. Screen removal reintroduced the risk of adult fish entry during high tide. Several recommendations have been developed to reduce downstream migrant mortality from passage through the saltwater drain and to manage risks to adult fish which may enter the discharge exit. At this time the Working Group has a heightened concern for juvenile outmigrants, although in summer 1994, several adult salmonids were observed by remote video in the diffuser well.

Saltwater drain operation and structural recommendations include: 1) evaluate the risk of adult fish entry into the discharge exit; and, 2) if adult exclusion is needed, evaluate operational options (such as low tide operation) and structural options (such

as graduated field barriers) to reduce the risk of entrapment for adult fish.

IV.C. California Sea Lions

The California sea lion, Zalophus californianus, occurs primarily on a seasonal basis in Washington waters, although a few animals may remain year-round. California sea lions migrate into Washington waters each fall from southern California and Mexico where they breed. California sea lions are found in Washington waters primarily from September to June. Except for one or two females that have been reported, all of the California sea lions that migrate into Washington are males of ages five to fifteen. California sea lions were first reported in Washington's waters in 1950 (Kenyon and Scheffer 1962); however, there is some evidence from archaeological digs that they may have occurred in Washington in pre-historic times (Huelsbeck 1983).

The west coast population ranges from the southern Baja Peninsula to British Columbia with individual animal sightings as far north as the Gulf of Alaska. The breeding range extends from San Miguel Island in the southern California Bight south to Isla Margarita on the Pacific coast of Baja California, Mexico and into the Gulf of California. Sea Lions exhibit a polygynous breeding structure in which males establish breeding territories onshore that may contain 10 to 20 females. Pups are born in May and June and breeding takes place shortly after the birth of the pup. Males are three to four times larger than females and develop a pronounced sagittal crest on their skull at the age of about five to six years. After the breeding season ends, adult and sub-adult males disperse from the rookeries and begin a northward migration which takes them along the coast of northern California, Oregon, and Washington to as far north as British Columbia. Several sightings have been made in recent years of California sea lions in Prince William Sound, Alaska, but these are viewed as rare occurrences outside their range. California sea lions begin arriving in Washington waters in August with numbers increasing through the fall and winter months. By June, most of these sea lions have departed Washington waters and migrated south back to the breeding areas off southern California.

The current west coast population is estimated in excess of 200,000 animals with about 111,000 of these in U.S. waters (Lowry et al. 1992). The current estimate contrasts with the estimates of about 1,000 animals in the early 1930s (Bartholomew and Boolootian 1960). These low numbers were possibly due to commercial exploitation as sea lions were hunted in the Channel Islands area for their oil, pelts, hides, and other products until the late 1930s (Cass 1985); or the low counts may be the result of biases in these old counts due to disturbance and

disruption of breeding areas (where counts were made) caused by exploitation. Sea lions also were hunted in Oregon and Washington and bounties were paid by the states until the early 1960s (Beach et al. 1985).

California sea lion pup counts in U.S. waters from 1975 to 1993 compiled by NMFS (1994) are shown in Figure 3. Two major declines in the number of pups counted occurred during El Niño events in 1983 and 1992 (Figure 3). The natural logarithm of the pup counts, against year, indicate that the counts of pups increased at an annual rate of 4.4 percent between 1975 and 1993 (NMFS 1994). The counts of pups between El Niño events increased at 8.8 percent between 1976 and 1982 and at 10.8 percent between 1983 and 1991. Overall, the west coast population has been increasing at a rate of 10.2 percent annually since 1983 (Lowry et al. 1992). Some of this increase may be due to recovery from past exploitation. Although the pre-exploitation size is unknown, recent studies indicate that the present abundance may be higher than any historical level (Low 1991). Increased numbers of California sea lion males have migrated into northern waters coincident with the population increase; the number of California sea lions in British Columbia increased ten-fold between 1972 and 1984 (Bigg 1985). The increased numbers observed were greater than the annual rate of increase for the breeding population off California; hence, a sudden shift to a more northward migration appears to have occurred (Bigg 1985). Large increases in 1984 also may have been a result of El Niño conditions. The numbers of California sea lions in British Columbia reached a peak in 1984 of about 4,500 animals then leveled off in subsequent years at 2,000 to 2,500 animals each year (P. Olesiuk, DFO, pers. comm. 1991). The trend in British Columbia also represents the population trend in Washington because all of these animals would have had to pass through Washington waters. Similar increasing trends have been noted in Oregon (Brown 1988). In the Columbia River, from 150 to 200 California sea lions have been counted annually from 1991 to 1993 in Astoria, Oregon (Matteson et al. 1993), whereas counts of over 50 California sea lions in the river were rare in the 1980s (Beach et al. 1985). Along with the increasing trend in numbers, California sea lions are now present in areas for which there is no documented historical occurrence. California sea lions now occur in all areas of Puget Sound and Hood Canal, as far up the Columbia River as Cascade Locks (above Bonneville Dam, over 145 miles upriver), at Willamette Falls which is 26 miles up the Willamette River (a tributary of Columbia River at river mile 100) in the Portland, Oregon metropolitan area, and far upstream in other river systems such as the Chehalis River.

In order to assess the status of the west coast California sea lion population relative to its optimum sustainable population (OSP) level, Boveng (1988) performed a dynamic response analysis on trends in pup counts. The dynamic response method analyzes

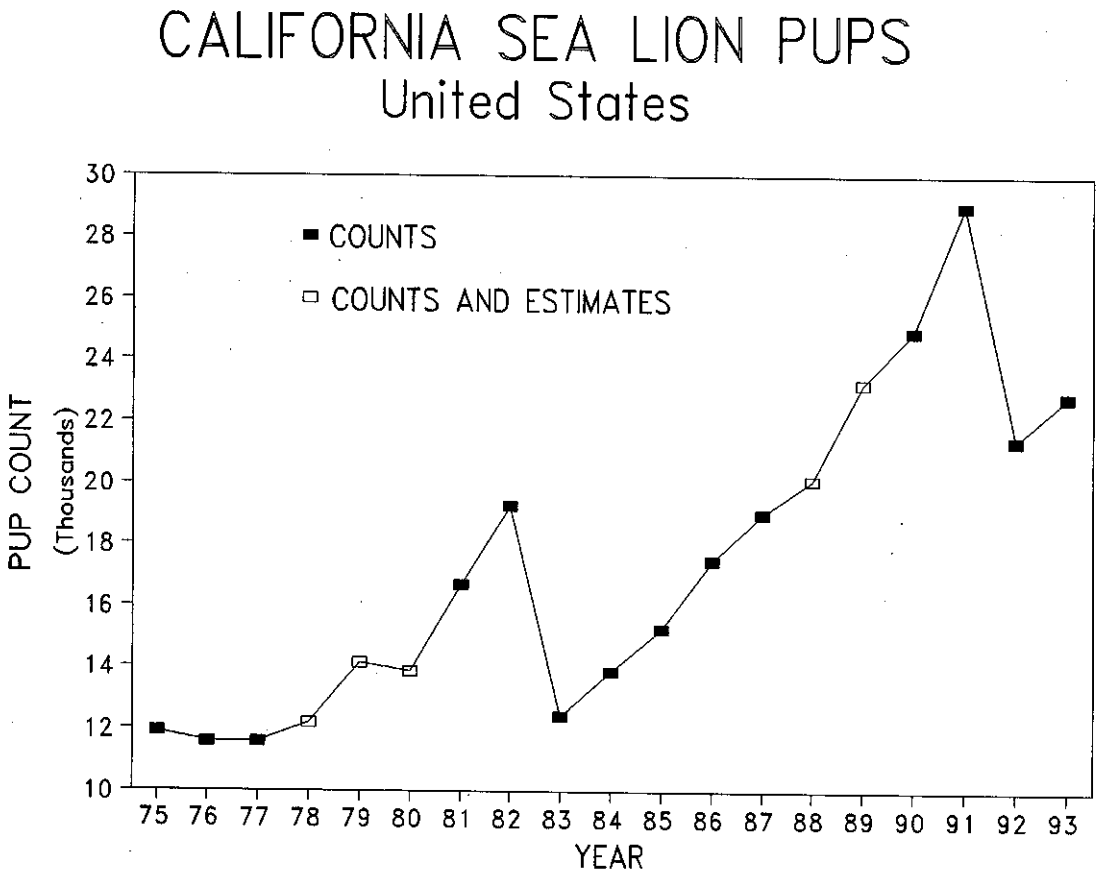

Figure 3. U.S. pup counts for California sea lions.

trends in abundance over time and looks for changes in the rate of population change that are attributable to density dependent mechanisms of population control. Theoretically, this method can be used to detect when a recovering population passes its maximum net productivity level (MNPL), the lower bound of the range of population sizes considered to be within OSP. The form of the dynamic response method used by Boveng assumes that no major environmental fluctuations affecting carrying capacity occur during the time-series analyzed. Since the El Niño event in 1983 violates this assumption, Boveng limited his analysis to the interval 1975 to 1982. The results of Boveng's (1988) analysis indicated that the California sea lion population was below its MNPL. The status of California sea lions was recently re-assessed using pup counts through 1990 (Lowry et al. 1992). This new assessment estimates the U.S. population size at 111,016 sea lions with an increase of 10.2 percent per year since 1983. However, scientists were unable to develop a quantitative assessment of status relative to OSP because 1) there are no data to estimate carrying capacity from historical population levels; and 2) the lack of a density-dependent signal in recent counts of

sea lion pups indicates that data are not sufficient for dynamic response analysis (Gerrodette and DeMaster 1990). Because the population of California sea lions is currently growing exponentially, it is unlikely that the population has reached the MNP level (i.e., there is not statistically significant evidence to suggest that density dependent mechanisms are slowing the growth rate of this population). When the net production of a population starts to decline, a statistically significant slowing trend in population growth should be detected, signaling that the point of maximum net productivity has been passed and the lower bound of OSP reached. Without evidence of density dependence and without knowing what limits or regulates maximum density of this species, it is not possible to estimate the population level where production will be maximized (MNPL). Unfortunately, it is unlikely that NMFS will be able to detect the lower bound of OSP until three to five years after it has been reached. Therefore, the OSP for California sea lions can not be determined at this time.

California sea lions feed on a wide variety of fish and squid. Some of the more common prey within the breeding range in California are Pacific whiting, anchovy, squid, and rockfish (Antonelis et al. 1984, Fiscus 1979, Fiscus and Baines 1966, Scheffer and Neff 1948). North of the breeding range, the diet shifts to those species which are locally and seasonally abundant. Sea lions appear to move into specific areas during the non-breeding season in response to local abundances of prey. In general, they congregate near the mouths of rivers or estuaries where prey are abundant. Seasonal aggregations of sea lions near the mouth of the Columbia and Fraser Rivers are believed to be related to large concentrations of smelt (Beach et al. 1985, Bigg 1985). Salmonids were the most often visually identified prey during surface observations of California sea lions feeding near the mouth of the Rogue River in Oregon (Roffe and Mate 1984). However, of 35 California sea lions collected for food habit studies by Roffe and Mate (1984) in the same area, lamprey was the principal prey occurring in 93 percent of the samples followed in importance by steelhead with 54 percent occurrence and chinook salmon with 11 percent occurrence. In British Columbia, researchers conducting surface observations of harbor seals and sea lions feeding on salmonids documented substantial predation rates as high as 46 percent of the returning adult fall chinook in Comox Harbour (Bigg et al. 1990).

In Puget Sound, sea lions congregate near the Everett/Port Gardner area apparently in response to a large spawning stock of Pacific whiting in Port Susan (Gearin et al. 1986). Important prey in Washington are Pacific whiting, herring, spiny dogfish, codfish and salmonids (Everitt et al. 1981, Gearin et al. 1986, Gearin et al. 1988a). California sea lions feed on steelhead, coho, sockeye, chum and chinook salmon throughout Washington, both on free swimming fish and from gillnets and hook-and-line

gear (Gearin et al. 1986, Gearin et al. 1988b). No estimates are available on the total biomass of salmonids consumed by California sea lions on a state-wide basis. Bite marks, scratches, and scars attributable to either sea lions or harbor seals have been observed on various salmonids in a number of the Columbia River fish hatcheries and fishways (Scordino 1993). Increased pinniped marks noted on spring chinook entering the Snake River (Harmon et al. 1994) have raised questions on the impacts of pinnipeds on Snake River salmon listed under the Endangered Species Act. These "marked" fish represent only those that escaped and survived a predation attempt; at this time, although the marks may provide an index to trends in pinniped/salmon interactions, they do not provide a measure of the incidence of successful predation on salmon (Scordino 1993).

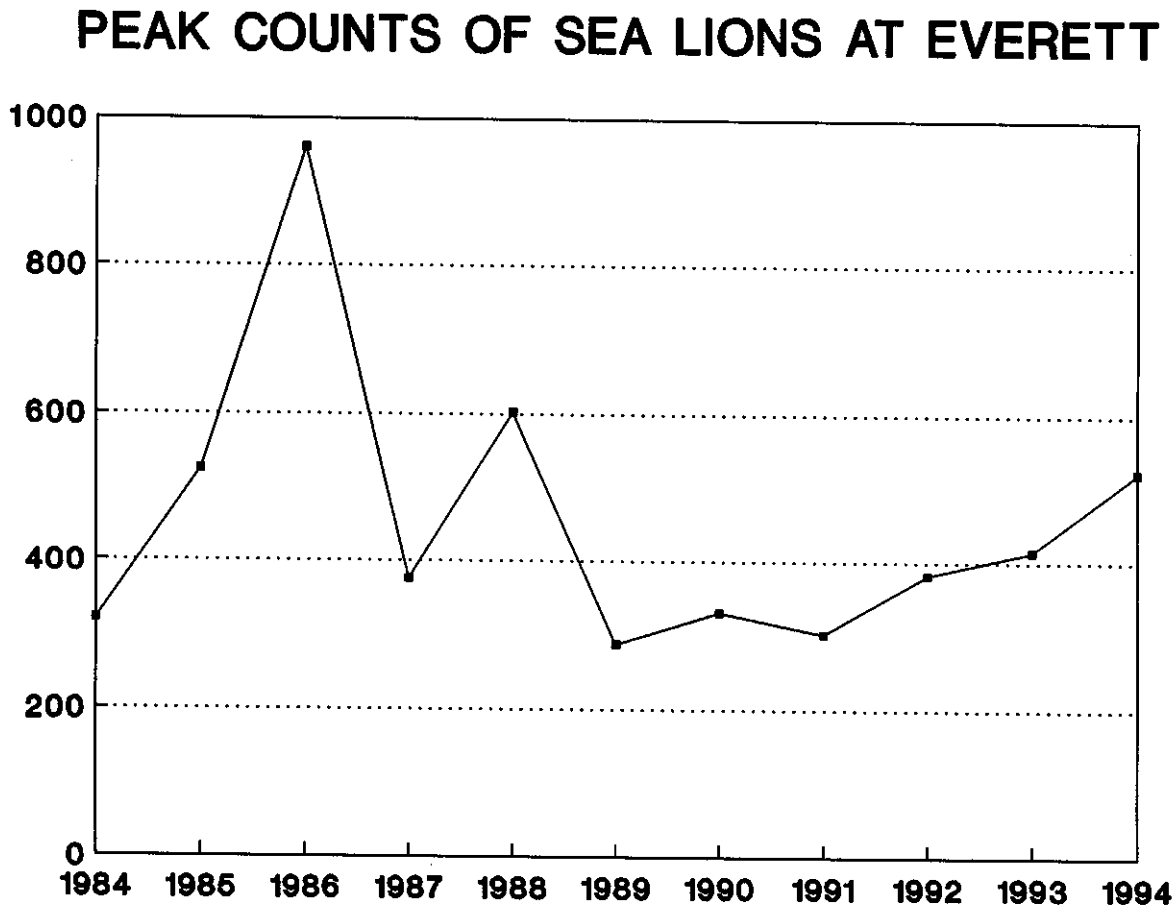

Figure 4. Peak counts of California sea lions each year at the Everett, Washington index area.

California sea lions interact with almost every commercial fishery in the Pacific Northwest. California sea lions have been documented interacting with tribal set-net fisheries for coho and steelhead in the Lake Washington Ship Canal and substantial losses of steelhead from nets have been observed (Gearin et al. 1986). NMFS studies on marine mammal interactions with treaty Indian gillnet fisheries in other areas of Puget Sound also documented that California sea lions caused considerable damage to the treaty Indian set-net fishery for steelhead in the winter (Gearin et al. 1988b). Sea lions commonly tear through salmonid gillnets when depredating the nets and entanglement mortality therefore is uncommon.

Large numbers of California sea lions were first recorded in Puget Sound in 1979 when 108 were sighted at Everett (Everitt et al. 1980) and increased each year through 1986. The numbers of sea lions counted throughout Puget Sound reached a peak in 1986 when over 1,000 animals were counted (Gearin et al. 1986). The numbers counted then leveled off at about 300 to 500 animals seasonally (Figure 4).

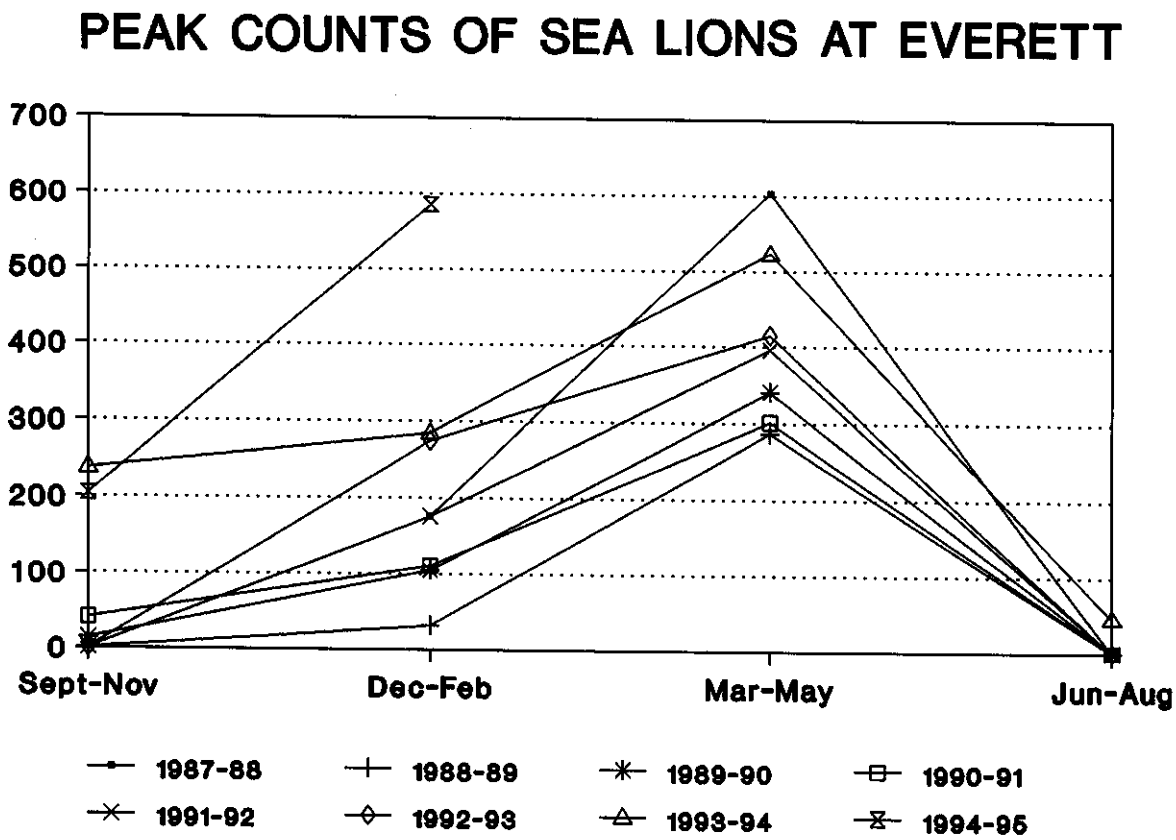

Figure 5. Peak quarterly counts of California sea lions at Everett, WA. (Note high peak count in December 1994).

Peak counts in Puget Sound occur in late March or early April when additional animals apparently move south from British Columbia. A recent count of over 600 California sea lions in Everett in December 1994 is the highest count recorded to date for Puget Sound in December. This count is also higher than the annual April peak count in most past years and may indicate a much larger population in Puget Sound in 1995 (Figure 5). It should be noted that these counts underestimate the total number of animals in Puget Sound since there is no time when all animals are accessible for counting.

The numbers of animals in Shilshole Bay (just outside the Ship Canal) have increased during the winter and early spring (Figure 6) in recent years. Counts at Shilshole Bay, at the entrance to the Ship Canal, have peaked at 40 to 50 sea lions in April in prior years (Figure 6). In 1994, however, the peak counts at Shilshole occurred in May and sea lions were present through June (Figure 6).

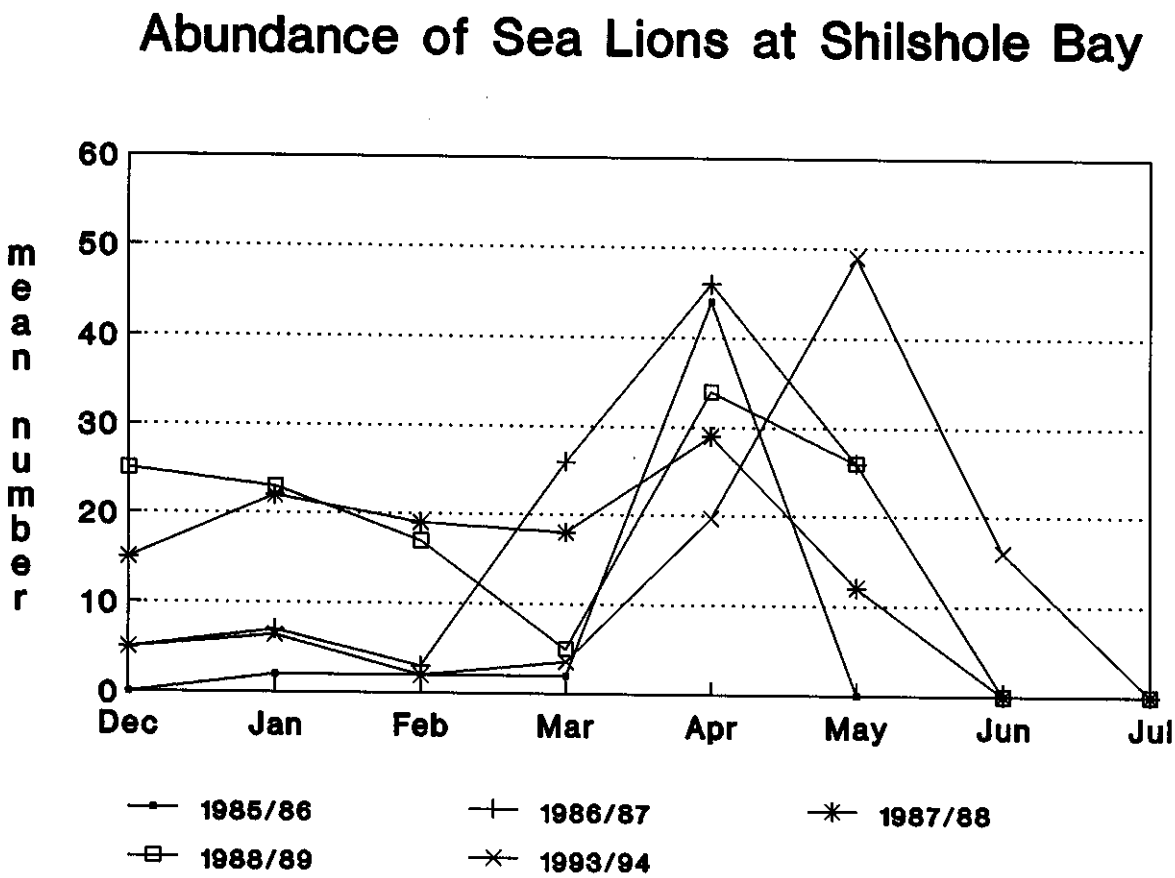

Figure 6. Mean monthly counts of California sea lions in Shilshole Bay.

Resights of California sea lions captured at Shilshole Bay

From February 1989 through April 1994, 45 sea lions were captured and permanently marked at Shilshole Bay. In 1989, 39 individuals were captured and 37 were translocated to the outer Washington coast. In 1990, 6 sea lions were captured and translocated to southern California. Three of the animals captured during 1990 were re-captures of animals (#17, #21 and #22) first captured in 1989. During 1994, four individuals were captured including one animal (#32) which was originally captured in 1989. Of the total of 45 individuals captured since 1989, 2 died during initial handling and 3 others have since been found beachcast (dead) on beaches in California or Washington. Records of resights of these marked sea lions over the last 5 years (see Appendix A) indicate that 26 of 45 individuals (58 percent) marked at Shilshole Bay have been observed in the Locks area either before or after their capture (Table 3). Twenty-two (49 percent) were observed at the Locks after their capture. Thirty-six individuals (80 percent) have been observed at Shilshole Bay since their initial capture, and 31 (69 percent) have been observed at Everett, Washington. Of the 22 animals which were seen at the Locks after their capture, 14 (64 percent) were observed there less than 5 days, and 8 were observed on 10 days or more, with 2 observed repeatedly on over 100 days at the Locks (Table 4). Sea lion #17 returned annually to the Locks from 1989 to 1994. During the 1993/94 season at Shilshole Bay, only 3 of the previously marked animals (#17, #32, and #45) were observed at the Locks.

Of the 45 individual sea lions captured and marked in Shilshole Bay through 1990, twelve of these have been observed preying on steelhead at the Locks facility (Table 4). One of these animals is known to be dead (#15). Only three of these marked sea lions (#17, #32 and #41) have been observed at the Locks facility after 1990 and only two of these (#17 and #41) have been observed preying on steelhead.

Table 3. Summary of sightings of 45 marked California sea lions at Locks, Shilshole Bay and Everett through October 1994.

Pre-Capture Sighting at Locks	Post-Capture Sighting at Locks	Resights at Locks	Resights at Shilshole Bay	Resights at Everett
11	22	26	36	31

Table 4. Marked California sea lions that have been observed in the Locks area and observed preying on steelhead.

I.D. Number	Number of Days Observed at Locks	Predation Observed	Last Sighting at Locks
1	10	yes	Feb. 1989
2	4		(dead 2/15/89)
6	3	yes	Feb. 1990
7	1		Mar. 1989
8	1		Dec. 1989
9	3		(dead 1/30/94)
11	1		Apr. 1989
12	1		Dec. 1989
15	19	yes	(dead 2/1/90)
16	1		Apr. 1989
17	133	yes	May 1994
19	71	yes	Apr. 1990
21	1		Mar. 1989
23	10	yes	Feb. 1990
24	1		(dead 6/23/89)
25	138	yes	Apr. 1990
28	1		Apr. 1989
29	1		Apr. 1989
30	23	yes	Apr. 1990
31	1		Mar. 1990
32	5		Nov. 1993
34	3	yes	Apr. 1989
38	42	yes	Apr. 1989
41	40	yes	Apr. 1991
42	88	yes	Apr. 1991
45	7		Mar. 1994

Sea Lion Predation Control Efforts at the Locks

Efforts to control California sea lion predation at the Locks were first undertaken during the 1980/81 run when WDFW agents attempted to harass a large sea lion that had been observed by sport fishermen consuming steelhead. Prior to 1980, most reports of pinniped occurrence or predation at the Locks were attributed to "seals." The earliest known positive identification of a California sea lion at the Locks is a newspaper article in December 1970 that had a photograph of a California sea lion at the Locks (Seattle Times, December 17, 1970).

During the 1983/84 steelhead run, WDFW agents used firecrackers intermittently to chase sea lions away from the fishway area. In the spring of 1984, WDFW wildlife researchers attempted to repel sea lions from the fishway area with an acoustic harassment device (a "Sealchaser" - see Section V.C.1.a. of this document). The acoustic device worked for only a short time in repelling sea lions before the sea lions appeared to ignore the noise and remain in the fishway area. During the 1984/85 run, WDFW agents

continued using firecrackers intermittently. Data collected by the Corps in early 1985, indicate that three to four different sea lions were foraging in the Locks area and averaging about one steelhead consumed every 1.5 hours (Van Doornik 1985). The 1984/85 wild steelhead spawning escapement dropped dramatically and it was assumed to be caused by sea lion predation.

Because of the dramatic decline in the 1984/85 spawning escapement, an interagency group consisting of NMFS, WDFW, the Corps and the Muckleshoot and Suquamish Indian Tribes began cooperative efforts in the fall of 1985 directed at increasing wild steelhead escapement and controlling sea lion predation. During the 1985/86 run, an intensive predation monitoring and sea lion harassment program was initiated. Underwater firecrackers ("Seal Control Devices" - see Section V.C.1.a. of this document), were used relatively successfully to remove sea lions from the Locks area. Predation on wild steelhead amounted to only 329 fish which was 15 percent of the wild run. The firecrackers were tossed from shore as well as from chaser boats. Acoustic harassment devices also were used in conjunction with the firecrackers; the acoustic devices were suspended from the cable in the spillway area and used in a small chaser boat. Methods and results from efforts in 1985/86 are provided in more detail in Gearin et al. (1986).

In 1986/87, the harassment efforts using firecrackers continued, however with less success. Some sea lions were either not responsive to the firecrackers even when deployed close to them, or would move briefly in response to the firecrackers, but quickly return. Capture was tested using an entangling net. Attempts were made over three days and no sea lions were captured. Taste aversion conditioning using tethered steelhead laced with lithium chloride also was attempted, but without success. Intensified harassment efforts involved long distance vessel chases, boat hazing, increased use of firecrackers and use of the Sealchaser. Initial ballistic testing with rubber projectiles that might be used at the Locks for tactile harassment were conducted (but not at the Locks). The overall predation increased to 42 percent of the run. Methods and results from efforts in 1986/87 are provided in more detail in Gearin et al. (1988a).

During the 1987/88 run, a barrier net was installed in the spillway near fish ladder to prevent sea lion access to principal predation areas. Harassment efforts continued using firecrackers in combination with boat hazing. The barrier was not fully successful because several sea lions quickly learned to forage effectively at the face of the barrier in spite of harassment and thereby likely impeded fish passage. Increased predation was documented downstream of the barrier and overall predation increased to 52 percent of the wild run. A radio controlled boat, from an avian predator control firm, also was tested as a

hazing platform for deterring sea lions and found to be ineffective. Several sea lions were darted with plastic streamers for identification and found to be using a mooring buoy at the entrance to the Ship Canal in Shilshole Bay as a haul-out platform. At least one sea lion remained on the freshwater side of the Locks through the summer of 1988 and was observed consuming sockeye exiting the fish ladder. Methods and results from efforts in 1987/88 are provided in more detail in Pfeifer et al. (1989).

During the 1988/89 run, a capture/transport program was implemented. A total of 39 California sea lions were captured on the mooring buoy in Shilshole Bay and transported to the outer coast of Washington (Long Beach peninsula). Sea lions were captured, transported to a NMFS facility for marking (branding and flipper tags), and then transported in a horse trailer to Klipsan Beach on the Long Beach peninsula and released. Two of the first four sea lions captured died as a result of complications from use of sedative drugs during marking, and use of drugs was suspended. 29 of the 37 sea lions transported to the outer coast returned to Puget Sound in an average of 15 days (ranged from 4 days to 45 days). 12 sea lions were recaptured more than once (9 twice, 1 three times and 2 four times) resulting in a total of 54 relocations. In spite of the capture/transport efforts, sea lions foraged daily at the Locks through the season and predation increased to 65 percent of the wild run (Pfeifer 1989). Sport and fisheries on all steelhead in the Lake Washington system were closed to eliminate all takes of wild winter-run steelhead. Further ballistic testing of rubber projectiles was conducted (not at Locks) with preliminary results indicating that most projectiles discharged from a firearm that may be effective with sea lions (without serious injury) would be difficult, if not impossible, to use at Locks because of public safety concerns due to projectile ricochet on the surface of the water (i.e., safety concerns for people and vessels in the area being struck due to projectile ricochet).

During the 1989/90 run, 6 sea lions were captured and relocated back to their breeding area off southern California (Channel Islands). Attempts to capture more animals were unsuccessful because animals did not utilize the haul-out trap. Three of the six animals returned to Puget Sound; one in 30 days and the other two in approximately 45 days from their release. A fourth animal returned as far as southern Washington (Columbia River). A tactile harassment program using rubber tipped arrows discharged from a crossbow was attempted, but found to be ineffective. An Interagency Technical Committee was convened to assess structural changes to the Locks facility to reduce predation or enhance fish passage. The Committee did not arrive at any structural modifications, but did make recommendations on fish passage studies and recommended modified water spill patterns over the dam. The recommended altered spill protocol was implemented by

the Corps to attempt to enhance fish passage thereby making steelhead less vulnerable to predation. Total predation was estimated at 59 percent of the wild run (Pfeifer 1991a).

During the 1990/91 through 1992/93 runs, no concerted effort was undertaken to control predation. Predation was monitored only in 1990/91 and was at the same level as 1989/90 with 59 percent of the wild run consumed (Pfeifer 1991b). Several fish passage studies were conducted to assess some factors influencing passage. Fish passage through the fish counter was documented and efforts were undertaken to monitor the salinity of the fishway attraction water and ambient salinity below the dam. Experimentation with illumination of the fishway to enhance nighttime fish passage was conducted in 1991 and 1992. During the 1992/93 run, a limited predation control experiment was conducted with acoustic deterrence devices (Pfeifer 1994c).

During the 1993/94 run, a predation control program was implemented using a phased approach with an acoustic deterrence device placed to create an "acoustic barrier" downstream of the fishway as the first phase, and a capture/relocation effort as the second phase applied only to sea lions that penetrated the acoustic barrier. Four sea lions were captured and translocated; one was transported to the outer coast of Washington and released, and three were relocated to southern California in April. In addition, one harbor seal was captured at the Locks and transported to Hood Canal. Total estimated predation amounted to 8 percent of the run. Although several sea lions penetrated the acoustic barrier, they exhibited different behavior when exposed to the acoustic noise and no predation was observed in the ensonified area. However, because the total run was only 76 wild steelhead, it is not possible to conclude that the reduced predation was attributable to the acoustic devices or if it was an artifact of the low run.

IV.D. Winter-run Steelhead

The life history of steelhead, Oncorhynchus mykiss, is described in Shapovalov and Taft (1954). Wild steelhead spawn from mid-March to early June, and their eggs hatch in four to seven weeks (depending on water temperature) and fry emerge two to three weeks later (Cooper and Johnson 1992). Juvenile steelhead spend up to two years in freshwater before migrating to sea as seven to nine inch smolts. Steelhead spend one to three years at sea with most returning to freshwater to spawn after two years at sea. About ten percent will spawn more than once.

The winter-run of steelhead returning to the Lake Washington basin is currently composed of wild naturally reproducing fish and hatchery origin fish that are stocked in the Lake Washington basin as smolts. The return timing of the two groups is

different, but does overlap. Hatchery fish return principally from early December to early February, and the wild fish return from late December through May. Both groups were taken historically in sport and treaty Indian fisheries, although in recent years when a harvest was permitted, tribal fisheries have been structured to target on the hatchery component of the run by focusing the timing of the fishery to coincide with the earlier hatchery return.

Hatchery origin steelhead. The early season steelhead returns (commencing late November) are primarily hatchery fish which can be identified by a clipped adipose fin and a scale growth pattern that is different from wild fish. Hatchery fish from Chambers Creek have been introduced into the Lake Washington basin since 1958 for the sole purpose of providing harvest opportunities when they return, and are not intended to be recovered for hatchery brood stock nor to survive to spawn within the system. Stocking of hatchery origin smolts (all have clipped adipose fins) into the Lake Washington basin occurs in the spring. About 60 to 65 thousand steelhead smolts used to be planted annually in the Cedar and Sammamish Rivers with virtually all smolts coming from WDFW's Green River rearing ponds or the WDFW South Tacoma Hatchery. Fish from the Chambers Creek stock are the source for steelhead production at both facilities because their run timing is predictably early and of short duration thereby permitting fisheries to target on hatchery fish. However, as described below under Fisheries Management, WDFW has terminated smolt stocking into the Lake Washington basin; no hatchery smolts were planted in the Lake Washington basin in 1992 and 1994, and only about 30,000 were planted in 1993.

Wild steelhead. Prior to the construction of the Locks in 1916, wild steelhead entered the Lake Washington basin through the old Black River lake outlet. The Black River drained into the Green/Duwamish River near present day city of Tukwila. When Lake Washington was lowered in 1916, the Black River was dewatered and the new lake outlet was through Lake Union and the new Ship Canal out into Shilshole Bay. Juvenile fish emigration from the Lake Washington basin was most likely not affected by the change of the lake outlet from the Black River to Shilshole Bay because smolts are believed to find their point of egress by moving along the shoreline until outflowing stream currents are detected. Once the current is located the smolts drift with it or actively swim downstream. Adult steelhead returning to the system would probably have been homing to an olfactory cue imparted by the organic and/or inorganic components unique to the Lake Washington basin (Brannon 1982). Some fish may have entered the Green/Duwamish River in the early years, since components of that river system would be part of the odor train that these fish experienced as emigrating juveniles, while others may have sought the new outlet at Shilshole Bay.

Genetic Uniqueness of the Wild Winter-Run Steelhead

Juvenile steelhead were collected from the Cedar River mainstem in the spring of 1993 and 1994. In 1993, the collections occurred at three locations below Landsburg dam (in the anadromous fish zone). In 1994, collections occurred in both the anadromous fish zone, as well as in the "middle" reach of the Cedar River between Landsburg dam and Cedar Falls, which supported steelhead prior to 1904, when that 11-mile reach was blocked to anadromous fish by the City of Seattle. Rainbow trout also were collected from the Chester Morse Lake system above the historic anadromous fish barrier.

Results from analysis of the 1993 Cedar River winter-run steelhead indicate that there has been minimal genetic contribution from past stocking with hatchery winter-run steelhead (Phelps et al. 1994). Most significantly, the lack of alleles associated with hatchery (Chambers Creek) fish in Cedar River steelhead was strong evidence for a low degree of past matings between the Chambers Creek stock and the wild Cedar River steelhead. Cedar River steelhead also exhibited several rare alleles not found in most other steelhead stocks examined in Washington.

Fisheries Management

WDFW fisheries managers meet regularly with treaty Indian tribe fisheries managers to set seasons and catch quotas designed to divide the harvestable surplus between treaty Indian and non-Indian sport users of returning hatchery and available wild fish (harvestable surplus). In recent years, a negligible or non-existent harvestable surplus of wild fish, coupled with reduced landings of harvestable hatchery steelhead due to sea lion predation on netted fish, has resulted in voluntary termination of tribal fishing due to uneconomical returns from small catches. The lack of a harvestable surplus of wild fish has resulted in sport fishery restrictions ranging from regulations requiring the release of any wild steelhead caught to total closure of steelhead fishing. In 1994/95, the sport steelhead fisheries will be closed, as they were in past years.

WDFW manages wild steelhead by establishing escapement goals that are sufficient to maintain a healthy self-perpetuating population within the capabilities of the available habitat. It has been determined that optimum use by spawning steelhead of the available habitat within the Lake Washington basin would be achieved with a spawning escapement of 1600 fish (Gibbons et al. 1985). In other words, adequate spawning habitat is available in the Lake Washington basin to provide optimum returns from a spawning escapement of 1600 fish. However, continuing shortfalls in wild steelhead spawning escapement results in under-utilization of viable habitat, abrogates both sport and tribal

opportunity for harvest, and adversely impacts the viability of this run.

Annual basin-wide surveys of wild stock escapements began in the Lake Washington basin in 1983, although mainstem Cedar River aerial surveys had been made in earlier years. Surveys and studies conducted by WDFW in the watershed indicate that adequate and substantial spawning and rearing habitat is available. Therefore, habitat in the Lake Washington basin is not limiting the wild breeding component of the winter run and, in fact, habitat is underutilized when the spawning escapement goal of 1600 wild fish is not reached.

Unlike the wild run, which depends on spawning escapement to maintain run size, hatchery runs are maintained by stocking smolts into the Lake Washington basin each year. The percent survival of hatchery fish is generally lower than wild spawned fish and numbers of returning fish can fluctuate from year to year due to environmental factors, predation or fisheries interceptions, either in freshwater as juveniles or in saltwater during their growth to maturity stage. The average annual return to catch of the hatchery component of the winter run into the Lake Washington basin from 1983 through 1988 was 1966 fish, with a high of 2183 and a low of 1117 (WDFW file records). Only 212 hatchery fish are expected to return in 1994/95 (from the 29,771 smolt plant in 1993). In late 1993, WDFW made the decision to terminate hatchery smolt stocking in the Lake Washington basin for the foreseeable future. The basis for the decision was primarily the need to maximize effectiveness of all efforts to eliminate all sources of mortality on wild steelhead. In the absence of hatchery fish, fisheries that had incidental takes of wild steelhead would cease. Also, hatchery runs had declined and stocking programs could be better applied in other systems with expected higher utilization of returning adult fish in sport and tribal fisheries. WDFW policy allows for immediate resumption of hatchery stocking if predation on the wild steelhead can be brought under control.

Steelhead fisheries are managed based on expected adult returns each year. Returns are adult fish which have survived the juvenile (freshwater) and the growth to maturity (saltwater) stages of their life cycle and have "returned" to the watersheds, in which they originate, to propagate future generations of fish. The number of returning fish in any given year is commonly referred to as "run size". Fisheries managers seek a balanced system which is based on a run size sufficient to ensure that an adequate number of fish "escape" the rigors of earlier life stages, including predators and possible harvest by man, to fully utilize the existing spawning habitat and produce a new generation of fish. The number of fish that return to a watershed that are beyond the "escapement goal," which is the number necessary for spawning and rearing success in the

available habitat, are commonly called the "harvestable surplus." Management of steelhead fisheries in Washington is designed to conserve wild fish. This is accomplished in the Lake Washington basin by regulating the harvest to maximize interception of hatchery fish and to ensure achievement of the 1600 wild fish spawning escapement goal. However, this task has become increasingly more complex as sea lion predation continues to reduce wild returns, so that escapement goals for the Lake Washington basin are not realized. For example, in 1989/90 when run projections indicated sufficient returning fish were expected to sustain a minimal harvest, the entire Lake Washington basin was managed with a wild steelhead release regulation for sport anglers and a brief, closely monitored, tribal commercial fishery designed to prevent incidental harvest of wild fish in excess of 10 percent of the total wild return.

Predictions of run size for winter-run wild steelhead in Lake Washington are complex and involve the use of a brood return formula, in addition to age class component models developed from years of intensive observation on Puget Sound river systems, particularly the adjacent Green River basin. Each year's run is comprised of adult fish from several age classes which are represented proportionally. The proportion of specific age class representation remains stable with only slight variability from year to year. However, actual numbers of returning fish for each age class vary considerably with the strength of the brood return based to a large degree on spawning escapement in the brood year. Each year's run is reconstructed using scale samples collected from commercial landings and, in the past, from samples taken from the Locks fishway. The scale data, which give hatchery/wild composition, as well as age structure needed for complete assignment of fish to all contributing broods, is applied to the treaty Indian harvest and sport harvest data and to the sea lion predation figures. Size of the run is then calculated as the sum of tribal harvest, sport harvest, fish lost to sea lion predation (which is calculated from observations in the lower Ship Canal), and the spawning escapement (as calculated from observations of redds in the watershed).

The number of wild steelhead returning to the Lake Washington basin, including those fish which are consumed by sea lions in the Ship Canal, ranged from 1520 to 2997 for the years 1984 through 1991. Reconstructed run size calculations were not done for 1991/92 or 1992/93 because a full monitoring of predation by sea lions was not possible. However, WDFW did conduct stream surveys in the Lake Washington basin and estimated that 599 steelhead survived to spawn during the 1991/92 run and only 184 steelhead escaped to spawn during the 1992/93 run. Spawning escapement for the 1993/94 run dropped to 70 fish. In two of the past three return cycles, the historically accurate spawner-recruit model for Puget Sound winter steelhead, was unsuccessful in predicting the actual total wild run size. Actual returns

were well below the pre-season prediction. Given the extreme nature of the decline that has been observed in recent years and the discrepancies between preseason forecasts and actual observed run sizes in recent years, WDFW has decided to revise the preseason estimation methodology to capture these negative trends and to weigh more heavily on recent information. Further, WDFW has cast the 1994/95 preseason estimate as a range rather than forecast a single point estimate, especially since the best of circumstances would not change the management regime that the tribes and state have adopted. Therefore, the 1994/95 run forecast is estimated to range between 60 and 371 steelhead based on proportionate averages of returns by age class over the past four years.

Spawner-Recruit Relationships

WDFW developed a generalized model of the number of adult steelhead that return from spawning escapements to western Washington rivers (Gibbons et al. 1985). Wild fish escapements are monitored on many rivers, including the Lake Washington basin, as part of routine management. This model has been used with varying success to predict adult returns from past escapements. It is based on the amount of low-flow habitat available within each basin and the number of parr (thence smolt) production expected on an average year. It does not effectively take into account variation in marine survival or the effect of drought on freshwater production. Nevertheless, it worked fairly well for a number of years leading up to the early 1990s. The ideal situation would be development of individual spawner:recruit curves, or relationships, for each major watershed. It generally requires 20 to 30 or more generations to do an adequate job of this, in order to include the full range of environmental conditions that result in high or low production from the basin. This has not been done for Lake Washington. Based strictly on the measurement of low-flow habitat done in the Lake Washington basin in the early 1980s, and by applying the generalized western Washington model, it is estimated that the Lake Washington basin, if fully seeded and with no harvest, could produce a return of about 3400 to 3900 adults, and with access to the upper Cedar River habitat (above landsburg Dam) about 4800 returning adult fish (Pfeifer 1994b).

Fish Tracking Study

Based on the recommendations of the Ad Hoc Technical Committee to conduct studies on steelhead behavior prior to considering structural modifications at the Locks (Norberg 1990), a fish tracking study was initiated in 1993/94 by Tabor et al. (1994) using acoustic tagging equipment to document movements of steelhead as they approach the Locks facility and the fish ladder. The details of the study and results are presented in Tabor et al. (1994) and are summarized here. Steelhead were

captured with gillnets and an acoustic tag was inserted into their stomach. Steelhead were tracked by a fixed hydrophone system below the spillway. Due to the small run size, only nine steelhead were captured and instrumented. All fish except one moved downstream and left the Ship Canal within 21 hours of release. The one tag that remained in the Ship Canal was in the same location for nine days and was presumed to be a regurgitated tag or a dead fish. Of the remaining eight fish, only two returned to the Ship Canal and passed upstream through the Locks. One fish passed during no-spill conditions and was accurately tracked by the fixed hydrophone array system. The fish spent 8 hours in the array, and was usually located near one of the three sources of freshwater (large lock, small lock, or fish ladder), until it passed through the fish ladder. The other fish passed through the Locks during spill conditions and was not detected by enough hydrophones to determine its exact positions. This fish was detected by the array for 4.7 hours before entering the fish ladder. Both fish took a little over an hour to pass through the fish ladder. Due to the small sample size in 1994, further capture, tagging and tracking of steelhead (hatchery component only) was determined necessary to meet study objectives and such studies are underway during the 1994/95 hatchery steelhead run.

Smolt Predation

In recent years, Locks operators have noted an increase in bird predation activity downstream of the lock chambers. Birds (primarily gulls) have apparently learned to use the turbulent upwelling associated with water releases from the lock chambers as opportunities for efficient predation. Further observations by biologists during the 1994 smolt outmigration period indicated that bird predation may be removing a significant number of downstream migrants. Birds have also been observed preying on outmigrants below the spillway.

In 1993/94, peak counts of sea lions were observed in Shilshole Bay in May (when downstream smolt migration occurs) in contrast to 1986 through 1989 when the peak was in April. There is no data to evaluate sea lion impacts on downstream smolts; however, sea lions were observed below the Locks well into May and June in 1994 when outmigrating smolts were present.

Harbor seals also have been observed with increasing regularity in the area below the Locks, spillway and fish ladder during the late spring and summer smolt migration. Harbor seals have been observed preying on smolts below the dam and several animals are observed on a regular basis in the area immediately above the facility.

It is difficult to quantify smolt predation by pinnipeds below the dam because the animals rarely bring small prey to the surface for consumption. Since pinnipeds are known to prey on

locally abundant species, including juvenile and adult fish, their presence below the Locks during smolt outmigration indicates that some level of predation must be occurring.

In regard to harbor seal predation on adult steelhead, from one to three harbor seals were observed at the Locks facility on 70 percent of the observation days between December 20, 1993 and May 14, 1994, but none were observed preying on adult steelhead. Harbor seals also were observed inside the fish ladder on six days in March 1994 and one was captured in a baited-trap cage (set for sea lions) on March 24, 1994. The presence of harbor seals in the fish ladder may have presented an obstacle to migrating adult fish. Nonetheless, potential effects of harbor seals on adult steelhead have not been determined.

V. ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION AND ALTERNATIVES

V.A. No Action Alternative

Under this alternative, no action would be taken to deter or remove sea lions from the Lake Washington Ship Canal. If no sea lion control occurs, it is likely that sea lions would continue to prey on steelhead and impact spawning escapement. In 1993/94, the predation rate (8 percent) was lower than past years. However, even this level of predation may be significant given the extremely depressed returns observed in 1994 (76 fish). Because of the small run predicted for 1994/95, even zero predation would not result in the escapement goal being met, and serious concerns have been raised over the continued viability of the run if steps are not taken to improve escapement numbers.

This alternative is not consistent with the recommendations to protect returning steelhead made by the Pinniped-Fishery Interaction Task Force.

NMFS is currently considering the eligibility of this run for listing under the Endangered Species Act (ESA) as part of a coastwide status review in response to a petition filed February 16, 1994. The no action alternative would likely result in a negative reaction by a large sector of the public including fishermen, conservationists, and Indian tribes who would want to see actions taken to reduce predation and increase the run. No action would continue, for the long-term, the current economic impact on tribal fishermen and the sport fishery infrastructure due to elimination of fishing opportunity as the run declines. Another consideration is that the effects of continued predation are cumulative. The wild return in any one year is comprised of several age classes of fish, which spreads the impact of predation over several subsequent runs. If unmitigated or unchecked, sea lion predation would continue to be a factor in

the decline of the steelhead run to the point where the run could be quickly driven to low levels that are extremely difficult to rebuild in wild populations. At low population levels, the run is even more vulnerable to loss through environmental perturbations (e.g., flooding, disease, drought) and damage to habitat (e.g., pollution, siltation).

V.B. Lethal Removal

This alternative is to lethally remove any sea lion that enters the Lake Washington Ship Canal. Animals could be shot with a bullet or with a dart which would inject a lethal drug. They could also be captured and transported to a facility for injection of lethal drugs. Because non-lethal approaches to date have not been totally effective in preventing the return of these sea lions or improving wild steelhead escapement, this alternative is considered as the last resort for a cost effective means to directly deal with the predation problem. This alternative differs from the lethal removal under Alternative V.G. in that it has no conditions on undertaking other measures prior to or concurrent with lethal removal as recommended by the Task Force.

The lethal removal of small numbers of male sea lions would have no impact on the population of over 200,000 animals, especially in view of the increasing population trend. Population reduction programs in Puget Sound are not considered within this alternative as they are unlikely to directly address the individual animal problem that is occurring in the Ship Canal.

To provide continued protection to the run, some animals would probably need to be lethally removed annually although the greatest number would likely be taken in the first year. Lethal removal of all problem animals may not be necessary if limited removals with gunfire would serve as a deterrent to other problem animals. It is possible that sea lions would learn quickly that they would be harmed if they enter an area where lethal controls are being applied. This type of aversive behavior to areas where killing occurs may have existed in the Columbia River during the seal bounty program. The seal hunter in the Columbia River bounty program reported that although he killed large numbers of seals in the early years, the numbers decreased in subsequent years because he felt the seals had learned to avoid the area and his vessel (Everitt et al. 1981). One of the principal concerns over this technique is public safety, so only trained, skilled marksmen familiar with sea lion behavior and the Locks environment could be used. There is also concern for safety of people involved in the effort as well as Corps personnel on site as there could be efforts to obstruct a lethal removal effort.

V.C. Non-Lethal Removal

This alternative consists of a number of measures that are each described separately below.

V.C.1. Deterrence

Deterrence consists of varying measures to deter sea lions from the Locks area as described below. Most of these measures have been used on pinnipeds at the Locks or in other areas.

V.C.1.a. Noise Stimuli

The objective of this measure is to use firecrackers or electronic devices to broadcast underwater or aerial sounds that scare sea lions or cause enough discomfort to repel them from the area of concern.

V.C.1.a.i. Underwater firecrackers

Underwater firecrackers (called "seal bombs") have been used to disperse pinnipeds and fish in a number of situations. Firecrackers were used successfully during the 1985/86 run to reduce sea lion predation on steelhead at the entrance to the fishway (Gearin et al. 1986). However, in subsequent years firecrackers became relatively ineffective on several sea lions that habituated to preying on steelhead in the Ship Canal (Pfeifer et al. 1989). Although these sea lions were initially frightened by the firecrackers, they soon began to either return in a few hours or start preying on steelhead in a new area. Some animals, which have been observed over several seasons, appear to have learned to ignore or tolerate the noise. They have also learned to evade close exposure to firecrackers by diving and surfacing in unpredictable patterns. Similar tolerance of firecrackers has been observed in fisheries interaction situations with harbor seals (Geiger and Jeffries 1986). Firecrackers have been shown, however, to be useful for short-term control of sea lions in conjunction with other methods, or if used for control of naive animals that have not previously been exposed to this method.

No visible injuries to sea lions from firecrackers have been observed during use at the Locks. Sea lions that were exposed to repeated use of firecrackers at the Locks from 1986-1988 were observed in subsequent years and showed no ill effects from the exposure. These animals continued to react to noise stimuli indicating they had not been deafened by use of firecrackers. Definitive conclusions on whether firecracker exposure has caused any damage to the inner ear of the pinniped would require

sacrifice of animals for such research. The firecrackers that have been used at the Locks are commercially available underwater firecrackers used for seal control; they produce source level pressures on the order of 190 dB re 1 μPa at 1 meter (Aubrey and Thomas 1984). Most of the sound energy is focused below 1 kHz which is below the range of maximum hearing sensitivity for sea lions (Schusterman et al. 1972). These firecrackers (Seal Control Devices) are manufactured in the U.S. and are regulated by the U.S. Department of Transportation (49 CFR Subtitle B). The Seal Control Devices used at the Locks and commonly available for use as deterrents in agriculture and commercial fishing applications consist of a spiral-wound cardboard tube containing 36 grains of potassium perchlorate and pyro-aluminum flash powder with an 8-second waterproof fuse (Gearin et al. 1986).

Repeated use of large numbers of firecrackers would likely disturb fish and other wildlife and may be potentially damaging to fish. A few dead fish have been observed during periods of intense underwater firecracker use at the Locks and it is possible that the firecrackers may have killed the fish if they exploded near them. Other potential problems with repeated use of firecrackers include handler safety, and possible damage to boats or gear.

Use of larger, stronger firecrackers may be more effective in repelling sea lions, but may have a greater likelihood of killing fish as well as presenting additional user safety problems. Larger firecrackers may only result in dispersing sea lions to other areas as was observed with less powerful firecrackers. The use of larger firecrackers would be considered only if procedures are developed to address the additional disadvantages of potential negative effects on sea lions, other wildlife, people, and steelhead.

V.C.1.a.ii. Cracker shells.

Cracker shells are shotgun shells containing an explosive projectile that is designed to explode in the air or on the water surface at distances of about 50 to 75 yards from the point of discharge. Although the noise may startle sea lions and cause them to flee, there is usually no physical discomfort to the animals involved since the explosion is in the air or on the water's surface. Cracker shells have been used in fishery interaction situations with harbor seals without harming the seals (Beach et al. 1985). The aerial noise from cracker shells likely would be objectionable to nearby residents. Potential impacts on other wildlife would be similar to those described for firecrackers above, except that aerial bursts are more likely to disturb birds in the area. In addition, deployment requires use of a firearm, which may offend some individuals. Based on past observations on the limited effectiveness of firecrackers, this

method does not appear to warrant further consideration.

V.C.1.a.iii. Acoustic harassment device.

An acoustic harassment device (AHD) called the "Sealchaser" was developed by Oregon State University specifically for repelling pinnipeds in fishery conflict and other situations where there was a need to non-lethally remove pinnipeds (Mate and Greenlaw 1981). Initial testing of the Sealchaser with harbor seals indicated it may be effective in repelling seals from certain areas (Mate and Harvey 1987). The Sealchaser produces a high amplitude, pulsed but irregular "white noise" underwater in the 12 to 17 kHz range that is intended to cause physical discomfort and to irritate pinnipeds, thereby repelling them from the area of the sound (Mate and Greenlaw 1981). A complete description of the Sealchaser and the areas that it has been used is presented in a workshop report on "Acoustic Deterrents in Marine Mammal/Fishery Conflicts" (Mate and Harvey 1987). The output of the Sealchaser is designed to vary randomly to reduce habituation. The Sealchaser produces bursts of short, upswept tones. Norberg and Bain (1994) measured the output of the Sealchaser and found that it produces source sound pressure levels of 188 dB_{RMS} re 1 μPa at 1 meter near the end of a tone. The individual tones last approximately 0.1 seconds, and sweep up in frequency from about 11.5 kHz to 15 kHz while increasing gradually in intensity. The bursts last between 4 and 5 seconds, and consist of approximately 20 to 25 tones.

Acoustic devices have been used with varying degrees of success. The principal problem encountered with acoustic devices is that the marine mammals learned to tolerate the noise. The Sealchaser was previously used to attempt to control sea lion predation at the Locks facility, but was found to be ineffective for long term use at that time (NMFS and WDFW 1989). Sound pressures from the Sealchaser were not high enough to create sufficient physical discomfort to overcome the ability of sea lions to learn that the negative stimulus could be tolerated. During predation control efforts at the Locks, sea lions also learned to tolerate close exposure to underwater firecrackers. Also, a negative side effect of this method is the potential development of a conditioned response in the animals whereby they learn that the noise is associated with the presence of fish thereby attracting rather than deterring animals (Geiger and Jeffries 1986). On the positive side, the AHD does not appear to affect fish. The Sealchaser was tested in the presence of steelhead in the fish ladder without causing noticeable behavioral changes in the fish. The use of AHDs do not warrant further consideration unless combined with other methods because, in the absence of pain, noise irritation is insufficient to provide little more than a short-term effect. The use of more powerful acoustic devices to create an acoustic barrier is described in Alternative V.C.3.

V.C.1.a.iv. Other devices.

There may be some other noise generating device that might have a practical or potential application to controlling sea lions. However, to date no such device has been found. A type of pneumatic plunger (Stone & Webster Engineering Co. 1986) trade named "Ribair" which produces underwater noises and bubbles was observed and evaluated by NMFS and WDFW in 1987 and determined to have no practical application at the Locks. Underwater transmission of hard rock music has also been suggested by the public, however it is unlikely to have any effect on sea lions. Other airborne sounds such as whistles, fog horns, aerial explosions and other loud noises are not feasible for consideration due to the disturbance they would cause to other wildlife species and people, as well as potential interference with navigational communications necessary for vessel traffic in the Locks.

V.C.1.b. Vessel Hazing and Chasing.

This measure would involve chasing or hazing sea lions with a vessel or with a radio-controlled model boat.

Vessel chases have been used in the past, but some animals learned to avoid the vessel or swim under it. No attempts were made to strike the animals with the vessels and all actions were directed at scaring the sea lions away from the spillway area or chasing them downstream. These measures are limited in application due to prohibitions on vessel use directly below the dam and adjacent to the fishway entrance (inside the safety cable in the spillway) due to safety concerns especially during times when large amounts of water is spilling over the dam. Chases are also restricted by structures in the area and must be restrained to avoid navigational conflicts. Vessel chases may be effective on some animals and possibly in combination with other measures.

A model "hazing" boat was tested in the spillway area of the Locks in 1987 and found to be impractical and ineffective (Pfeifer et al. 1989). Hazing sea lions with the radio-controlled model boat did not cause sea lions to leave the area. Further drawback is that the model boat could not be navigated in the turbulence in the spillway during spills. The model boat approach does not warrant further consideration.

V.C.1.c. Tactile Harassment

This measure involves shooting target animals with non-lethal projectiles such as rubber bullets or blunt-tipped arrows. Firing could be from either a boat, or from piers or walkways

along the shore. If successful, sea lions could be conditioned to avoid the area. Tactile harassment has been used successfully by instilling an avoidance reaction in other wildlife species (e.g., grizzly bears and polar bears) in certain situations. The projectiles being considered under this measure are designed not to penetrate the sea lion's hide and would not be used if there is a potential public safety or property damage problem.

Ballistic tests were conducted in 1988 and 1989 on some of the projectiles that have been used on other wildlife species. The intent was to evaluate the safety of the method both to the public and the sea lions. Several firearm-discharged projectiles and blunt arrows were found to be safe if used under specific established protocols.

Tactile harassment was attempted in 1989/90. Because of the urban setting and concerns about firearm discharge noise and projectile ricochet, tethered rubber tipped arrows discharged from a cross-bow were used. The discharge protocol required that all shots be made at the back area of the animal; no shots were to be taken if there was any possibility of striking the animal's head. During the tactile harassment tests in 1990, sea lions entered the target zone near the entrance to the fish ladder 241 times and 33 hits (out of 40 shots) were documented (Pfeifer et al. 1989). Some animals showed avoidance behavior after being hit while others did not. Sea lion #25, which accounted for the majority of the steelhead kills in 1989/90, entered the target zone 70 times and was hit 6 times. This animal appeared to avoid the surface area near the ladder when the "shooter" was present, but still preyed on steelhead. Based on no significant change in predation rates with use of this measure (Pfeifer et al. 1989) and the avoidance behavior observed, this method is not viewed as an effective technique.

V.C.2. Aversive Conditioning

The objective of this measure is to condition sea lions to avoid eating steelhead and/or avoid the Locks area. This avoidance response (aversion) would be accomplished by conditioning or "training" the animals to associate eating steelhead with illness or pain. This technique has been used with other wildlife species such as with coyotes to condition them not to eat sheep (Forthman-Quick et al. 1985).

V.C.2.a. Taste aversion through treated fish

This measure involves putting an emetic agent into a steelhead to induce vomiting by the sea lion when consumed. The technique requires implantation of emetic salt gelatin capsules in the body cavities of dead steelhead to be used as bait. The theory is

that if a sea lion is made sick by eating a specific type of treated fish, it would develop an aversion to that fish. This measure would not result in an aversion to all fish, only to those to which the animal has been conditioned. This technique has been successfully used on a prey specific basis with captive California sea lions (Kuljis 1986). Using lithium chloride treated fish, Kuljis (1986) conditioned captive sea lions to avoid one of three preferred prey species without affecting the animals desire to eat the other two species.

Taste aversion using lithium chloride was attempted on sea lions at the Locks during the 1986/87 run. However, the effort was discontinued because the treated sea lions remained in the area exhibiting predatory behavior and pre-treatment predation rates resumed within 5 days (Gearin et al. 1988). Because this technique requires successful, repeated conditioning of many individual sea lions in the Locks area to be effective, it does not appear to be an effective deterrent in this situation. The overall effectiveness is compromised as it is possible that some of the problem animals may not be treatable. Drawbacks to this technique also include the possibility of lost or partially eaten fish being consumed by other wildlife. Water quality concerns with the chemical would be minimal due to the small quantities used.

V.C.2.b. Taste aversion through injection

Another method of applying an emetic agent would be to dart (inject) it directly into the target sea lion at the time that it consumes a fish. This approach would negate the possibility that the aversion would apply only to eating dead fish as has occurred during aversion conditioning using treated bait with other wildlife (Forthman-Quick et al. 1985). Potential drawbacks include: 1) inability to strike animals that may stay in the middle of the channel out of range; 2) aesthetic concerns by some over use of gun; and, 3) lack of testing on wild sea lions. Some testing with captive animals may be necessary to determine dosage levels and any side effects before this technique is applied to wild animals.

V.C.2.c. Shock collars

This approach would require affixing a shock collar or pack on a sea lion that would be triggered to shock the animal when it enters the Locks area thereby potentially conditioning the animal to avoid the area to avoid being shocked. This concept has been used to control the movement of dogs with "invisible fences." However, such devices have not been developed for the marine water environment and use on sea lions would need to be tested on captive animals prior to use in the field. Due to apparent lack

of skin sensitivity in sea lions, the electrical probes would likely have to penetrate deeply into the skin to be effective. The devices also would have to be designed to fall off naturally with time so that they do not encumber the sea lion when it migrates south. Use of such devices would be complicated by use in the marine environment and potential long periods underwater depending on where and how the "shocker" is attached and/or triggered. This approach could be harmful to individual animals if the shocker malfunctions. Given the uncertainties of the technology and application to wild marine animals and the necessity to capture and immobilize the animals to apply and possibly remove the collar, this measure is not feasible for application on the sea lions at the Locks.

V.C.3. Acoustic Barrier

The objective of this measure is to establish an acoustic ensonified zone (an acoustic "barrier") underwater in the area below the spillway dam and fish ladder to control the presence of California sea lions and reduce their predation on returning wild winter-run steelhead. The acoustic barrier would be implemented by placing arrays of directional and omni-directional acoustic deterrent devices (ADD) in the area below the spillway dam to create an ensonified zone with sufficient intensity to cause a negative reaction to the area by sea lions. An acoustic barrier was implemented using ADDs during the 1993/94 steelhead run.

The ADDs are an advanced version of the acoustic harassment devices that were developed for use in deterring seals and sea lions from commercial salmon net pen and salmon ranch facilities (described above under Alternative V.C.1.a.iii.). The omni-directional ADD array produces periodic sound emissions at a frequency centered at 10 kHz with source levels between 190-196 dB_{RMS} re 1 μPa at 1 meter (Norberg and Bain 1994). The array cycles through four transducers in a period of 17-17.6 seconds. Each transducer fires individually in sequence during a cycle and produces a chirp lasting 2.3-2.5 seconds. Each chirp is composed of about 60 pulses lasting from 0.5-2.5 mseconds each. A pause, lasting about 2 seconds occurs between chirps as the transmitter signal advances from one transducer to the next. The directional ADD array produces higher sound pressures than the omni-directional transducers. Pulse source levels of the directional array are about 206 dB_{RMS} re 1 μPa at 1 meter with a duration of approximately 1 msecond; the frequency centers at 15 kHz rather than 10 kHz (Norberg and Bain 1994).

Sound pressure levels produced by the directional ADD array are designed to be at or above the 200-220 dB estimated pain threshold for California sea lions (Greenlaw 1987, Aubrey and Thomas 1984). However, because of spreading losses on the order of 20 dB re 1 μPa for each ten fold increase in distance (Urick

1983), sea lions would not be exposed to sound pressures of this intensity unless they approach within about 3 meters of an operating directional transducer. Pain threshold estimates are based on extensive medical research which has been done on the human ear and on hearing in other terrestrial mammals but little empirical work has been done in this area for pinnipeds. The pain threshold estimates may be affected by diving adaptations of the inner ear in sea lions. Measurements of the sound pressures produced by the ADD arrays at the Locks in 1994 indicated that the acoustic barrier was strongest near the dam. In the area where the arrays were deployed, sound pressures of approximately 170 dB_{RMS} re 1 μPa were measured. These sound pressures were significantly decreased in the presence of turbulence caused by spill over the dam (Norberg and Bain 1994).

In open water tests of the ADD equipment by Norberg and Bain (1994) in water depths of approximately 15 to 23 meters, measured sound levels (dB_{RMS} re 1 μPa for strongest pulse) at sampled distances greater than 1 meter ranged from 185.6 dB_{RMS} for the directional array at 10 meters down to 139.7 dB_{RMS} for the omni-directional array at 1000 meters. During the open water measurements, signal levels from the arrays declined by approximately 17.8 dB for each 10-fold increase in distance as shown by regression analysis. This is similar to the 20 dB decline with each ten-fold increase in distance expected under ideal conditions (Urick 1983).

During the initial consideration of use of ADDs in 1992, a concern was expressed that sound pressure levels on the order of 200-220 dB_{RMS} re 1 μPa (for a constant tone of more than 1 second) could present some potential for causing temporary or permanent hearing loss for sea lions that enter the ensonified zone and remain there (Ann Bowles, Hubbs Sea-World Research Institute, pers. com. 1992). The potential hearing loss may be confined to a narrow frequency band at the operational frequency of the devices. In response to these concerns, NMFS conducted calibrated "in-situ" measurements of the actual sound pressure levels produced by the array to determine if the theoretical outputs are in fact realized in the field (Norberg and Bain 1994). The measurements showed that the directional ADDs produce sound pressures in this range, however, the duration of a pulse is approximately 1 msecond. In addition, because of spreading losses and boundary effects (i.e., reflection from surface and bottom, and absorption by entrained air), the area where sound pressures of this magnitude would be encountered by sea lions is quite small (within three meters of transducer). It is unlikely that sea lions would be in the immediate vicinity of an operating transducer for sufficient time to sustain permanent hearing damage. To minimize the likelihood of unintentional close exposure while the acoustic barrier is being activated, the ADD array is designed to come on gradually on initial start-up, which would allow animals to leave the immediate area before maximum

sound levels are reached.

In regard to effects on fish, tests conducted by Mate et al. (1987) with acoustic devices indicate that sound pressure levels of 195 dB/μPa at one meter and frequency ranges from 8 to 12 kHz within an enclosed tank had no effect on adult salmonids or spawn viability. Frequencies above 1 kHz were shown to be beyond the normal "hearing" range of the fish. To determine if the increased sound pressure levels produced by the ADD's might cause a reaction by returning salmonids, tests were conducted at the Locks facility on September 25, 1992. An omni-directional ADD unit was tested in the fishway viewing chamber with adult chinook and jack coho salmon present. No response by the fish was observed. Discussions with a fish pathologist indicated that tissue damage to steelhead would be unlikely if no sign of response was observed from the fish when exposed to the sound (John Morrison, USFWS, pers. com. 1992). Because previous tests conducted by Mate et al. (1987) showed that exposure to sound from acoustic transducers operating at similar pressure levels and frequencies had no effect on salmonid behavior or spawn viability, and because observations of returning coho and chinook in the fishway viewing chamber yielded no observable response, operation of the ADDs should have no effect on returning steelhead.

WDFW conducted some preliminary tests with the ADDs at the Locks facility during the 1992/93 steelhead run (Pfeifer 1994c). The devices were tested during three 7-14 day timeframes with alternating days of the devices "on" and "off." The ADDs initially appeared effective in deterring sea lions from entering the spillway area. However, after about three days of operation, one sea lion was observed inside the "ensonified" area. This sea lion had a #17 brand on it (from the 1988/89 marking/relocation effort) and had been documented as one of the principal problem animals in past years. The majority of the observed steelhead mortalities in 1992/93 were attributed to animal #17 although additional sea lions were observed passing the acoustic barrier during the second and third test periods. The results of the preliminary tests in 1992/93 were inconclusive because 1) the experimental design was strongly influenced by fiscal constraints resulting in limited test periods, i.e. the ADD array was only "on" for a total of 13 days spread over three test periods spanning a four month period; 2) sea lions may have habituated to feeding in the area during the long "off" periods and therefore may have been less affected by the devices; 3) the devices may not have performed at maximum efficiency during the later tests due to algal and barnacle growth on the transducers which accumulated during the periods between testing; and 4) due to small numbers of steelhead passing through the fishway, the sample size was too small for statistical analyses on steelhead kill rates during periods when the device was "on" versus "off". The devices were therefore reinstalled during the 1993/94 season.

For the 1993/94 steelhead run, ADDs consisting of four omni-directional transducers and three directional transducers were installed on January 7, 1994 and activated on January 8. The location of the transducers in the spillway area near the fish ladder are shown in Figure 7. The acoustic barrier was in operation for 24 hours per day through June 6, 1994 except during periods of malfunctions or short term shutdowns. The omni-directional array was off for repairs 76 hours in February, 10 hours in March, 30 hours in April, and 84 hours in May. In addition, one of the directional transducers was found to be inoperative when it was removed in June. Indications are that the transducer failed shortly after installation. Also, the ADDs were intentionally turned off for short periods of up to two and one half hours at a time during sea lion capture attempts near the dam in March. This was done to encourage sea lions to investigate and enter a floating baited trap near the dam. Trapping activities involving ADD shut downs occurred on 10 days in March and trapping, using the baited trap was discontinued on March 27.

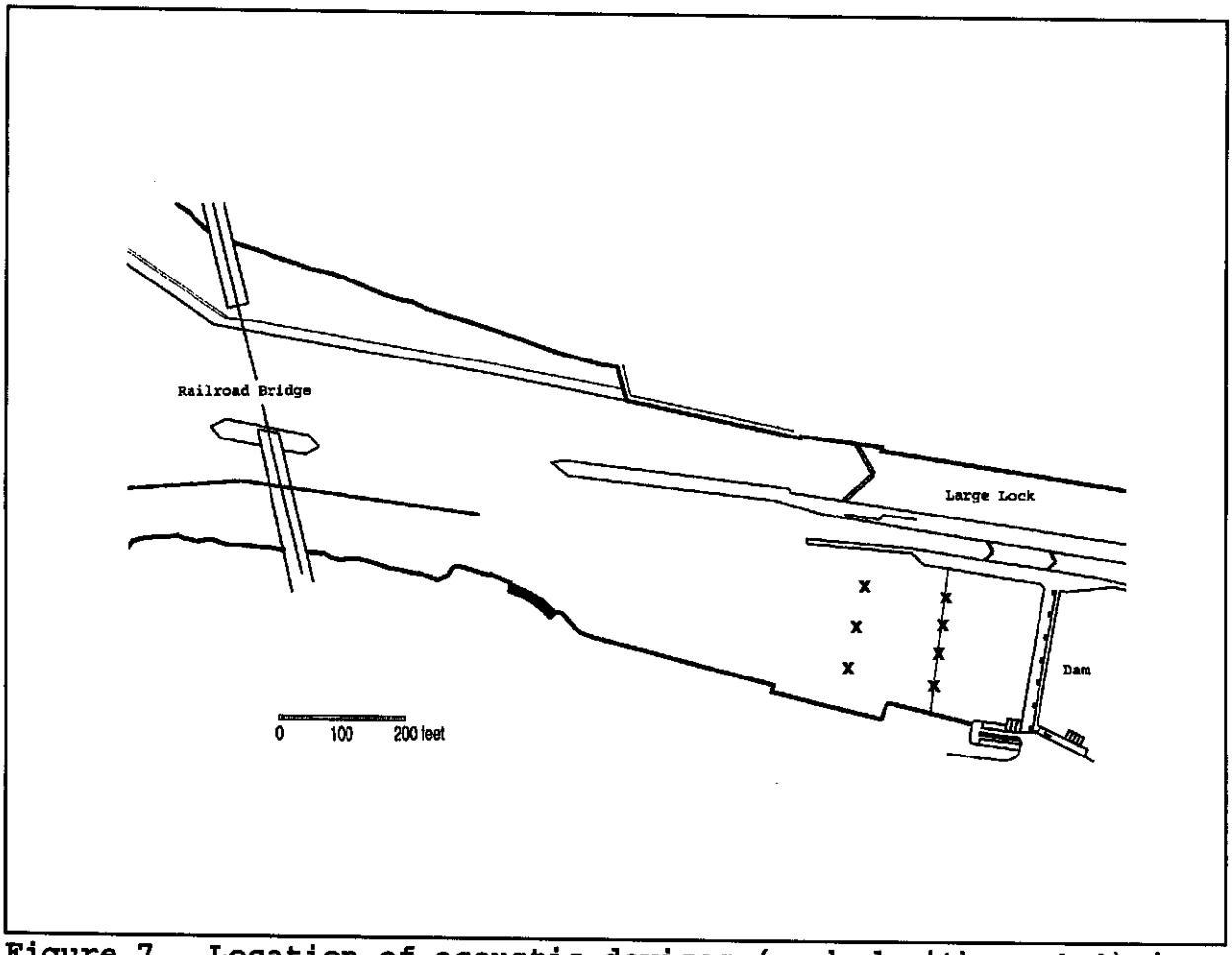

Figure 7. Location of acoustic devices (marked with an 'x') in the spillway area in 1993/94.

Sea lion behavior was directly affected by the ADDs in 1993/94. Sea lions approaching the area did not frequently enter the ensonified area adjacent to the fish ladder, and on the few occasions when they did, they were there for very short periods of time. Sea lion #17, which appeared to be oblivious to the ADDs in 1992/93, was observed to react to the ensonified area and only entered the ensonified zone for very short periods on 8 days with obviously altered behavior when in the zone. No steelhead predations occurred in the ensonified area. In that regard, the ADDs appear to have been effective in eliminating predation in the prime area (in front of the fish ladder) where most predation has occurred in past years. However, these sea lion behavioral observations must be viewed in light of the low abundance of steelhead (76 fish) during the 1993/94 run. It is possible that the extremely low numbers of steelhead played a role in the attendance of sea lions. Nonetheless, during previous steelhead runs, sea lions have been seen to establish easily-observable foraging patterns and maintain those patterns even when foraging success below the dam was low or nil. In 1994, when the acoustic barrier was in operation, these foraging patterns in the ensonified area did not seem to develop nor were they maintained. When the ADDs were not in operation, however, foraging patterns similar to previous years were observed.

The propagation of the signal from the acoustic devices is strongly influenced by turbulence and entrained air caused by water spilling over the dam. Air bubbles in the water column absorb the acoustic signal because of the inefficiency of sound transmission across the water/air interface and decrease the sound levels as spill increases (Norberg and Bain 1994). Depending on the amount of spill over the dam, substantial portions of the ensonified area may have air bubbles, which, because of reduced sound levels associated with air absorption, may allow sea lions to enter the spillway area without being exposed to the noise. For example, surface measurements of sound levels directly below spillway gates 4 and 5 at low tide, showed strong reductions (more than 30 dB) when those gates were opened 1 foot as compared to sound levels measured when the gates were closed. Several observers at the Locks in 1993/94 noted the sea lions were in the more turbulent areas when entering the ensonified area. This information was not quantified however and needs to be examined further to assess effectiveness of the ADDs in this situation.

On one occasion, following a system repair, observations of sea lion #17 indicated that this animal was immediately aware of the acoustic devices when exposed to the low sound pressure start-up process. Sea lion #17 was foraging near the dam when the omni-directional array was activated (the directional array had been in operation when the animal entered the area). This sea lion reacted to the acoustics and immediately moved to the end of the

small lock finger pier before returning to the dam. This sea lion left the area a short time later. In spite of this animal's previous exposure to firecrackers and ADDs, these observations would indicate that it was able to detect the initial low output start-up signal of the omni-directional array. The response also indicates that it would return to its foraging activity and exhibit some degree of tolerance. These observations indicate the animal had not sustained hearing loss from previous exposure.

Noise levels produced by the units above the water have been described as similar to an electronic wristwatch alarm or "crickets". Tests of the ADDs at the Locks facility in 1992/93 and 1993/94 indicate that ambient noise levels at the dam spillway often mask the sound of the units. Previous tests of an earlier prototype of the ADD in Monterey, CA, resulted in complaints of annoying sounds resonating through the hulls of boats, from live-aboard tenants in the quiet harbor there. At the Locks facility, the sound produced by the array may be audible to boaters awaiting passage through the locks from downstream. However, because of the ambient noise levels at the Locks facility, from spillgate flows, traffic noise, railway operations etc., and because vessels at the Locks facility are transient rather than anchored or moored in a quiet residential harbor setting, operation of the acoustic barrier array would have no effect on the human environment. Also, there are no data to indicate the ADDs affect other wildlife such as seabirds. There have been no observations to suggest that noise from the arrays has any effect on diving birds foraging below the dam. To the contrary, many observations have been made of western grebes, cormorants and other seabirds diving in the ensonified area.

Based on observations of sea lion behavior in the presence of the acoustic barrier in 1993/94, it is anticipated that at a minimum, the use of an acoustic barrier may reduce the recruitment of naive animals to the predation problem. However, it should be noted that the devices would have no effect on animals that are deaf naturally or have suffered hearing loss as a result of previous trauma. Sea lions are expected to generally avoid the area of the acoustic barrier. They may, however, occasionally approach the area immediately below the spillway dam and remain there for a short time especially if they enter with their heads out of the water or remain in turbulent areas where bubbles attenuate the sound. Because the ADD equipment is designed to emit elevated sound pressure levels in short pulses, rather than constant tones, and because spreading losses limit the area where sound pressures are at or above 200 dB_{RMS} re 1 μPa to within three meters of a directional transducer, operation of the acoustic barrier array should have no effect on sea lions beyond eliciting the desired avoidance behavior.

In order to re-implement the acoustic barrier to prevent sea lions from accessing the spillway area during the 1994/95

steelhead run, the omni-directional devices were installed and operational on November 30, 1994, and the directional devices were installed and operational on December 9, 1994. The arrangement and numbers of transducers installed for 1994/95 is different from 1993/94. The number of omni-directional transducers in the spillway area was doubled to increase the area covered and decrease the time between transmissions. The directional transducers were placed closer to the omni-directional transducers to implement a more intense "acoustic barrier." In addition, further testing of ADDs in 1994/95 will include increased tone length in the sound generated and the placement of new directional transducers in the large lock area that would generate 10 kHz and 17 kHz sounds to test the effectiveness of varying frequencies.

V.C.4. Capture and Removal

This measure involves capture and removal of sea lions that have been observed preying on steelhead in the Ship Canal. Several capture methods could be used depending upon the number and accessibility of specifically identifiable sea lions. Captures would have to occur during the timeframe of the wild run from January through May. If the captures occur outside the Locks area, they should target on identifiable sea lions that have been observed in the Locks area, otherwise the captures could involve over 60 sea lions. Some sea lions are individually identifiable because they have permanent brand marks that were applied during capture programs in 1988/89, 1989/90, and 1993/94, or during research being conducted under separate scientific research permits. Other sea lions may be individually identifiable from distinctive physical characteristics (distinctive coloration, scars, etc.). In order to distinguish the "problem" sea lions from others, sea lions in the Locks area may be darted with temporary tags. Captures also may occur for the purpose of permanently marking (branding) sea lions to allow for individual animal recognition. NMFS previously prepared an EA on the effects of branding pinnipeds (NMFS 1993).

Three capture methods, two "passive" and one "active" are described below.

V.C.4.a. "Passive" Capture Using a Haul-out Structures

This is a "passive" capture approach that would involve non-lethal, non-injurious trapping of sea lions on haul-out structures that are used by sea lions. Such captures would involve "voluntary" entry by sea lions onto platforms modified into traps. The captures would be on floats, docks or other structures where sea lions are observed to haul-out.

A capture float consisting of a 12 x 12 foot mooring buoy that is modified into a cage trap has been used successfully in past years. The capture float is anchored in Shilshole Bay, near the entrance to the Ship Canal, and when not being operated as a trap is commonly used as a resting haul-out by sea lions. The cage trap has a guillotine type door which is manually triggered to drop down and enclose the sea lions inside. This floating trap was used successfully to capture sea lions during the winters of 1989, 1990 and 1994. Over 60 sea lions have been captured on this type of cage trap through November 1994 and none were injured or adversely affected during trapping by experienced NMFS and WDFW personnel.

Use of the floating cage trap closer to the Locks could serve to better target solely on the problem animals without the need for identifying marks. However, use of a haul-out trap near the Locks is not a desired method because it could provide a haul-out attraction or refuge for sea lions near the area where steelhead are most vulnerable to predation. A haul-out platform close to the Locks would likely have the effect of increasing the number of predators in the Locks area.

In 1993/94, a dock in Shilshole Marina that was being used by sea lions as a haul-out was fenced off to form a trap. Two sea lions, both of which had been observed in the Locks area, were successfully captured. This approach of utilizing haul-out structures to trap and capture sea lions (if it is shown that the problem sea lions from the Locks are utilizing the site) could be applied to other structures.

There are several drawbacks to the passive capture approach. The greatest drawback is that passive capture is totally dependent on individual animal behavior in hauling-out on a trap or site that can be modified for trapping. This passive trapping approach also is not selective and could involve sea lions that are merely moving through the area and are not involved in the conflict at the Locks (as noted above, float traps cannot be placed in the Locks area without possibly exacerbating the problem). Based on prior capture efforts it is anticipated that some of the "problem" sea lions would not avail themselves to capture by this method. Some animals may be wary of hauling-out on the trap while others, which have been exposed to previous capture attempts, may become trap-shy (avoid hauling on trap).

Experience with the passive capture technique indicates that it involves the least possible risk to the animals and to capture personnel. Some level of risk still exists, however, since the animals might behave unpredictably. Risk to personnel must be considered, since the method sometimes requires close handling of the animals inside the trap during the transfer process.

V.C.4.b. "Passive" Capture Using a Partially Submerged Baited Trap

Another "passive" capture approach is the use of a partially submerged baited trap. Such a trap was constructed in 1993/94 and designed to be a selective trap which would capture single individuals from the immediate vicinity of the Locks fish ladder. The advantage of this trap is that known fish predators could be targeted and removed. Since it is not a haul-out platform, it would not attract additional animals to the area where it is used.

The partially submerged cage trap, measures approximately 12 feet x 6 feet x 6 feet, and can be baited with hatchery steelhead to attract sea lions to enter it. The trap door is triggered either manually, remotely, or by the sea lion removing the bait. There is sufficient clearance between the top of the trap cage and the water to allow an animal, once captured, to surface and breathe without difficulty. The distance from the trap door to the bait makes it unlikely that an animal would be accidentally struck by the trap door when triggered. Once an animal is trapped inside, the entire cage can be lifted out of the water using one of the winch arms in place at the Locks. The cage could then be placed on a transport barge and the animal transferred into a transport cage. There is some risk for the animal and capture personnel associated when lifting the cage from the water following a capture.

This trap with a tethered live hatchery steelhead inside was tested in 1993/94 initially downstream of the small lock chamber. No sea lions entered or even approached the trap at this location. The trap was then moved to the spillway area and the acoustic devices were turned off for short periods of time to allow sea lions to approach the trap. Again, no sea lions were observed to enter the trap. The trap was then moved back to the small lock area and a harbor seal was caught in the trap. The trap was removed after the harbor seal capture.

V.C.4.c. "Active" Capture Using Tangle Nets

This is an "active" capture approach that would involve efforts to capture sea lions in the water. Active capture would involve the use of entangling or encircling nets, use of drugs, and use of other techniques to selectively capture "predatory" sea lions. Entangling nets could be set in the spillway area or used in combination with sedative darts and/or vessels to encircle or force sea lions into the net. Another potential approach is use of the small or large lock chambers to capture sea lions. Active capture would also likely involve the use of sedatives or anesthetics under the direction of an Animal Care Committee (ACC).

An active capture operation, utilizing a tangle net stretched across the spillway, was tested during the 1986/87 season. The operation was not successful because sea lions were able to leap over the capture net or avoid the gear altogether. For this reason, a modified tangle net with an apron and revised techniques to address these evasive maneuvers would have to be developed.

Removal of sea lions captured in a tangle net would likely require the use of darting and drugging the sea lion to immobilize it so that it can be safely removed from the net. An alternate approach is to dart the animals with drugs to slow it down before encircling it with the tangle net. Because techniques have not been developed to tranquilize sea lions in the water, there is a possibility of mortality to darted animals from drowning or complications from drugging. Mortality is also possible without using drugs if the animal becomes stressed or severely entangled and drowns before it can be raised out of the water. Drugs were used previously on captured sea lions during the early phases of the 1988/89 capture and transfer program under the advice of consulting veterinarians on an ACC. Two of four sea lions, which were chemically immobilized during the 1988/89 program, died during recovery from anesthesia and drug use was suspended. Histological examination of tissues taken during necropsy of the two animals which died indicated that both animals had experienced chronic stress as the lymphoid tissues of the spleen were exhausted. The fact that these animals died as a result of complications which were probably attributable to prior stress could not be anticipated during external examination prior to administering the anesthetic. Darting animals in the water would involve the additional risk of animals aspirating water, as well as risks associated with estimating dosages based on observed size of the free swimming animal.

Encircling sea lions in the spillway area with specially designed nets that could be hoisted directly out of the water with a crane might allow this type of capture without use of drugs. However, there is still the concern for stress and drowning which could be overcome with use of sedatives. Because of the size (over 600 pounds) and strength of these sea lions, it is unlikely that they can be safely handled and removed from a net without use of some immobilizing drugs.

An alternate approach for active capture is to first dart the target sea lion with an injectable anesthetic to slow it down and then immediately encircling or entangling it in a net for removal. This approach has the above described problems with drugs as well as the risk of the animal evading the net before succumbing to the effects of the drugs and possible resultant mortality. However, initial use of a sedative may make capture easier and reduce stress on the animal to avoid possible mortality. This approach also reduces the risks for the people

involved in the capture.

Another active capture approach suggested was to lure or chase sea lions into the lock chambers. The lock chamber could be drained when the sea lion is captured, or nets could be used in the confined area of the chamber which could preclude animal avoidance of the net. The principal drawback to use of the lock chamber would be the conflict in its intended operation to move vessels and the obstruction to navigation such use would cause. Security also would be an issue because of easy public access to the locks. Also, the tunnels and water chambers inside the lock chamber would provide animals with escape routes during capture attempts. Other problems with this approach are possible inability to entice problem sea lions into the lock chamber, complications with attempting to use nets in the lock chamber, potential escape during the closure of the lock doors, and the possibility that animals may learn to avoid the lock chambers during capture operations.

Active capture was recommended by the Task Force to capture "predatory" sea lions that are not available for passive capture. The Task Force acknowledged that drugs would be necessary for active capture and that sea lion mortalities are possible with this technique. The risk of such mortalities would need to be authorized under Section 120 of the MMPA.

V.C.5. Translocation

This alternative is to translocate captured sea lions away from the Locks area to prevent them from foraging on steelhead. In order for this alternative to be effective, the translocated sea lions would have to be away from the Locks area during the entire timeframe of the wild steelhead run (January through May). Translocating sea lions to distant waters outside their existing range to locations such as Alaska or the western Pacific (such as Japan) would not be consistent with the MMPA. Transport to distant waters, within the range of California sea lions, but under the jurisdiction of Canada or Mexico is not considered feasible because of export restrictions and foreign affairs implications. Also, relocation to British Columbia, Canada would not provide a location sufficiently distant from Puget Sound to maximize the absence time of the sea lions should they return in the same year. Relocation to Mexico would require additional transportation times and costs beyond funding levels which are currently available. In addition, the export and transportation of sea lions across international boundaries would likely require foreign permits and negotiation with the governments of the destination countries to secure legal consent prior to moving the captured animals.

The results of the 1988/89 capture/transport of sea lions to the

southern outer coast of Washington indicate that translocation sites must be of sufficient distance to provide an adequate delay in the return time and to minimize recaptures of relocated animals. Of the 37 sea lions captured between February 17, 1989 and April 19, 1989 and released on the outer coast, 29 were subsequently observed back in Puget Sound within about 15 days. Twelve of the returning animals were recaptured one or more times and were relocated each time to the outer Washington coast. During the summer breeding season, 11 of the 37 marked sea lions from the Lake Washington basin were reported back in California waters, with eight of them recorded on breeding islands in the Channel Islands off southern California. These observations also confirm that the sea lions in the Lake Washington Ship Canal originate from the Channel Islands breeding populations. These efforts also confirmed that capture and relocation has no negative effect on the sea lions.

In order to maximize the potential effectiveness of relocation in reducing predation on steelhead, it was determined based on the 1989 translocation experience that sea lions would have to be relocated as far south as the starting point of their migration at their breeding area. Relocation experiments in 1990 and 1994 indicate that transporting the captured sea lions within their natural range as far south as back to the Channel Islands may be a possible, however costly, means of delaying or postponing their return to Puget Sound for at least 30 days. Based on actual experience with six California sea lions which were captured, marked and transported to California in 1990, it is known that some animals will return to Puget Sound. But, their return occurred 30 to 45 days following their release. During a subsequent translocation program in April 1994, three sea lions were returned to the Channel Islands; none of these animals returned to Puget Sound that season. It is possible that the late season (April) release of the 1994 relocated sea lions did not allow sufficient time for their return prior to the initiation of their southward migration period.

Prior to the 1990 relocation effort, NMFS determined that relocating a small number of sea lions back to their breeding islands would not affect the coastal environment and therefore such relocation was not inconsistent with the Coastal Zone Management Act (NMFS and WDFW 1989). This determination was based on a number of facts. California sea lions from Washington migrate back to California on their own in spring and the "early return" to southern areas (as a result of the translocation) would have no appreciable effect on marine/commercial fishery resources in the release area. The feeding behavior of these animals is not unique except in their adaptation to the Ship Canal and Locks area. Because of their opportunistic feeding behavior, the relocated sea lions would prey on the locally abundant prey species that are already the target of resident animals. Although fishers have protested the transport of

"problem" animals from Washington to their waters, available scientific information indicates that no appreciable effects on fisheries resources by these animals are likely to occur because the majority of the 111,000 U.S. population of California sea lions are already present in the coastal areas off California. The insignificant numbers of relocated animals would not change, to any measurable degree, whatever conditions that otherwise exist with sea lions that remain year-round off California. Also, assertions that these sea lions would seek out steelhead creeks/rivers in California and impact those steelhead runs could not be substantiated. However, regardless of these facts, the California Coastal Commission disagreed in both 1990 and in 1994 with the NMFS determination that relocation of California sea lions back to their breeding islands was consistent with the approved coastal zone management plan of the State of California. The Commission declared that the translocation would "directly affect" the coastal zone and was not consistent with the California Coastal Management Plan to the maximum extent practicable. Ultimately, the Commission did agree to allow an experimental one-time only relocation of no more than 10 sea lions. It is not likely that the California Coastal Commission will reverse itself and agree with future determinations of the insignificance of relocations.

Sea lions relocated to California in 1990 and 1994 were clearly marked with brands, tags, and radio packs prior to their release. These animals were not reported involved in fisheries interactions following their release, and were tracked via radio as they moved northward back to Washington waters. The problem with these animals appears to be site-specific as the sea lions have habituated to feeding on steelhead at the Locks where a unique situation occurs with the presence of a dam at the convergence of saltwater and freshwater. Such a situation does not occur anywhere else along the west coast; most dams are built upstream within the freshwater environment. Further, the information gained from the relocation in 1990 to southern California indicates the relocated animals moved directly back to Puget Sound and did not stop to forage on steelhead in other rivers or creeks along the coast.

Although the animals transported in 1990 and in 1994 were not observed foraging at the Locks for the remainder of the respective seasons, it is possible that animals transported early in a season may return to the Locks to forage on steelhead and therefore may require subsequent captures and translocation. If the relocated animals show the same behavior in quickly migrating back north as did the 1990 relocated sea lions, they would spend little time in California waters during the January through May relocation period. Several approaches have been suggested to prevent relocated sea lions from returning to Puget Sound. One is to have a "soft release" which would involve temporary holding in the release area to allow the animals to "acclimate" to the

relocation site. Another approach suggested is to "confuse their biological orientation." This approach is dependent on affirmation of the theory that animals may use magnetic fields to orient themselves, and would involve attempting to confuse the animals spacial orientation by disrupting the magnetic fields in the animal and preventing migration by gluing a magnet to the sea lions hair so that the relocated animal may not have sufficient environmental cues to successfully find its way back to Puget Sound.

Information from past efforts indicates that relocation would not provide a total resolution to the problem as it is known that the sea lions eventually would return. However, a relocation to southern California does provide at least thirty days of steelhead passage through the Locks facility without the presence of these sea lions. This in itself could save substantial numbers of steelhead if the sea lions are removed during the peak of the steelhead run. Nonetheless, the legal obstacles that may transpire in overriding the California Coastal Commission objections make this alternative unfeasible at present.

V.C.6. Temporary Captive Holding

This alternative is to temporarily hold captured sea lions in captivity during the duration of the steelhead run and then release them back to the wild in late May or early June. The Task Force identified this alternative as its highest priority and recommended that lethal removal not occur unless adequate holding facilities are unavailable. There are uncertainties surrounding whether sea lions can be held captive for 3 to 5 months and kept "wild" before release. The advantage to temporary holding of sea lions in captivity would be that once captured, the animals would not return to the Locks area for the remainder of the season. However, the logistical constraints, individual animal problems, and high costs make this alternative unrealistic unless only a small number (6 to 10) of sea lions are involved. Unfortunately, the numbers of sea lions that may need to be removed cannot be determined in advance. There are risks with this alternative both to the animals and to people involved in caretaking, as well as the general public if the animals habituate to being near and fed by people. This alternative is only a temporary solution to the problem because the animals would likely return in the next season and may be more difficult to capture.

Feeding wild sea lions in captivity is problematic. There is disagreement among those involved with marine mammal caretaking on whether the animals must be fed live food (e.g. herring) to keep them "wild" versus feeding them dead fish as is done with other captive pinnipeds. There is no direct experience in this area because pinnipeds held in captivity are either held

permanently for exhibition or are sick animals held temporarily for rehabilitation and release as soon as they are well. NMFS believes, based on expert animal husbandry advice, that use of live food is necessary to avoid having the sea lions adapt to human feeding and potentially developing a dependency on hand-fed dead fish. The use of dead and or previously frozen fish would require the development of elaborate "blind" food delivery systems to eliminate the possibility of conditioning the animals to seek or accept food from people. If these sea lions do become accustomed to close proximity of people and possibly associate people with food, there is a risk to public safety when the sea lions are released. The animals may jump into small boats seeking food or approach unknowing people at docks causing fear and possible injury to people. These public safety concerns for animals that have adapted to humans may require either lethal dispatch or permanent holding of such animals.

There is uncertainty on the amount of food necessary per sea lion. Sea lions consume prey totalling about five to ten percent of their body weight per day. The average weight of sea lions during the 1988/89 capture program was about 600 pounds, with the largest animal weighing over 900 pounds. Because this captivity would occur during winter/spring seasons when these animals are normally putting on weight prior to the summer breeding season, NMFS believes that they would need more than the five percent maintenance level. It is estimated, based on the average weight (600 pounds) of the animals likely to be captured and a food budget of approximately seven percent, that about 40 pounds of food per day per sea lion would be required for the duration of captivity. Such amounts of food raises some concerns about the availability of large volumes of live herring or other marine species.

Wild sea lions may not readily accept food in captivity. Force feeding large adult male sea lions may not be feasible. Humane concerns would necessitate determining immediate disposition of non-feeders before their health and well-being is compromised. Release of such animals back to Puget Sound would likely result in further predation problems at the Locks with the added complication that such animals may become "capture-shy." The Task Force acknowledged these captive holding problems and recommended that an Animal Care Committee determine disposition, including euthanasia, of sea lions that do not feed or have other problems in captivity.

The challenge of this alternative is to provide caretaking in captivity while ensuring that the sea lions do not habituate to people or the captive environment. Whether live or dead food is used, feeding approaches would need to be developed to ensure that the animals do not associate food availability with people. This approach is further complicated when holding multiple animals in an enclosure and ensuring that each sea lion is

obtaining adequate amounts of food. If any one animal is not feeding because of interactions with other animals, a separate enclosure may be needed to isolate less dominant animals from others to provide feeding opportunities. Animal handlers, who are trained to promote the development of positive relationships between newly captured animals and people/captive environment, would need to develop different techniques to avoid the possibility of domesticating the sea lions. This may involve risks of injury to the caretakers caused by the sea lions and conflict with traditional captive husbandry practices. Personnel involved with rehabilitation facilities that have handled sick adult male sea lions believe it can be done, although not without considerable difficulty and risk.

The costs for food, caretakers, and veterinary care for holding only 4 to 6 sea lions in captivity for three to four months has been estimated at over $35,000. This estimate does not include capture and transportation costs, temporary isolation or other contingency costs, or costs for modifications to facilities.

There are four holding options under this alternative as described below.

V.C.6.a. Holding Captured Sea Lions in an Existing Facility

Aquarium or zoo facilities with existing enclosures (tanks/kennels) capable of temporarily holding 10 or more adult male sea lions for upwards of four months have not been identified. Because there is a risk of bringing pathogens into a facility from wild animals, these sea lions cannot be put in tanks with other animals on exhibition. Most aquariums and zoos use available space and staff to hold and maintain animals for exhibition and do not maintain large unused areas suitable for holding marine mammals. For this reason, holding sea lions in captivity would likely require the use of small areas of several facilities, or the construction of a new enclosure with sufficient accommodations for all of the animals.

Construction of a new enclosure designed to hold up to 20 sea lions on a temporary basis annually would likely cost over $2,000,000. Such facility/enclosure would not be available for holding sea lions this season nor possibly next season due to unavailability of funds, construction logistics, permit requirements, etc. which could easily lapse over a year timeframe.

Several facilities have identified small areas (enclosures) that could possibly be used to hold no more than 4 to 6 sea lions. In all cases, some type of modification or minor construction would be necessary. Some of the potentially available enclosures are designed for exhibition and would have to be fenced to prevent

public access due to concern that constant human exposure may result in these animals becoming accustomed to human presence. Although saltwater tanks are preferred, freshwater tanks would be considered for this temporary holding as long as the sea lions are provided dietary supplements. Most of the potentially available enclosures in zoos have tanks that only have freshwater supply thereby precluding live feeding in the tanks of marine fish species (e.g. herring). Most existing pinniped facilities are not designed for holding many adult male sea lions. As there is a high probability of aggressive interactions between these adult male sea lions, accommodations may need to be made for separating these animals for short or long periods of time. One facility that has empty fiberglass holding tanks for sea otters advised that the tank walls could not withstand the force of a sea lion weighing 600 pounds. Consideration also may need to be given to allowing limited public viewing of these animals because there would likely be a large demand for such. Special blinds or one-way mirrors would need to be installed (at costs) to allow viewing while preventing animal exposure to people. Another area requiring attention is that most zookeepers and marine mammal caretakers in existing facilities are trained in methods to ensure that captive animals habituate to their captive environment so that the animals can be easily fed and cared for. Caretakers may have to use untried and unconventional methods to feed and care for these sea lions to ensure they do not "tame" them. Further, the sea lions would have to be treated as quarantined animals to prevent potential disease transmission to animals on exhibit. This would require separate water and filtration systems for the tanks/pools housing the sea lions as well as possibly separate caretakers (at additional costs) because caretakers may need to keep their activities and handling of exhibit animals separate to avoid transmission of disease.

Prior to being put into any temporary holding enclosure, the sea lions would likely need to be placed first in a kennel where they can be temporarily observed and possibly medically screened so that determinations can be made on their health. There may be situations (health, aggressiveness, etc.) where some of the captured sea lions cannot be put into an enclosure with other captured sea lions. It would be preferable to place all of the captured sea lions into an enclosure at the same time to possibly avoid problems with some animals establishing "territories" or dominating haul-out or tank space in the enclosure and other problems with negative interactions with new introductions to the enclosure.

Although Animal Welfare Act (AWA) requirements may not apply to the temporary holding of sea lions, they would likely need to be considered as guidance on the holding and caretaking of the sea lions. Construction of a new enclosure/facility would likely need to meet AWA requirements so that it could be used for other purposes. AWA regulations implemented by the U.S. Dept. of

Agriculture - Animal and Plant Inspection Health Service require that exhibited animals be provided dry resting area (DRA) and a pool. For the safety and welfare of the animals, both are subject to construction material and design restrictions. The pool ramps and resting area, provided the pool is not subject to cleansing by tidal action, must be constructed of nonporous waterproof materials to facilitate cleaning and disinfecting the enclosure. There are also drainage requirements if the pool is not tidal. Water quality is to be monitored and maintained, through flushing or filtration, within specified standards. Minimum DRA is calculated using a formula based on the average adult length of the animals held times the number of animals held. Average length for male California sea lions is specified at 7.4 feet. Captive maintenance requires a DRA of the length squared (i.e. 55 square feet). Additionally the minimum surface area of pool water needs to be equal to the DRA (55 square feet). Minimum horizontal distance across the tank, needs to be 1.5 times the adult length; 11 feet and minimum depth needs to be .5 times the average adult length or 3.7 feet. Although all of these regulatory standards may not apply to temporary holding of sea lions in existing pools/tanks, the standards would be used as guidelines to ensure that facilities are adequate for holding these animals.

Holding animals in rehabilitation facilities where sick/stranded animals are being treated introduces the risk of spreading pathogens to these sea lions that may otherwise be healthy animals. Rehabilitation facilities normally handle younger, smaller pinnipeds or larger animals that are debilitated and weak. Such facilities are not necessarily designed to house healthy adult male sea lions for extended periods. In most cases, a rehabilitation facility would only hold an animal until it has regained its health and it is then immediately released. The approach of holding a healthy animal for extended periods is not consistent with the approach and operations of rehabilitation facilities.

V.C.6.b. Holding Captured Sea Lions in a Floating Pen Facility

An alternative to holding sea lions in an existing display or rehabilitation facility is construction of a floating pen facility and placement in Puget Sound. Size and configuration of the pens would be comparable to holding facilities on land. Holding sea lions in open water sea pens would be subject to cost constraints and require sufficient lead time to obtain the necessary permits, and to design, construct and place the pens. An adequate anchoring system also would need to be designed and constructed. The pens would need to be designed with adequate haul-out space, kennels and working area to allow flexibility for isolating individual animals as necessary to administer medical treatment or to implement contingencies such as for individuals

that fail to feed. Special procedures and/or devices may need to be developed to remove or separate sea lions inside the pens (in water).

Designing a floating facility has the added complication of determining appropriate containment material (mesh, fencing, etc.) that must be sufficiently small to hold live food (e.g. herring), sufficiently large to allow adequate water circulation to clear-out sea lion excrement quickly, and sufficiently strong to withstand sea lion attempts to escape. To date, no such pen has been used for large wild adult male sea lions and the potential for escape is of concern.

Locating a site for these pens is problematic. They must be located in an area protected from strong currents and adverse weather/storm conditions which could break-up the pens, while also having sufficient currents (or tidal action) to allow "cleansing" of pens. Access by the public (boaters) also is of concern for security reasons. Complaints by residents in area of pens over noise (sea lion vocalizations) would also have to be taken into account. Several Task Force members suggested placing the pens in the Lake Washington Ship Canal; however, this is not desirable because it would likely attract increased numbers of sea lions to the Locks area (due to the gregarious nature of sea lions) exacerbating the predation problem. Co-locating the sea lion net pens with existing aquaculture (salmon) net pen facilities is not feasible for several reasons including increased bio-loading associated with holding a number of large mammals, and possibly the most likely and least desirable for the existing facility, the probability that the vocalizations and presence of the captive animals would draw additional wild sea lions to the vicinity where they would present a threat to the cultured fish within the facility.

Dependent on where the sea lion net pens are located, they may contribute to water quality problems and the degradation of the adjacent and subsurface areas surrounding the pen. For example, concentrations of harbor seals on the Dosewallips River delta resulted in closures of extensive shellfish beds due to fecal coliform bacterial contamination by the seals (DSHS 1988, Calambokidis et al. 1989). In addition, anchoring the pens in shallow waters may affect light penetration and growth of algae or sea grasses found there. Therefore, selection of an appropriate location would require careful consideration and research to avoid areas of significance with respect to subsurface resources in order to avoid potential liabilities for reclamation of damaged resources should damage result from the activity.

Once a site for the pen holding facility has been determined, complete plans must be prepared including aspects of site location, bottom topography, subsurface resources, construction

design, anchoring methods and structures. Further, there are a number of federal, state and county permits, approvals, and variances which must be obtained prior to construction. The permitting processes involve at least six federal, state and local agencies and include site leases, hydraulic and construction permits, local variances, and Coastal Zone Management Act consistency determinations. Estimated permit fees range up to approximately $10,000 not including the costs of compliance with the State Environmental Policy Act or subsequent liabilities for any aquatic resources which may be damaged as a result of construction or operation of the project. Timeframes for completion of the formal permitting processes (involving public notification review and comment) would likely be from two to three months if the processes could be administered concurrently (there are at least three applicable public processes under the various permitting requirements).

This approach for holding numbers of large sea lions has not been tested and prototype pens would need to be specifically designed for this purpose. The design and construction of a pen designed to hold about eight sea lions with a haul-out area is estimated to cost about $40,000 (cost estimate is just for construction of pen; it does not include costs for a site lease, permits, and anchoring structures and placement/construction of such structures, nor food and caretaker costs). Because of costs, innumerable potential problems with finding a desirable site and obtaining a lease, obtaining necessary permits, needed construction and anchoring lead time, and uncertainties with the pen holding concept, this approach is not feasible in the near future.

V.C.6.c. Holding Captured Sea Lions in Other Facilities (not otherwise used for marine mammals)

Another alternative to holding sea lions in an existing display or rehabilitation facility is holding them in a facility that has pools, etc. for other purposes. One approach suggested was the use of the Seattle City Parks Coleman Pool in West Seattle. This is a saltwater pool that is not used in winter. However, the City of Seattle advised that the pool was not available for holding sea lions.

Another approach is to use State salmonid hatchery facilities as they may have unused raceways or holding ponds during some portions of the year that might be modified for holding sea lions. Such facilities only use freshwater and sea lions would require dietary supplements. Feeding live herring may not be feasible, and the dead food problems discussed above would be inherent to this approach. Caretakers are normally onsite year-round at hatcheries providing some level of security. However, experienced marine mammal caretakers would need to be hired and

possibly located onsite or nearby. There are concerns about sea lion excrement discharged into a river or stream and potential effects on salmonids that may be migrating upstream at that time. The hatcheries used may need to be close to the ocean or bays (rather than far upriver) to avoid sea lion excrement concerns. Although some space might be available at some hatchery facilities at certain times, it may not be available through the entire 3 to 5 month timeframe needed to hold sea lions. This availability problem may preclude use of some facilities or require movement of sea lions among facilities as space is available. The design of ponds and raceways in hatcheries varies and would require site visits to determine feasibility and availability.

V.C.6.d. Holding Captured Sea Lions in an Enclosed Cove in Puget Sound

This concept would entail fencing the shoreline of an existing cove or bay and closing off the mouth of the inlet using netted or fenced pilings to create a holding enclosure. There are a number of obstacles to this approach but one obvious issue would be the size of the cove. If the cove is large, so that the sea lions can roam around in an unconstrained manner and therefore are not concentrated in one spot, the cost of fencing the entire area could be excessive. If the cove is small, to keep the cost of enclosing the area to a minimum, the animals would be concentrated to the degree that subsequent liability for damage to local resources, shellfish beds, intertidal flora and fauna etc., would likely be incurred. This approach has the same problems as net pens, and possibly more complicated in finding an appropriate site, and therefore is not feasible for implementation in the near future.

V.C.7. Permanent Captive Holding

This alternative is the same as temporary holding except that the sea lions would be kept permanently in captivity and not be released to the wild. The advantage to this approach is that the sea lions would not be a problem at the Locks in current or in future years. Further, the concerns for "domesticating " the sea lions would not be an issue. The drawbacks are costs and availability of facilities similar to temporary captive holding. There is concern by many that permanent captivity for these sea lions may not be the most humane approach for handling the sea lions.

There is no interest by existing facilities exhibiting marine mammals to obtain these adult male sea lions because most facilities interested in displaying sea lions already have California sea lions and there are ample supplies of young sea

lions (which are preferred by exhibitors and more adaptable to captivity) available from other facilities or from rehabilitation centers. A permanent captivity approach would likely require construction of a new facility. Construction costs are likely to exceed $2,000,000. Costs for food and caretaking would need to be available on a permanent basis. A permanent holding facility would not be available for holding sea lions this season nor possibly next season due to unavailability of funds, construction logistics, permit requirements, etc. which could easily lapse over a year timeframe.

V.C.8. Other Non-Lethal Sea Lion Measures

The measures in this alternative are those that were recommended by the public during the 1989 NMFS/WDFW public hearing on the sea lion-steelhead conflict or have been recommended in letters and/or telephone calls from the public in recent years. Most of these measures have not been attempted because they have been determined by scientists to have low potential success or are unfeasible for consideration. The specific aspects of the determinations on success/feasibility are described for each measure below.

V.C.8.a. Visual Scare Tactics (Predator Models)

This measure would involve placement of "scarecrow" items that frighten sea lions such as predator models or decoy riflemen, or use of mobile radio-controlled models of sea lion predators such as killer whales or large sharks to frighten target animals. Recent reports on use of a killer whale model indicate that it was effective in repelling seals from net pens. However, observations on sea lion behavior in the presence of predators and field testing has shown that these methods are largely very short term or ineffective. Killer whale models would likely have to be combined with playback of sounds generated when killer whales are attacking sea lions. Nonetheless, sea lions have been shown in varying experimental regimes to quickly become non-responsive to activities that do not result in infliction of pain. Vessel navigation conflicts and maneuvering these predator models in high velocity turbulent waters especially in the presence of large spills of water over the dam would limit the opportunities to use such devices. Killer whales also are predators of salmonids, and therefore a model killer whale, if effective, could also deter returning steelhead from the Ship Canal. Past field observations of pinnipeds and their predators and problems and limitations with maneuvering predator models in the spillway area indicate that the predator model approach is not practical and does not warrant further consideration.

V.C.8.b. Repelling Sea Lions with Animal Sounds

The objective of this measure is to play recordings of sounds from sea lions, their predators or other animals that would elicit a fright/flight reaction in the sea lions thereby repelling them from the Locks area.

California sea lions sometimes make loud noises (vocalizations) when frightened or startled. When this call is emitted by animals on land, it tends to cause surrounding animals to flee. A "playback" of this vocalization could be broadcast in the area around the Locks to attempt to elicit the fright/flight reaction. This approach has not been field tested. However, based on knowledge of these animals, it is likely that sea lions would quickly learn that there was no real danger and would likely ignore the sound, making it ineffective. The broadcast of such noise would likely result in disturbance to birds and people in the area.

Another approach would be to use predator sounds (killer whale vocalizations) to scare animals away from the area. The effective use of killer whale vocalizations to frighten sea lions is questionable, based on past studies on pinnipeds (Shaughnessy et al. 1981) and field observations of sea lions in the presence of killer whales. Sea lions have been observed resting, feeding, or playing in California waters with killer whales in close proximity. In addition, sea lions were attracted out of curiosity to a researcher's broadcasts of predator vocalizations in the Baja California area (M. Dahlheim NMFS/NMML, pers. comm., 1988). Killer whale vocalizations have been used to mitigate fishery interaction problems with beluga whales, but were ineffective on seals and sea lions (Fish and Vania 1971). Underwater playback of taped killer whale vocalizations has been tested on steelhead in the fish ladder and no obvious reactions were observed. Although there are no adverse impacts associated with this technique, past field observations indicate that this approach is not practical and does not warrant further consideration.

V.C.8.c. Impairment of Feeding Efficiency

This measure would entail covering the prime sea lion foraging area near the spillway dam with some material such as a plastic sheet in order to darken the underwater area to reduce predation by impairing sea lion vision and fish capture efficiency. This approach is based on past observations which indicate that predation rates are low at night. However, it is likely that fish passage also would be affected by this method because steelhead are reluctant to enter dark areas in fishways and in hatchery structures. Covering the stilling basin to attract fish is discussed in Section V.D.2. of this document. This measure

does not warrant further consideration because of the design and construction impediments as well as the potential negative effects on fish passage.

Other measures suggested by the public to impair feeding include muzzles, physically restraining the movements of sea lions by applying a harness attached to floats, conical neck collars, etc.. These methods are not feasible because they would impair the ability of the sea lion to forage on other natural prey.

V.C.8.d. Alternate Food Sources (Feeding the Sea Lions)

This measure is to provide live or dead fish to sea lions in the vicinity of the Locks facility in an effort to satisfy their hunger so that they would not prey on steelhead. Such a feeding program would be costly and would probably attract additional sea lions to the area, thereby exacerbating the problem. Because sea lions naturally chase and consume live fish, it is unlikely that they would forego the opportunity to consume steelhead when available even in the presence of other prey species (especially dead fish). Although there are other prey currently available to sea lions in Puget Sound, it appears that some sea lions preferentially prey on steelhead as a principal or supplemental component to their diet. In regards to dead fish, wild sea lions would not be expected to solely eat dead fish as that is not a normal behavior. Uneaten dead fish could cause water quality and odor problems with uneaten decomposing fish. Additionally, this measure, if it could be successfully implemented, could condition sea lions to approach people closely to obtain food in areas other than the Locks, thereby creating unwanted human/sea lion interactions. Therefore, this approach is not practical and does not warrant further consideration.

V.C.8.e. Hormonal Injections

This measure would involve stimulating the sea lions to begin their southward migration several months early by changing the sea lions' hormonal balance through use of reproductive hormones. The hormones would alter the animal's physiological state, thereby stimulating the animal's preparation for the breeding season. Use of hormones on wild sea lions is untested and it is uncertain whether it would result in the desired behavioral change. This technique also could be combined with a relocation program whereby the sea lion's hormonal balance would be changed to increase the probability that the animal would migrate back to their breeding area in southern California. Testing with captive animals would be necessary before this technique is applied to wild animals. This measure could also raise concerns in California due to early return of sea lions. Because of the unknowns to this alternative, it is not practical at this time

and does not warrant further consideration.

V.C.8.f. Chemical Repellents

This measure involves the use of repellant chemicals that would deter sea lions from entering the area. Such chemical agents would have to be added to the water without affecting fish, other organisms or water quality. To our knowledge, no such chemical is commercially available at this time. Biological agents such as predator (killer whale) excrement are not obtainable and the effect of such chemicals on both sea lions and fish and other wildlife would have to be assessed. In order to be effective, a chemical agent would need to be an irritant or stress producing agent. The development of such a chemical with the added constraint that it be environmentally benign and more or less species specific, would be very costly and would require extensive research. This approach does not merit further consideration because of the potential environmental consequences and water quality problems.

V.C.8.g. Predator Introduction

This measure would involve capturing a sea lion predator and releasing it live in the Locks area. Predators suggested by the public include killer whales, sharks, and polar bears. There are a multitude of problems with this measure. Besides the legal (MMPA and NEPA) and logistical problems with the capture and survival of the predators, it would not be feasible to keep such predators in the area. If they did stay, they would likely also prey on steelhead thereby exacerbating the predation problem. Large sharks, if they survived capture and transfer to the Locks, could jeopardize public safety. Given the problems with this measure, it does not warrant further consideration.

V.C.8.h. Other measures

Other non-lethal measures that have been considered are those that have been investigated at hydroelectric facilities to guide fish including bubble screens, strobe lights, and other visual cues (Stone and Weber Engineering Co. 1986). However, these measures have been assessed and found to be impractical or not feasible for application to the sea lion problem. Additional non-lethal measures suggested by the public would be considered if they appear practical. Proposed measures would need to be reviewed by NMFS and WDFW biologists to determine the applicability and merits of the proposal and any adverse environmental consequences.

V.D. Modify the Locks Facility with Barriers or Escape Cover

This alternative is to modify the Locks facility or install downstream structures to separate sea lions from steelhead. Structural modifications to the Locks facility itself should not impact operation, safety and maintenance of the Locks for the authorized purpose of providing a navigable waterway between Puget Sound and Lake Washington, nor should it impair the release or retention of water necessary for regulation of lake levels. In addition, the structure should not decrease the existing passage of other salmonid runs. Feasibility and physical model studies as well as hydraulic implications of any possible modifications would likely be necessary prior to any decision for implementation.

The Task Force recommended an assessment and possible implementation of all viable options for a non-net barrier across the spillway as well as steelhead refuge options. Because of the necessary studies and construction timeframes for implementing these concepts, the Corps has advised that implementation of a viable concept, if funded and found to be feasible, could not occur in the short term (during the 1994/95 steelhead run), but may have long term application.

V.D.1. Physical Barrier

The objective of this measure is to install a structure that is sufficiently large to allow fish to pass, but not sea lions. Such barrier should not impede or slow passage or cause steelhead to mill in front of it, otherwise the predation problem would just shift to the face of the barrier. Fish inside the barrier would be provided a "sanctuary" downstream of the Locks that is free from predation. The barrier would have to be installed on the south side (downstream from the spillway basin) of the Locks facility so that it would not impede vessel navigation. This could be a slotted rigid type structure, a supported net type structure, or other device located downstream of the fishway. A net type structure could be made with various materials such as nylon mesh, steel mesh, or steel rings. A slotted structure could be of concrete, wood pilings or other rigid material. The size of openings for any type of barrier would have to be large enough to allow passage of all anadromous fish but small enough to preclude entry of sea lions. A physical barrier must be able to withstand maximum anticipated discharges and potential debris, not impede the flow of water from the dam structure, and not create hydraulic conditions which might cause structural damage to the project area.

An experimental nylon net barrier was installed during the 1987/88 season to test the feasibility of the barrier concept. In general, no detectable decrease in predation rates was

observed. The presence of the barrier appeared to only transfer predation further downstream. Also, several sea lions quickly learned to forage effectively at the face of the barrier in spite of harassment and thereby likely impeded fish passage. Some fish were deflected at the face of the net and thus were vulnerable to predation for longer periods than those that passed promptly through the net. Due to low rainfall, the volumes of water spilled over the dam (and associated debris) were low in January through March 1988 (Figure 8).

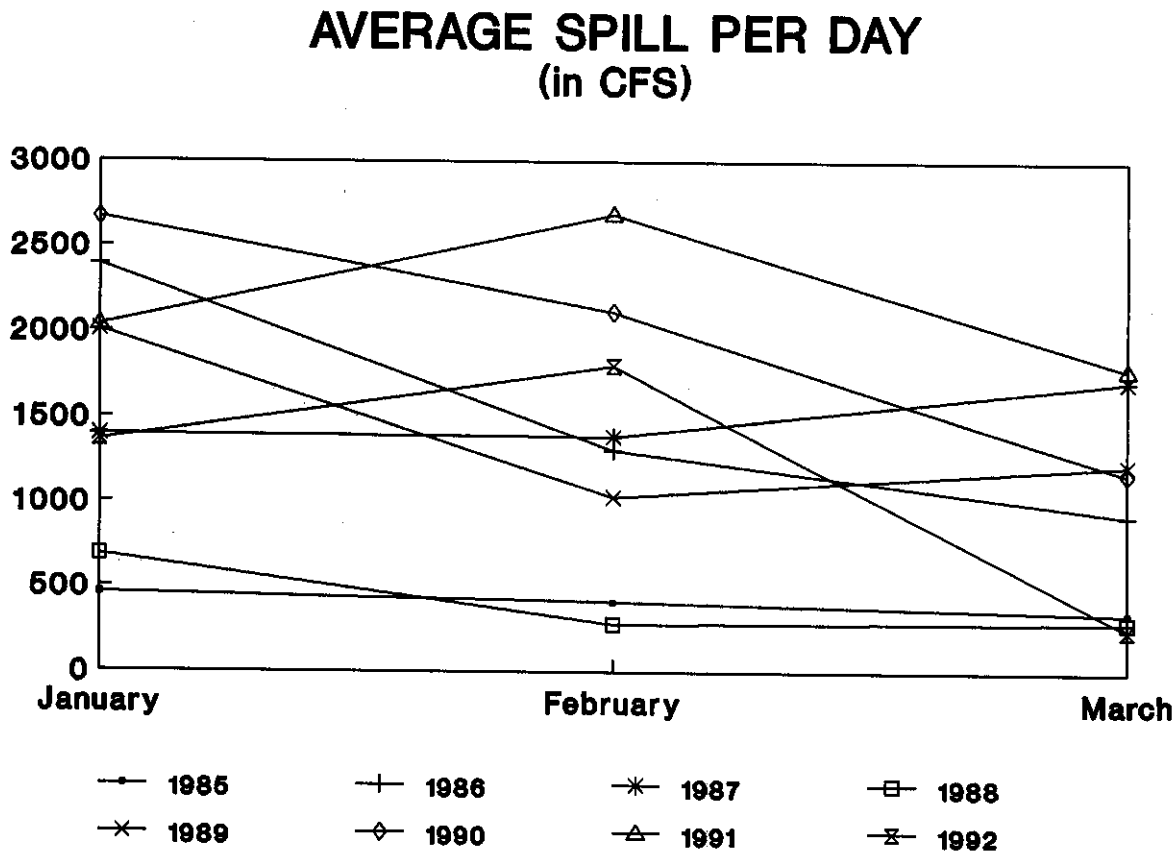

Figure 8. Average spill of water (in cubic feet per second) over the dam at the Locks facility in winter, 1985 to 1992 (note the low flow in 1988 when the experimental barrier was tested).

Several fish passage experts have expressed the opinion that high flows are necessary for optimal fish passage through barriers and that the low flow conditions during the barrier testing period in 1988 may have contributed to the observations of steelhead not readily passing through the barrier. The cable supporting the net barrier gave-out when large volumes of water and large debris (logs measuring up to 14 feet) came over the dam causing the net

barrier to collapse. The net itself did not rip from this pressure, rather the support cable socket gave-out, but the barrier was not reinstalled as it was planned preseason to remove the barrier in only two or three more weeks after the collapse.

Several configurations, locations and construction materials were considered during the design phase of the experimental barrier. Wire mesh, rather than nylon net webbing, was rejected because several engineers believed that under tension, the wire mesh would have a tendency to put-out low frequency vibrations possibly resulting in fish disturbance or passage delay. Materials such as pipe, pilings or other rigid structures were rejected because of cost and installation difficulties. Although the original test concept called for installation near the end of the small lock finger pier, in order to maximize the area of protection, this approach was rejected because of differing and unstable bottom topography resulting in increased installation costs.

Nylon mesh was found to be the least expensive material from which to construct the test barrier. To determine whether nylon mesh would cause passage delays, test panels of 16 and 18 inch mesh, consisting of #60 twine, were suspended in the fishway viewing chamber. Observations were made of the reaction by sockeye and chinook salmon to the mesh panels. All salmon were seen to pass through the mesh although some paused momentarily at the net face before moving through. For ease of installation, and lowest cost, the test barrier was installed at the edge of the concrete stilling apron. This provided a solid flat base for attachment. At the time of installation, several Corps engineers noted that the experimental barrier was placed in a bad location with respect to hydraulic stresses and collection of debris (Pfeifer et al. 1989).

Post-season estimates of predation when the barrier was in place showed no significant difference from times without a barrier (Pfeifer et al. 1989) and that in the absence of additional measures to deter sea lions in the Ship Canal, predation just shifted further downstream when the barrier was in place. Beyond the lack of significant decreases in predation rates, there are additional problems associated with a physical barrier. The barrier must be designed to be lowered or opened to allow passage of maintenance barges to the area of the spillgates and fishway. Maintenance of the structure (especially debris problems) are significant. Placement of a trash boom above the dam is problematic due to space and maintenance requirements. Debris up to the size of a spillgate opening may pass through the facility during storm run-off conditions. Bio-fouling by algae and barnacle growth would cause increased drag on the structure during spill. If the structure is placed further downstream, attached to, or imbedded in, the irregular bottom substrate, spill flows could cause scouring below the structure. Because of

navigational requirements, such barriers are limited in placement to downstream of the spillway stilling apron to the south end of the small lock wall.

All avenues for access to the sanctuary area behind a barrier must be addressed in order to keep sea lions out of the sanctuary. In 1988, several sea lions, which had entered the upstream (freshwater) side of the dam through the locks, were observed to jump over the spillgates on the dam from the lake to the area behind the barrier. The spillgates would need to be modified to keep sea lions from jumping over. In addition, the edges of the barrier must be covered based on the observation of one animal in 1988 that went overland around the concrete apron at one end of the barrier to access the sanctuary. During examination of the net webbing after removal, several areas were found showing signs of upstream forces that likely were caused by sea lions attempting to charge through the barrier. Two sea lions did become entangled and died in the net during attempts to access the sanctuary.

The current channel width and design below the spillway is utilized to capacity during high spill periods, i.e. it cannot be further constrained without affecting its hydraulic capacity to carry water away from the dam during spill (Norberg 1990). If the design of a barrier structure were sufficiently robust to withstand the force of water and debris passing the stilling apron, the flows across the apron and through the inner bay would be constrained to unacceptable levels, precluding effective use of the spillways to regulate lake levels.

If effective, a barrier would be expected to provide a sanctuary area free from predation at the freshwater/saltwater convergence where steelhead may mill before passing into the fishway thereby saving some fish from predation. However, because a barrier would not prevent predation downstream of the barrier, in front of the two lock doors, or above the dam, it is possible that sea lion predation would shift to those areas and possibly negate the savings created by the barrier. Concern has been expressed by many fish passage experts that a barrier, if not designed correctly and adequately tested, could impede passage of steelhead. Because of the severely reduced size of the 1994/95 run, the high risk of losing additional steelhead to predation because of restricted passage through a quickly installed, untested barrier makes this alternative unfeasible in the short term. As noted above based on the experimental barrier tests, the uncertainty of weather and spills in future years must be taken into account in designing a barrier that would be effective in variable flows to ensure fish passage. The design and construction of a barrier could be costly and require long periods for installation and testing. This concept requires more study to determine what the merits and drawbacks are, how to approach, best design, timeframes involved, and necessary studies

(and whether they can be conducted with low number of steelhead with undue risk to steelhead run), etc. Because of this, this concept is not feasible in the short term, but should be reviewed as a potential long term approach. The action federal agency in determining whether to install and provide necessary funding for a barrier is the Corps.

V.D.2. Escape Cover/Structural Additions

The objective of this measure would be to provide a shelter area where steelhead can "hide" from sea lions or provide "safe" corridors or tunnels for fish. Members of the public have recommended using rubber or vertical pipes interspaced in the spillway area to allow fish passage and impede sea lions that are actively pursuing the fish. Large diameter slotted pipes, interconnected pipe structures, interlocking cages or tires, reefs and rubble mounds are some examples of escape cover structures. These structures would have to withstand the high discharge conditions in winter and not cause damage to the surrounding area. Although ideally such structures should be placed close to the fish ladder entrance, they may have to be located downstream of the spillway stilling apron to ensure that they do not result in conditions that might damage the stilling basin. They also would need to be placed in such a manner that does not restrict or adversely affect the hydraulic characteristics of the downstream area. These limitations would preclude placement of escape cover in the primary sea lion foraging area in front of the fishway.

Although several ideas for "escape cover" type structural additions have been examined, three key areas have yet to be addressed in the development of this concept. The first is that there does not appear to be anything in the scientific literature to suggest that returning adult steelhead would use escape cover to avoid predation. The question is whether these pelagic fish would use reef structures for protection or as an aggregating feature. Observations made at the Locks indicate the returning steelhead may use the mid to upper portions of the water column during their passage through the Ship Canal, and that they bolt for open water rather than cover to avoid a predator. It is important that the structures not delay fish movement thereby making them more vulnerable to predation. The second issue that must be addressed is how to adequately assess the performance of various prototypes given the limitations of the environment for observation (e.g., underwater observations during the turbulence of large spills). Thirdly, it is possible that cover placed near the ladder would obscure attraction flow patterns and thus impede the ability of the steelhead to locate the ladder entrance. To investigate the feasibility of these escape cover type structures, further studies and development of prototypes and/or experimental designs for field testing and analysis would be

necessary.

This measure has been examined by fish passage experts and hydraulic and structural engineers to determine appropriate structures and whether and how such structures might be field tested (Norberg 1990). To be tested, prototypes should be of adequate size and appropriately placed to provide opportunity for observation of results, but small enough to allow placement and removal for modification if appropriate. Tests would need to be conducted in a low-risk setting so that they do not cause adverse hydraulic conditions, and not threaten other structures. Also, to determine effectiveness, fish passage experts felt that fish tracking studies (e.g. tracking sonic-tagged fish) would be essential to assess effectiveness of such structures.

To examine the feasibility of providing escape cover for steelhead, NMFS and WDFW convened an Ad Hoc Technical Committee of appropriate experts to investigate escape cover or structural modifications that may provide long term or partial solutions to the sea lion/steelhead conflict (Norberg 1990). The Committee discussed a number of recommended designs which ranged from artificial reef structures made of tires, cast concrete, rip-rap or other debris to networks of rods either inter-twined or hanging from rafts or protruding from the bottom into which fish could escape. Also discussed were fanned grids of poles and boulder shelves designed to provide cover at varying tide heights. Following the discussions on the possible benefits and limitations of differing escape cover designs, the Committee indicated that implementation of this concept would be dependent on several factors. The cover should be installed to take advantage of the normal migration routes, behavior and distribution of the returning fish. The cover design should to the maximum extent possible have low maintenance requirements and be constructed of materials which would be durable. It should be able to withstand hydraulic conditions below the dam, particularly during heavy spill periods, and not impede or restrict the designed operation of the dam and Locks facility. The Committee concluded however that insufficient information about the behavior and movement patterns of returning steelhead precluded further analysis of possible structural alternatives and recommended further studies on steelhead passage and behavior in the Ship Canal (Norberg 1990).

Submerging escape structures in the navigable portion of the Ship Canal would likely be inappropriate due to the obstruction they would pose to dredging activities and the problems they would create for deep draft vessels utilizing the locks and Ship Canal. Placement below the spillway dam would require substantial anchoring to avoid shifting of the structure downstream during heavy spills. In addition, the erosion effects caused by any structure placed in the channel must be considered because they might negatively impact the stability of the canal walls or might

form bars or eddies which could present a hazard to navigation. Size and number of structures would need to be addressed based on analysis of fish distribution and behavior during predator avoidance. Large structures would require substantial anchoring, and may present more erosion hazard than smaller structures. Smaller structures may have to be more numerous to provide adequate protection opportunities for returning fish.

Another escape cover approach is to cover the prime sea lion foraging area near the spillway dam with some material in order to darken the underwater area to reduce predation by impairing sea lion vision and/or possibly restricting their access to the surface for air thereby reducing fish capture efficiency. This approach is based on past observations which indicate that predation rates are low at night and on the consideration that sea lions would spend more time, during a foraging attempt, moving to and from the closest available air. However, it is likely that fish passage also would be affected by this method because steelhead are reluctant to enter areas of sharp contrasting light levels. The use of fabric covers in hatchery raceways and similar facilities provides cover for fish in very shallow exposed conditions, similar to the use of cover by fish in a stream environment. It is not known whether returning fish would utilize darkened cover in the more open and relatively turbid waters below the dam which are several meters deep. No observations have been made which would indicate adult steelhead are using existing darkened areas below the dam, such as under the wooden piers or wing walls, as protective cover or holding areas. A fabric cover would need to be porous to allow the escape of air introduced during spill and yet heavy enough to eliminate the possibility that sea lions could push the material up to obtain air. The fabric would need to be held away from the face of the dam a sufficient distance to allow spill without allowing water flow over the fabric causing pockets or folds which may trap fish or sea lions. The space left near the dam would provide an access for sea lions to air, adjacent to the primary foraging locations at the fishway. A fabric cover would need to be sufficiently buoyant and rigid enough to maintain its shape while fluctuating with the surface during tidal exchanges. However, there should not be sufficient buoyancy or rigidity to allow sea lions to haul-out on top of the fabric.

The design and construction of many of the escape cover concepts could be costly and require long periods for installation and testing. Each potential approach for escape cover requires more study to determine what the merits and drawbacks are, how to approach, best design, timeframes involved, and necessary studies (and whether they can be conducted with low number of steelhead with undue risk to steelhead run), etc. Because of this and the uncertainty on whether such approaches would indeed save fish from predation, the escape cover concept does not appear to be feasible for implementation in the short term, but should be

reviewed as a potential long term approach. The action federal agency in determining whether to install and provide necessary funding for escape cover structures at the Locks facility is the Corps.

V.D.3. Electric Barriers

The objective of this approach would be to erect an electric barrier that allows or guides passage of fish but not sea lions. Electric fences have been used effectively in the Great Lakes where electric barriers are used to prevent lamprey passage while allowing trout to pass. Other electrical devices, which elicit an avoidance response in fish to electric stimuli (electrotaxis), have been designed to prevent passage of upstream migrants and to keep fish away from structures or to guide them into bypass areas (Stone and Weber Engineering Co. 1986).

Any electrical device would have to be tested at the Locks to assess effects on steelhead passage and the sea lions before it could be considered. The use of electrical devices are unlikely to be applicable to the Ship Canal because of the saltwater environment (in contrast to freshwater where these devices have been tested and used).

V.E. Implement Other Fish Passage/Management/Habitat Measures

There are three separate components to this alternative, and each is discussed separately below.

V.E.1. Fish Passage Enhancement

This alternative is to implement several measures to enhance fish passage at the Locks facility and to evaluate further actions which may serve to improve the movement of both upstream and downstream migrants. These measures have been developed and recommended by an Interagency Working Group convened by the Corps to review operating procedures and the structural features of the Locks, the spillway dam and the fishway. The Task Force recommended that the Corps provide a report to NMFS on Corps efforts to address fish passage issues. The Working Group also included the Task Force recommendations on fish passage in its review.

During its review, the Working Group identified areas of concern and possible measures to address and improve fish passage at the Locks facility. To address concerns about maintaining adequate attraction flows from the ladder, the Corps has replaced the original fishway control modules for use in the fishway controller during the 1994/95 steelhead run. The controller

adjusts water supply and entrance gate settings to maintain attraction flows within the limits of its design. The original unit has been in place since the fishway was reconstructed in 1976 and had periodically experienced failures which prevented operation at the original design criteria. The Corps has advised that the control modules will be electronically changed to accommodate opening and closing the north entrance slot during periods of high spill. For the long term, the Corps has begun to prepare design specifications for a new automated fishway controller. The resource agencies are participating in identifying the necessary design parameters for inclusion in the new controller.

To address concerns about the use of spill for fish attraction and reduce the possibility of distracting fish from the fishway, the Corps has advised that it will continue to use the spill protocol developed by NMFS in 1990 during the 1994/95 steelhead season. The USFWS has indicated that they would provide guidance on changes to the protocol, for evaluation purposes as part of the planned steelhead tracking study during the hatchery portion of the run. If alternate spill patterns prove to be advantageous for improving fish attraction to the fishway, without creating conditions conducive to structural damage, a new protocol would be developed and utilized. The Corps is evaluating possible methods for providing surface spill for smolt attraction away from the locks. If feasible, an experimental design, utilizing a modified cofferdam, may be tested during smolt out migration in 1995.

A water spray system to reduce bird predation on downstream migrants below the large lock has been used in the past and appears to work well. The Corps has advised that it plans to utilize the water spray system in 1995 and increase its area of coverage to further reduce avian predation potential.

Regarding the concern about adult fish entry and entrapment in the saltwater drain, the Corps has advised that it will continue to evaluate this and develop operational strategies to reduce the risk of adult entrapment. To ensure that outmigrants are provided with an egress through the saltwater drain which is as safe as possible, the Corps has advised that the excluder screen will not be reinstalled when outmigrating juvenile fish are present.

Major structural modifications to enhance fish passage are beyond the scope of this EA since they could not be implemented in time to save fish this year and are outside the authority of NMFS and WDFW; they are under the authority of the Corps. Such projects would include construction of a second fishway, extending the current fishway or retro-fitting the dam, locks or fishway with new spillgates, valves, or entrance gate designs respectively.

V.E.2. Fisheries Management

This alternative is to take fisheries management actions to eliminate sources of steelhead mortality and/or increase the numbers of steelhead in the population.

V.E.2.a. Restrict Fisheries

This approach has been used in the past due to the depressed size of the wild run, and no tribal or sport fisheries were permitted on either hatchery or wild fish. However, these closures did not result in increased escapement because sea lion predation still occurred. The State and the tribes have advised that they will continue steelhead fisheries closures in the Ship Canal in 1994/95. Impacts of restricting fisheries include lost sport fishing opportunity and revenues generated by such, and economic impact on tribal fishers.

V.E.2.b. Increase/Decrease the Numbers of Steelhead

This approach involves increasing the wild steelhead run and/or increase/decrease the hatchery component to minimize the impacts of sea lion predation on wild steelhead. One approach would be to increase hatchery smolt stocking levels in order to dilute predation pressure on wild fish. However, it is possible that this could attract more sea lions to the area and aggravate the predation problem. On the other hand, reducing or eliminating the hatchery component could reduce predation by sea lions by lessening the availability of steelhead causing the sea lions to leave the area. The approach of eliminating the hatchery run has been taken by the State as described in Section IV.D. of this document.

Another approach would be to attempt to augment natural production of wild steelhead. Brief hatchery culture could be used to improve natural egg-to-fry survival rates of wild fish from about 20-25 percent to 70-90 percent. A basin-wide stocking program could place more fry into rearing areas than might be produced naturally. Concerns with this approach include the degree of artificial (and possibly deleterious) selection imposed on the wild fish population. Potential negative effects include possible mortality of all fry during culture thereby resulting in loss of wild production. Because of the extremely reduced size of the wild run, the risks to the population may outweigh potential benefits. Also, increased numbers of steelhead may result in increased numbers of sea lions in the area if measures are not taken to control predation.

Additional production of wild fish in the Lake Washington basin could be accomplished by making habitat available to steelhead

above the Landsburg Dam on the Cedar River. NMFS, WDFW, the U.S. Fish and Wildlife Service, and the Muckleshoot Indian Tribe are working with the Seattle Water Department to implement plans to reintroduce wild winter-run steelhead above the Landsburg diversion dam. Successful re-seeding of this 11-mile area of prime habitat could double returns to the Cedar River adding about 1000 adult fish to the overall wild run.

V.E.2.b. Capture and Transport Steelhead

This measure is to capture steelhead below the Locks and transport them above the Locks. Captures would have to occur with weirs, purse seines or gillnets. Handling captured steelhead would likely introduce mortality. There is no feasible area in the lower Ship Canal to place a weir and not all wild steelhead would be captured in it. Purse seine captures are not feasible because steelhead do not appear to enter the Ship Canal in large schools. Gillnets are used to capture steelhead in the Ship Canal, but not all would be captured and netting and handling mortality could be especially high in this gear. Lastly, because the capture would occur in saltwater and the release in freshwater, the uncertainty on potential effects on physiological changes that steelhead undergo before entering freshwater and potential mortality that may occur make this approach unfeasible.

V.E.3. Habitat Improvement

This alternative is to implement the recommendations of the Task Force on habitat as described in section II.B. of this document. Studies by WDFW indicate that habitat is not a factor limiting steelhead spawning. Sufficient habitat currently exists for seeding by over 1600 steelhead (spawning escapement goal). The limiting factor is the failure of returning spawners to migrate into freshwater through the Locks facility due to sea lion predation. Implementation of this alternative would have no direct effect on the 1994/95 run of steelhead that will be vulnerable to sea lion predation; nonetheless, implementation of habitat improvements that enhance steelhead survival would benefit the overall status of the stock. In this regard, further investigations are needed on freshwater smolt rearing habitat and downstream smolt passage to determine if there are any factors limiting freshwater survival.

V.F. Remove the Locks Facility

This alternative has been suggested by some in the public who feel that removing the man made obstacle to fish passage (i.e. the Locks/dam facility) and returning the system back to its

original state of the early 1900's would resolve the predation problem. This is not a viable alternative because the repercussions of such an action are so significant and socially and economically overwhelming to so many components of the Northwest that serious consideration of such a proposal is not warranted.

V.G. Lethal Removal in Combination with Other Measures (Proposed Action)

This is the preferred alternative to implement the Task Force recommendation to allow lethal removal of individually identifiable "predatory" California sea lions only under certain conditions. The term "predatory" would mean an individually identified sea lion (i.e., one bearing a brand mark, dart tag, flipper tags or other distinguishable natural marks) that has been observed preying on steelhead at anytime (including past years) in the Lake Washington Ship Canal. The conditions on lethal removal would include first attempting to deter the sea lions with acoustic deterrence measures and then making all practicable attempts to capture and successfully place the "predatory" sea lions in captivity during the duration of the run; lethal removal would occur only if adequate holding facilities are unavailable. Lethal removal would not commence unless and until the sea lion predation rate exceeds 10 percent of the steelhead passing in any consecutive 7-day period after January 1, 1995.

The acoustic deterrence efforts that would be used in conjunction with the proposed action are described in Section V.C.3. of this document. This non-lethal deterrence effort would be attempted prior to lethal removal. Further, sea lions that enter and remain in the ensonified area that are exhibiting predatory behavior or are attempting to forage on steelhead in the area in front of the fish ladder, would be identified for non-lethal capture and placement in captivity if temporary holding is feasible and practical. Past experience has shown that sea lions exhibiting this behavior in spite of the acoustic deterrence will be killing steelhead when they are available in the prime predation area in front of the fish ladder. This approach is necessary because it is much more effective to remove these animals as soon as they are identified rather than waiting for them to begin killing steelhead and then risk not being able to capture them quickly. This approach would save more steelhead from predation.

Lethal removal would consist of capturing identifiable sea lions and euthanasia under guidance of an Animal Care Committee (ACC) consisting of marine mammal veterinarians and experts. Use of the ACC would ensure that methods used to dispatch the animal are the most humane possible recommended by experts. The lethal

removal would be accomplished in a manner that results in the least stress and pain possible to the individual animal.

The proposed action would be to lethally remove individually identifiable sea lions as a last resort only after deterrence in combination with captive holding are not sufficient to remove predatory sea lions from the Locks area. The requirement to only lethally remove individually identifiable animals that have been observed eating steelhead in the Locks area would minimize the number of animals affected by this action and further ensure that other non-involved sea lions in Puget Sound are not impacted. Sea lions entering the Locks area would be identified by existing marks or tags, or temporary dart tags would be applied when such animals enter the fishway area so that they can be subsequently identified for capture if they meet the aforementioned criteria. The proposed action would include use of active capture, but only for predatory sea lions that do not avail themselves to trapping. Active capture operations (described in Section V.C.4.c. of this document) would likely involve the use of tangle nets and drugs to slow-down the animals to allow for safe handling (both for people involved and the sea lion). There would be a risk that some sea lions may die during active capture operations.

Lethal removal would not occur unless and until the sea lion predation rate[1] exceeds 10 percent of the available steelhead in any consecutive 7-day period after January 1, 1995. If, after the initiation of lethal removals, the predation rate equals or falls below 10 percent for 14 consecutive days when steelhead have been recorded passing through the fish ladder[2], removals of newly identified predatory sea lions will cease until the predation rate again exceeds 10 percent for any consecutive 7-day period. However, predatory sea lions identified prior to the end of a 14-day reduced predation period may still be lethally removed. This "trigger" for initiation of lethal removal was recommended by the Task Force. By having a "trigger" on when lethal removal occurs, it ensures that lethal action is not applied prematurely on sea lions that are removing proportionately small numbers of the entire wild run. However, if the run is small, this inseason "trigger" ensures that action is taken to protect fish as soon as numbers of steelhead begin to be preyed on. This "trigger" mechanism would not allow lethal removal to occur until after January 8 (i.e. after 7 consecutive

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[1] Predation rate would be defined as the percentage of the available steelhead that are killed (estimated predation). The estimated predation would be a statistically reliable estimate (based on observations during the 7-day period) of the total number of steelhead killed by sea lions within the observation area. The available steelhead would be the number of steelhead that have been recorded passing through the fish ladder counter, plus the estimated predation.

[2] Any day when no steelhead pass through the fish ladder would not counted for the purpose of determining 14 consecutive days.

days of steelhead passage after January 1). Although some wild steelhead might be consumed during this week, the numbers would likely be low because early January is a timeframe when the proportion of wild to hatchery steelhead is lower. Later in January, the proportion of wild to hatchery steelhead changes quickly towards predominately wild steelhead and predation then becomes more of a concern. The "trigger" mechanism pertain to any steelhead consumed or counted by the fish counter, rather than just wild steelhead, for several reasons. In regard to monitoring, there is no way for the fish counter to distinguish between a wild or hatchery steelhead, and it would be very difficult for an observer documenting predation to confirm the presence or absence of an adipose fin (the identifying characteristic). After January 8, there is a some probability that a steelhead in the area of the fishway is a wild steelhead and that probability increases over time through late January when the probability is much greater that the steelhead is wild. Because of the low numbers of wild spawners predicted to be returning, this approach ensures that necessary protection of the wild run is maintained, while safeguards discussed above ensure that sea lions are not unnecessarily removed. This "trigger" for lethal removal of sea lions would also apply to active capture using entangle nets and drugs because active capture involves a risk of mortality to the sea lion (in contract to passive capture which has been conducted successfully without drugs and no risk of mortality). However, this "trigger" would not apply to the non-lethal removal of sea lions for placement into captivity which otherwise is authorized under Section 109 of the MMPA. During the first 7-day period, predatory sea lions could be removed into captivity, even though lethal removal is not authorized, thus providing additional protection to the steelhead.

Only "predatory" sea lions would be targeted for lethal removal. The acoustic barrier is intended to "screen-out" naive animals that have not preyed on steelhead at this site and thereby minimizes the potential number of sea lions that might be candidates for lethal removal because they have preyed on steelhead. The acoustic deterrence approach also would minimize the possibility of replacement of "predatory" animals by new entrants. Past data indicate that although 40 to 50 animals may occur in the Shilshole Bay area, only a few of these routinely enter the Locks area; and of those that repeatedly enter the Locks area, only 3 to 6 are responsible for most of the predation that occurs. Action to minimize or eliminate sea lion predation on steelhead by these few sea lions at the Locks facility is necessary because past data clearly shows that a few animals can consume 60 percent of the returning adult steelhead destined for the spawning grounds. The restrictions on the authorization of capture and removal would limit the effects of the proposed action to a small number of sea lions. Lethal taking would be applied only to those few predatory sea lions that are not

successfully placed in captivity. Although 20 to 40 sea lions could possibly be involved, if the acoustic devices are successful in deterring most new entrants to the Locks area, then the numbers of sea lions that may need to be captured and removed (to captivity or killed) is unlikely to be more than 15 sea lions. Past data on marked sea lions (see "Resights of California sea lions at Shilshole Bay" in Section IV.C. of this document) supports this contention that the numbers of "predatory" sea lions is likely to be a fraction of those that occur in Shilshole Bay. Further, as an additional safeguard to avoid actions on many sea lions, the Task Force would be reconvened if removals (non-lethal and lethal) reach 15 animals so that the measures can be evaluated and further recommendations made as necessary. The potential lethal removal of such small numbers of male sea lions would have no impact on the population of over 200,000 animals, especially in view of the increasing population trend. Further, because sea lions are polygamous, with one male reproducing with multiple females, removal of a few males would have no effect on the reproductive status of the population.

Potential mortalities of some of these sea lions may occur during active capture operations (if the animals do not avail themselves to capture on the trap) or during captivity if complications develop. An Animal Care Committee including consulting veterinarians and marine mammal biologists would be formed to develop and review all capture and holding protocols to reduce any potential risks to individual sea lions to the minimum attainable level.

Past studies have shown that no non-lethal method by itself would be totally effective, and that any non-lethal efforts must be combined with more effective removal techniques such as lethal removal as a last resort to resolving the predation problem. To be effective in reducing predation to insignificant levels, any measures undertaken to deter sea lions must effectively remove the "predatory" sea lions from the foraging area since even a small number of sea lions foraging in the Ship Canal are capable of inflicting substantial losses on the steelhead run. The use of the acoustic devices, which would be used in combination with this alternative, has been previously assessed in prior EAs and determined to have no significant effect on the human environment (see NMFS and WDW 1994).

The Task Force recommendation to undertake lethal removal as a last resort only after acoustic deterrence and attempts to place animals in captivity have failed was based on Task Force concerns that Lake Washington wild steelhead population is severely depressed for a number of reasons, one of which is their vulnerability to predation by California sea lions at the Locks. With the conditions applied and dependent on the effectiveness of the acoustic devices, it is unlikely that this alternative would

result in the lethal removal of more than 15 sea lions.

The Muckleshoot Indian tribe has expressed an interest in receiving the sea lions identified for lethal removal so that the tribe may use them for subsistence purposes in the exercise of their treaty rights. Such use may preclude the need by the tribe to remove additional animals for subsistence purposes.

VI. CONSIDERATIONS UNDER SECTION 120(d) OF THE MARINE MAMMAL PROTECTION ACT.

In accordance with Section 120(d) of the MMPA, in considering whether an application should be approved or denied, the Pinniped-Fishery Interaction Task Force and the Secretary shall consider:

1) population trends, feeding habits, the location of the pinniped interaction, how and when the interaction occurs, and how many individual pinnipeds are involved;

2) past efforts to non-lethally deter such pinnipeds, and whether the applicant has demonstrated that no feasible and prudent alternatives exist and that the applicant has taken all reasonable non-lethal steps without success;

3) the extent to which such pinnipeds are causing undue injury or impact to, or imbalance with, other species in the ecosystem, including fish populations; and

4) the extent to which such pinnipeds are exhibiting behavior that presents an ongoing threat to public safety.

The information that was considered pertinent to each of the points is described below.

VI.A. Consider population trends, feeding habits, the location of the pinniped interaction, how and when the interaction occurs, and how many individual pinnipeds are involved.

The current west coast population of California sea lions is estimated in excess of 200,000 animals with about 111,000 of these in U.S. waters. The west coast population has been increasing at a rate of 10.2 percent annually since 1983. Because the population of California sea lions is currently growing exponentially, it is unlikely that the population has reached its optimum sustainable population level. Increased numbers of California sea lion males have migrated into northern waters coincident with the population increase; the number of California sea lions in British Columbia increased ten-fold between 1972 and 1984. The increased numbers observed were

greater than the annual rate of increase for the breeding population off California; hence, a sudden shift to a more northward migration appears to have occurred. The numbers of California sea lions in British Columbia reached a peak in 1984 of about 4,500 animals then leveled off in subsequent years at 2,000 to 2,500 animals each year; this trend also represents the population trend in Washington because all of these animals would have had to pass through Washington waters. Large numbers of California sea lions (over 100) were first recorded in Puget Sound in 1979 and increased each year through 1986 when over 1,000 animals were counted. The peak numbers counted leveled off at about 300 to 500 animals seasonally after 1986.

California sea lions feed on a wide variety of fish and squid. In Puget Sound, sea lions congregate near the Everett/Port Gardner area apparently in response to a large spawning stock of Pacific whiting in Port Susan. Important prey in Washington are Pacific whiting, herring, spiny dogfish, codfish and salmonids. California sea lions feed on steelhead, coho, sockeye, chum and chinook salmon throughout Washington, both on free-swimming fish and from gillnets and hook-and-line gear. No estimates are available on the total biomass of salmonids consumed by California sea lions on a state-wide basis. In the Lake Washington Ship Canal, a few California sea lions target on returning adult steelhead and have consumed as much as 65 percent of the returning adult spawners in one season.

Prior to 1980, sea lion presence at the Locks was infrequent or rare with the first known incident of predation occurring in 1970. The occurrence of California sea lions preying on steelhead at the Locks was not viewed as a resource issue until 1985, when serious declines in the wild winter-run steelhead were noted. Subsequent studies documented that the sea lions were removing significant numbers of adult fish that were returning to spawn. Because of the small size of the total wild run, which historically averaged about 2,500 fish each year, sea lion predation, in itself, has prevented achievement of the wild steelhead spawning escapement goal of 1,600 fish in the Lake Washington drainage in five of six years between 1985 and 1990, when total wild run size was otherwise large enough to assure attainment of the escapement goal. The proportion of the total run consumed by sea lions increased between 1986 and 1989 from 42 percent to 65 percent. During this same period, the wild steelhead run has decreased by 61 percent. Steelhead escapement goals have not been met for the Lake Washington drainage for the past 8 years and the predicted total run size for 1994/95 is at its lowest level in the past 10 years (lower than the escapement goal). Continued shortfalls in achieving the spawning escapement goal (by as much as 96 percent experienced in 1993/94) could result in unrecoverable damage to this run.

Much of the predation is attributable to three to six individual

sea lions that return to the Locks each year and prey on wild steelhead during the run period of January through May. The principal area of predation is the area in front of the fishway, although steelhead predation has been observed throughout the Ship Canal from the Locks facility downstream to the Ship Canal entrance at Shilshole Bay. Although 40 to 60 California sea lions may frequent the Shilshole Bay area, marking data indicates that many of these sea lions do not enter the Ship Canal and only a small number are actually observed to prey on steelhead (see Table 4).

VI.B. Consider past efforts to non-lethally deter such pinnipeds, and whether the applicant has demonstrated that no feasible and prudent alternatives exist and that the applicant has taken all reasonable non-lethal steps without success.

NMFS and WDFW have undertaken a number of non-lethal predation reduction efforts since the 1985/86 season. These non-lethal efforts have included harassment using underwater firecrackers, boat chasing and hazing, sonic repulsion devices, taste aversion conditioning, tactile harassment with rubber-tipped arrows, experimental barrier nets, acoustic barriers, and trapping and relocation of sea lions to the outer coast of Washington and to their breeding grounds off southern California. In addition, efforts have been made to increase wild steelhead spawning escapement through restrictions and closures of the sport fisheries; restrictions and closures of treaty Indian fisheries; modified flow patterns at the spillway to improve passage into the fish ladder; collection and spawning of broodstock at the fishway and rearing their progeny to fry for planting in the upper Cedar River; and, collection of adult steelhead below Landsburg Dam and transport above the dam (upper Cedar River) for spawning in otherwise unavailable habitat.

The initial predation control program in 1985, consisting of harassment with underwater firecrackers, resulted in a reduction in sea lion predation down to about 15 percent of the returning fish. However, the use of firecrackers subsequently became ineffective in deterring predation and was ultimately discontinued in 1988. Other predation control efforts also have had limited effectiveness in allowing more returning wild fish to contribute to the spawning escapement.

Non-lethal alternatives have been shown to have limited success in reducing predation as some animals "learned" to avoid or tolerate the negative stimuli generated. Capture and relocation efforts have not been totally successful as relocated animals do return. Passive capture efforts also have had drawbacks in that not all predatory animals could be captured. To be effective in reducing predation to insignificant levels, any measure

undertaken must effectively remove the predatory sea lions from the foraging area since even a small number of sea lions foraging in the Ship Canal are capable of inflicting substantial losses on the steelhead run. This is exemplified by the NMFS/WDFW experience in 1990, when 6 sea lions were removed and transported to the Channel Islands (three of which were primary predators of steelhead). Although predation rates did drop during the following week and fish passage did increase immediately after the removal of the primary predators, it returned to high levels within a week. However, this increase in predation was not due to replacement by new animals, it was because not all of the "problem" sea lions that had been observed eating steelhead during the season were captured. Two of these other sea lions, branded #25 and #19, which had been in the Locks area feeding on steelhead previously, began utilizing the prime forage area in front of the fish ladder and after one week, the predation rates increased and remained high for the remainder of the season. Post season accounting of predation by individual animals show that #25 was responsible for the highest percentage of the steelhead kills in 1989/90 followed by #42, #19, #17 and an identifiable, but unmarked sea lion (see page 46 of Pfeifer 1991). In March 1990, #42 and #17 were captured and relocated to southern California. Prior to capture, #42 was the principal sea lion occupying the prime predation area and #25 was frequently observed in the secondary predation area in front of the large lock. However, the post-season accounting showed that #25 was responsible for the highest percentage of the steelhead kills even before #42 was captured. These data clearly indicate that the "problem" sea lions that habituate to preying on steelhead in the Locks area must be removed, otherwise the adverse effects of sea lion predation will not be resolved.

Past experience has shown that non-lethal efforts must be combined with other measures in order to be effective in reducing predation. Past efforts by NMFS and WDFW have been unsuccessful in finding a feasible non-lethal approach that is continuously effective in eliminating predation. Non-lethal deterrence measures appear to be effective on new entrants to the Locks area, but quickly become ineffective if used on naive animals in the presence of the non-responsive "problem" sea lions that do not react to deterrence. Removal of these "problem" animals therefore may enhance the effectiveness of non-lethal measures on other sea lions.

A broad range of other non-lethal measures that have not been attempted are described herein. They have not been attempted because they are unlikely to be effective, logistically or otherwise unfeasible, impractical, untested and of questionable merit, or extremely costly.

The proposed action is a phased approach with use of non-lethal acoustic devices and potential capture/removal to captivity;

therefore, the probability of having to lethally remove sea lions is low. Nevertheless, in order to minimize/eliminate predation on wild steelhead, lethal removal is necessary as a last resort for those animals that cannot otherwise be deterred from the area. Past studies indicate that predation by California sea lions on returning adult spawners, unless significantly reduced, can compromise the viability of this wild run. Because the overall run size is now so reduced, even one sea lion remaining in the primary foraging area could remove an excessive number of returning fish.

VI.C. Consider the extent to which such pinnipeds are causing undue injury or impact to, or imbalance with, other species in the ecosystem, including fish populations.

The level of predation observed in past years, over 50 percent of the returning steelhead in the four years (1987-88 through 1990-91) when extensive data were collected and non-lethal measures were ineffective, is more than a healthy population of steelhead can sustain. At the extreme low levels of returns expected in 1994/95, all mortality factors, including predation, must be eliminated if possible. Treaty Indian and sport fisheries that may impact the returning wild winter-run steelhead have been closed. The remaining exploiter of these returning adult fish that needs to be controlled is the sea lions. As described above, only a few sea lions consumed the majority of the steelhead run in years when over 1600 steelhead (the spawning escapement goal) returned. Given the depressed spawning escapements in the last two years, it is important to protect as many of the spawners from this years run as possible to ensure the viability of this run. Although there are a number of factors that may be contributing to the current decline, the adult spawner vulnerability to predation by sea lions at the Locks is a principal factor that must be addressed in order to increase spawning escapement.

Individual sea lions that have preyed on steelhead can be identified and have been monitored over time (see Appendix A). Data collected on these identifiable sea lions demonstrate that animals that have preyed on steelhead and are still in the area are almost certain to continue predation. Observed numbers of steelhead consumed by sea lions at the Locks have been as high as 32 steelhead consumed in one day. With a total projected wild run of only 60 to 371 fish, the sea lions obviously can consume the bulk of the run if such high predation rates occurred unabated. Even a single sea lion can cause severe damage to the run. In 1986, one easily identifiable sea lion averaged 12 steelhead consumed per 8 hour period per day in the absence of harassment. In many years of observations, most of the entire estimated amount of steelhead consumed can be attributed to three or less sea lions. In 1988/89 for example, when sea lion

predation was estimated at 1287 wild steelhead (65 percent of the run), three sea lions accounted for about 70 percent of the predation. Based on this and the expected low return, it is reasonable to conclude that any sea lion that meets the definition of "predatory" has had a negative impact on the steelhead run, and if not removed, will have a significant impact on the status or recovery of the wild steelhead population.

Other alternatives identified that do not involve actions with the sea lions are not likely to address the problem of protecting the low returns in 1994/95 from sea lion predation. Some of these alternatives warrant further study as they may have longer term implications in providing information on increasing the survival and/or numbers of steelhead. Other factors such as habitat improvements may be beneficial in the long term, but do not have clear short term implications for the 1994/95 run. Surveys and studies conducted by WDFW in the Cedar River indicate that adequate and substantial spawning and rearing habitat is available and therefore habitat in the Lake Washington basin is not limiting the wild breeding component of the winter run, but rather, spawning habitat is underutilized when the spawning escapement goal of 1600 wild fish is not reached.

VI.D. Consider the extent to which such pinnipeds are exhibiting behavior that presents an ongoing threat to public safety.

The California sea lions preying on steelhead in the Locks area are not a threat to public safety.

VII. FINDING OF NO SIGNIFICANT IMPACT

The alternative to take no action could result in unrecoverable damage to the Lake Washington basin winter-run wild steelhead and therefore is not a viable alternative. The wild steelhead population has declined dramatically in recent years to an all time low total run-size of 76 fish in 1993/94. Steelhead escapement goals have not been met for the Lake Washington basin for the past 8 years. Because the predicted 1994/95 returning wild run is already substantially below the spawning escapement goal (77 to 96 percent below goal), predation by sea lions needs to be eliminated, if possible, to protect the viability of this unique winter-run population that has been shown to be different from the hatchery fish that have been planted in the Lake Washington basin. Only those feasible and prudent alternatives that have some reasonable chance of success in reducing or eliminating predation and that can be implemented in the short term are considered for implementation this season. The viable alternatives considered for implementation this season are unlikely to have any adverse affects on other wildlife species or any human activities in the Locks area. Approaches that may

adversely affect water storage and operational Lake levels, vessel navigation through the Ship Canal and locks, and hydrologic aspects of operations and maintenance of the Locks facility are not proposed in this action. Structural modifications to the Locks facility under the jurisdiction of the Corps are not proposed for implementation in the short term.

The alternative for creating a physical barrier or escape cover is an area that needs to be studied further to fully understand the implications of such on fish passage. It is unlikely that these approaches can be implemented in the short term without definitive studies that show these efforts would be beneficial and not detrimental to fish passage. The numbers of wild steelhead are too low to take the risk of putting in a structure that may be found to impede rather than improve fish passage. Such concerns for these fish necessitate complete studies on possible modifications before implementation is considered. It is acknowledged that the small numbers of fish would also preclude use of these fish for experimentation with new concepts, but hopefully surrogate species can be used to test such concepts. The proposed action does include the use of acoustic devices to implement an "acoustic barrier" that serves the same purpose as a physical barrier except that it in no way impedes fish passage as it is outside the hearing range of fish. Use of the acoustic barrier in 1993/94 does indicate that it modifies the predatory behavior of the "problem" animals and appears to serve as a deterrent to the entrance of new animals into the prime predation area in front of the fishway. With additional efforts to capture and remove those animals that are non-responsive to the acoustic deterrence, the acoustic barrier may be viewed as implementing the barrier concept without the need for construction of physical structures.

The proposed action is a combination of non-lethal deterrence with acoustic devices, capture and removal to captivity, and lethal removal as a last resort. These actions would be implemented on a phased approach with the acoustic barrier and other non-lethal deterrents such as boat chasing and firecrackers utilized to prevent most animals from accessing the areas of high predation (i.e., area in front of fishway). Only "predatory" sea lions that prey on steelhead would be targeted for lethal removal. The acoustic barrier is intended to "screen-out" naive animals that have not preyed on steelhead at this site. This approach would minimize the possibility of replacement of these "predatory" sea lions by new entrants. Past data indicates that although 40 to 50 animals may occur in the Shilshole Bay area, only a few of these routinely enter the Locks area; and of those that repeatedly enter the Locks area, only 3 to 6 are responsible for most of the predation that occurs. Action to minimize or eliminate sea lion predation on steelhead by these few sea lions at the Locks facility is necessary because past data clearly shows that a few animals can consume over 50 percent of the

returning adult steelhead destined for the spawning grounds. The proposed action is to capture and remove only the individually identifiable sea lions that have been observed to prey on steelhead in the Lake Washington Ship Canal. This restriction on application would limit the effects of the proposed action to a small number of sea lions. Lethal taking would be applied only to those few captured animals that are not placed in captivity. While the removal of 20 to 40 male sea lions is negligible in relation to the overall sea lion population size and status, if the acoustic devices are successful in deterring most new entrants to the Locks area, the numbers of sea lions that may need to be captured and removed (to captivity or killed) is unlikely to be more than 15 sea lions. Potential mortalities of some of these sea lions may occur during active capture operations (if the animals do not avail themselves to capture on the trap) or during captivity if complications develop. An Animal Care Committee including consulting veterinarians and marine mammal biologists would be formed to develop and review all capture and holding protocols to reduce any potential risks to individual sea lions to the minimum attainable level. These measures would be applied only to male sea lions (as essentially only males occur in Northwest waters) and therefore because of the polygamous breeding behavior of this species, would have no effect on the reproductive status of the population. Overall, the numbers of male California sea lions that may be involved in removal is extremely small in comparison to the overall California sea lion population and therefore would have no detectable effect on the size or status of the west coast California sea lion population. For these reasons and those described in more detail in this document, it is hereby determined that neither approval nor implementation of the predation reduction program will significantly affect the quality of the human environment, and that preparation of an environmental impact statement on this action is not required by Section 102(2) of the National Environmental Policy Act or its implementing regulations.

Assistant Administrator for Fisheries

JAN. 4, 1995
Date

VIII. COORDINATION AND CONSULTATION

This is a follow-up to the previous Environmental Assessments prepared in 1989, 1992 and 1994 which included extensive consultations. The preparation of this document has been coordinated with various programs and offices in NOAA, NMFS, WDFW, and the Corps as well as with experts from Point Defiance Zoo and Aquarium, Seattle Aquarium, Airmar Technology Corp., and the U.S. Fish and Wildlife Service.

This EA also is being adopted under the Washington State Environmental Policy Act and will be circulated to the public and listed by the Washington State Department of Ecology in the State Register for environmental documents, which is published weekly.

IX. LIST OF PREPARERS

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APPENDIX A. RESIGHTS OF CALIFORNIA SEA LIONS TAGGED AND BRANDED DURING CAPTURE/TRANSLOCATION EFFORTS AT THE LOCKS.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
1	Jan. 14-15, 17-18, 1989	*Ballard Locks, WA
	Jan. 20-21, 1989	*Ballard Locks, WA
	Jan. 28-29, 1989	*Ballard Locks, WA
	Feb. 03,12, 1989	*Ballard Locks, WA
	Feb. 15, 1989	Captured Shilshole Bay, WA (398 lbs)
	Feb. 16, 1989	Released Klipsan Beach, WA
	Mar. 09, 1989	Hood Canal, WA
	May 20, 1989	Shilshole Bay, WA
2	Feb. 09, 1989	Dart tag, Shilshole Bay, WA
	Feb. 10-14, 1989	Ballard Locks, WA
	Feb. 15, 1989	Captured Shilshole Bay, WA (548 lbs); this animal died during recovery from anesthesia.
3	Feb. 16, 1989	Captured Shilshole Bay, WA (572 lbs)
	Feb. 18, 1989	Released Klipsan Beach, WA
	Mar. 20, 1989	Resight (30 days) Everett, WA
	Apr. 03, 1989	Everett, WA
	Apr. 13, 1989	Shilshole Bay, WA, 06:30 am
	Apr. 13, 1989	Everett, WA, 12:40 pm
	May 26, 1989	Everett, WA
4	Jan. 27, 1989	Dart tag, Shilshole Bay, WA
	Jan. 28-29, 1989	Shilshole Bay, WA
	Feb. 16, 1989	Captured Shilshole Bay, WA (629 lbs); this animal died during recovery from anesthesia.
5	Feb. 20, 1989	Captured Shilshole Bay, WA (525 lbs)
	Feb. 21, 1989	Released Klipsan Beach, WA
	Mar. 06, 1989	Resight (13 days) Shilshole Bay, WA
	Mar. 13, 1989	Everett, WA
	Mar. 24, 1989	Recaptured Shilshole Bay, WA (580 lbs)
	Mar. 24, 1989	Released Klipsan Beach, WA
	Apr. 03, 1989	Resight (10 days) Everett, WA
	Apr. 13,17,18, 1989	Everett, WA
	May 02, 1989	Shilshole Bay, WA
	May 26, 1989	Everett, WA
	Feb. 22, 1990	Everett, WA
	Mar. 15-16, 1990	Everett, WA
	May 07, 1990	Everett, WA
	Oct. 11, 1990	Shilshole Bay, WA
	Dec. 06, 1990	Everett, WA
	Jan. 04,22, 1991	Everett, WA
	Mar. 20, 1991	Everett, WA
	Apr. 16, 1991	Everett, WA

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
6		Feb. 13, 1989Dart tag, Shilshole Bay, WA
	Feb. 17, 1989	Ballard Locks, WA
	Feb. 20, 1989	Captured Shilshole Bay, WA (615 lbs)
	Feb. 21, 1989	Released Klipsan Beach, WA
	Mar. 10, 1989	Transmitter Recovered Shilshole Bay, WA
	Mar. 21,28, 1989	Everett, WA
	Apr. 09, 1989	Shilshole Bay, WA
	Apr. 14, 1989	Elliott Bay, WA
	Apr. 17, 1989	Shilshole Bay, WA; Elliott Bay, WA
	Feb. 5,21, 1990	*Ballard Locks, WA
	Dec. ?, 1993	Everett, WA
7	Jan. 27, 1989	Dart tag, Shilshole Bay, WA
	Jan. 28-29, 1989	Shilshole Bay, Wa
	Feb. 11, 1989	Shilshole Bay, Wa
	Feb. 20, 1989	Captured Shilshole Bay, WA (521 lbs)
	Feb. 21, 1989	Released Klipsan Beach, WA
	Mar. 03, 1989	Resight (10 days) Ballard Locks, WA
	Mar. 04, 1989	Shilshole Bay, WA
	Mar. 13,21, 1989	Everett, WA
	Apr. 11, 1989	Shilshole Bay, WA
	Apr. 12,19,23, 1989	Everett, WA
	Dec. 13-14, 1989	Everett, WA
	Feb. 22,24, 1990	Everett, WA
	Apr. 12, 1990	Everett, WA
	May 05, 1990	Everett, WA
	Dec. 05, 1990	Shilshole Bay, WA
	Dec. 06, 1990	Everett, WA
	Mar. 20, 1991	Everett, WA
	Dec. ?, 1993	Everett, WA
	Apr. 11, 1994	Shilshole Bay, WA
	May 01,23, 1994	Shilshole Bay, WA
8	Feb. 24, 1989	Captured Shilshole Bay, WA (470 lbs)
	Feb. 25, 1989	Released Klipsan Beach, WA
	Mar. 12, 1989	Resight (15 days) Everett, WA
	Mar. 21, 1989	Everett, WA
	Apr. 07, 1989	Duwamish Waterway, WA
	Apr. 10, 1989	Elliott Bay, WA
	Apr. 13,14, 1989	Shilshole Bay, WA
	Dec. 13, 1989	Everett, WA
	Dec. 22, 1989	Ballard Locks, WA
	Jan. 11, 1990	Everett, WA
	Feb. 22,24, 1990	Everett, WA
	Mar. 07, 1990	Everett, WA
	Apr. 05, 1990	Shilshole Bay, WA
	Dec. 06, 1990	Everett, WA
	Mar. 20, 1991	Everett, WA

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
	Apr. 12, 1991	Shilshole Bay, WA
	Apr. 17, 1991	Everett, WA
	Nov. 16, 1993	Everett, WA
9	Feb. 13, 1989	Dart tag, Shilshole Bay, WA
	Feb. 17, 1989	Ballard Locks, WA
	Feb. 24, 1989	Captured Shilshole Bay, WA (609 lbs)
	Feb. 25, 1989	Released Klipsan Beach, WA
	Mar. 12, 1989	Resight (15 days) Everett, WA
	Mar. 21, 1989	Everett, WA
	Mar. 23, 1989	Shilshole Bay, WA
	Mar. 24, 1989	Recaptured Shilshole Bay, WA (605 lbs)
	Mar. 24, 1989	Released Klipsan Beach, WA
	Apr. 03, 1989	Resight (10 days) Everett, WA
	Apr. 07-12,14, 1989	Shilshole Bay, WA
	Apr. 17,18, 1989	Shilshole Bay, WA
	Jan. 11, 1990	Everett, WA
	Mar. 15, 1990	Everett, WA
	Mar. 18, 1990	Ballard Locks, WA
	Dec. 06-07, 1990	Everett, WA
	Dec. 12, 1990	Shilshole Bay, WA
	Feb. 05, 1991	Ballard Locks, WA
	Feb. 06, 1991	Everett, WA
	Dec. 30, 1991	Everett, WA
	Jan. 30, 1994	Found dead Whidbey Is., WA
10	Feb. 24, 1989	Captured Shilshole Bay, WA (666 lbs)
	Feb. 25, 1989	Released Klipsan Beach, WA
	Mar. 05, 1989	Resight (8 days) Shilshole Bay, WA
	Mar. 06, 1989	Shilshole Bay, WA
	Mar. 10, 1989	Recaptured Shilshole Bay, WA (635 lbs)
	Mar. 10, 1989	Released Klipsan Beach, WA
	Mar. 22, 1989	Recaptured (12 days) Shilshole (600 lbs)
	Mar. 23, 1989	Released Klipsan Beach, WA
	Apr. 03, 1989	Resight (11 days) Everett, WA
	Apr. 17, 1989	Edmonds, WA
	Apr. 24, 1989	Shilshole Bay, WA
	May 15,20 1989	Shilshole Bay, WA
11	Feb. 27, 1989	Captured Shilshole Bay, WA (636 lbs)
	Feb. 28, 1989	Released Klipsan Beach, WA
	Mar. 13, 1989	Recaptured (13 days) Shilshole (580 lbs)
	Mar. 14, 1989	Released Klipsan Beach, WA
	Mar. 22, 1989	Recaptured (8 days) Shilshole (550 lbs)
	Mar. 23, 1989	Released Klipsan Beach, WA
	Mar. 30, 1989	Resight (7 days) Shilshole Bay, WA
	Apr. 01, 1989	Ballard Locks, WA
	Apr. 02,04, 1989	Shilshole Bay, WA

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
	Apr. 06, 1989	Recaptured Shilshole Bay, WA (595 lbs)
	Apr. 07, 1989	Released Klipsan Beach, WA
	May 03, 1989	Shilshole Bay, WA
12	Feb. 27, 1989	Captured Shilshole Bay, WA (708 lbs)
	Feb. 28, 1989	Released Klipsan Beach, WA
	Dec. 29, 1989	Ballard Locks, WA
	Jan. 11, 1990	Everett, WA
	Mar. 16, 1990	Everett, WA
	Apr. 12, 1990	Everett, WA
	May 07, 1990	Everett, WA
13	Feb. 27, 1989	Captured Shilshole Bay, WA (653 lbs)
	Feb. 28, 1989	Released Klipsan Beach, WA
	Mar. 21, 1989	Resight (21 days) Everett, WA
	Mar. 28, 1989	Everett, WA
	Apr. 03, 1989	Everett, WA
	Apr. 14, 1989	Shilshole Bay, WA
	Apr. 17-18, 1989	Everett, WA
	Apr. 28,29, 1989	Shilshole Bay, WA
	May 03,12, 1989	Shilshole Bay, WA
	Jan. 14, 1990	Everett, WA
	Apr. 09,12, 1990	Everett, WA
	Dec. 06, 1990	Everett, WA
	Mar. 27, 1991	Everett, WA
	Dec. ?, 1993	Everett, WA
14	Mar. 06, 1989	Captured Shilshole Bay, WA (660 lbs)
	Mar. 07, 1989	Released Klipsan Beach, WA
	Mar. 20, 1989	Resight (13 days) Race Rocks, B.C.
	Mar. 28, 1989	Shilshole Bay, WA
	Mar. 29, 1989	Recaptured Shilshole Bay, WA (535 lbs)
	Mar. 30, 1989	Released Klipsan Beach, WA
	Apr. 13, 1989	Resight (14 days) Shilshole Bay, WA
	Apr. 17,19,22, 1989	Shilshole Bay, WA
	Apr. 24-26, 1989	Shilshole Bay, WA
	May 15,20, 1989	Shilshole Bay, WA
	Mar. 15, 1990	Everett, WA
	Apr. 12, 1990	Everett, WA
	Apr. 24, 1990	Shilshole Bay, WA
	Dec. 12,14, 1990	Shilshole Bay, WA
	Jan. 22, 1991	Everett, WA
	Mar. 27, 1991	Everett, WA
	Dec. 30, 1991	Everett, WA
	Apr. 07,25, 1994	Shilshole Bay, WA
15	Feb. 13, 1989	Dart tag, Shilshole Bay, WA
	Feb. 17, 1989	*Ballard Locks, WA

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
	Mar. 06, 1989	Captured Shilshole Bay, WA (618 lbs)
	Mar. 07, 1989	Released Klipsan Beach, WA
	Mar. 18, 1989	Resight (11 days) Ballard Locks, WA
	Mar. 19-22, 1989	Ballard Locks, WA
	Mar. 23, 1989	Shilshole Bay, WA
	Mar. 24, 1989	Recaptured Shilshole Bay, WA (605 lbs)
	Mar. 24, 1989	Released Klipsan Beach, WA
	Mar. 31, 1989	*Resight (7 days) Ballard Locks, WA
	Apr. 01-07, 1989	*Ballard Locks, WA
	Apr. 09,11, 1989	Shilshole, WA
	Apr. 11-12, 1989	Ballard Locks, WA
	Apr. 14,17,24, 1989	Shilshole, WA
	Apr. 15,18,26, 1989	Ballard Locks, WA
	Apr. 22,24,29, 1989	Shilshole Bay, WA
	Dec. 06,08,19, 1989	Ballard Locks, WA
	Dec. 11, 1989	West Point, WA
	Feb. 1990	Found dead, Whidbey Island, WA
16	Mar. 06, 1989	Captured Shilshole Bay, WA (420 lbs)
	Mar. 07, 1989	Released Klipsan Beach, WA
	Mar. 14, 1989	Resight (7 days) Shilshole Bay, WA
	Mar. 23, 1989	Shilshole Bay, WA
	Mar. 24, 1989	Recaptured Shilshole Bay, WA (390 lbs)
	Mar. 24, 1989	Released Klipsan Beach, WA
	Mar. 29, 1989	Recaptured (5 days) Shilshole (385 lbs)
	Mar. 30, 1989	Released Klipsan Beach, WA
	Apr. 05, 1989	Resight (6 days) Ballard Locks, WA
	Apr. 06, 1989	Recaptured Shilshole Bay, WA (435 lbs)
	Apr. 07, 1989	Released Klipsan Beach, WA
	Apr. 17, 1989	Resight (10 days) Shilshole Bay, WA
	Apr. 18,26, 1989	Shilshole Bay, WA
	Apr. 28,29, 1989	Shilshole Bay, WA
	May 29, 1989	Resight (30 days) San Miguel Is., CA
	May 30-31, 1989	San Miguel Is., CA
	Jun. 01-26, 1989	San Miguel Is., CA
17	Mar. 04, 1989	Ballard Locks, WA
	Mar. 08, 1989	Captured Shilshole Bay, WA (400 lbs)
	Mar. 08, 1989	Released Klipsan Beach, WA
	Mar. 20, 1989	*Resight (12 days) Ballard Locks, WA
	Mar. 21-24,26-30, 1989	*Ballard Locks, WA
	Apr. 03,06, 1989	Ballard Locks, WA
	Apr. 06, 1989	Shilshole Bay, WA (escaped capture)
	Apr. 07-18, 1989	*Ballard Locks, WA
	Apr. 17,26, 1989	Shilshole Bay, WA
	Apr. 20, 1989	Ballard Locks, WA
	Dec. 18,23,26, 1989	*Ballard Locks, WA
	Jan. 16,17,20, 1990	Ballard Locks, WA

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
	Jan. 18, 1990	Shilshole Bay, WA
	Jan. 22-25,27-29, 1990	*Ballard Locks, WA
	Feb. 08, 1990	Shilshole Bay, WA
	Feb. 11,21,23-24,1990	*Ballard Locks, WA
	Feb. 26, 1990	Ballard Locks, WA
	Mar. 01,08,11-12, 1990	*Ballard Locks, WA
	Mar. 13, 1990	Captured Shilshole Bay, WA (649 lbs)
	Mar. 21, 1990	Released San Miguel Island, CA
	Mar. 22-28, 1990	San Miguel Is., CA
	Dec. 06, 1990	Everett, WA
	Dec. 31, 1990	Ballard Locks, WA
	Jan. 04,17, 1991	Ballard Locks, WA
	Jan. 22, 1991	Everett, WA
	Jan. 24,28-31, 1991	*Ballard Locks, WA
	Feb. 4-7,13,19, 1991	Ballard Locks, WA
	Feb. 22,26-28, 1991	Ballard Locks, WA
	Mar. 07,13-14, 1991	Ballard Locks, WA
	Mar. 20,25-27, 1991	Ballard Locks, WA
	Apr. 01,10,15, 1991	Ballard Locks, WA
	Apr. 16, 1991	Everett, WA
	Apr. 19,24,26,29-30,1991	Ballard Locks, WA
	May 01-03,8-10, 1991	Ballard Locks, WA
	Dec. 16-17,20, 1992	*Ballard Locks, WA
	Dec. 21,24 1992	*Ballard Locks, WA
	Jan. 27,28,29,31, 1993	*Ballard Locks, WA
	Feb. 01-05, 1993	*Ballard Locks, WA
	Mar. 05,09-13,15,1993	*Ballard Locks, WA
	Dec. 17,20,22, 1993	Ballard Locks, WA
	Dec. 28-29,31, 1993	Ballard Locks, WA
	Jan. 01-03,06-07, 1994	Ballard Locks, WA
	Jan. 10,16,20,23, 1994	Shilshole Bay, WA
	Jan. 29,31, 1994	Ballard Locks, WA
	Feb. 03-04,09,11, 1994	Ballard Locks, WA
	Feb. 17, 1994	Ballard Locks, WA
	Feb. 08, 1994	Shilshole Bay, WA
	Mar, 9-10,12,24, 1994	Ballard Locks, WA
	Apr. 07,30, 1994	Shilshole Bay, WA
	Apr. 21, 1994	Ballard Locks, WA
	May, 06-07,12, 1994	Ballard Locks, WA
18	Mar. 08, 1989	Captured Shilshole Bay, WA (575 lbs)
	Mar. 08, 1989	Released Klipsan Beach, WA
	Mar. 22, 1989	Resight (14 days) Shilshole Bay, WA
	Mar. 23-24,26-31, 1989	Shilshole Bay, WA
	Apr. 1-7,09-11,13, 1989	Shilshole Bay, WA
	Apr. 17-18,24, 1989	Shilshole Bay, WA
	Apr. 28-29, 1989	Shilshole Bay, WA
	May 03,15,20,21, 1989	Shilshole Bay, WA

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
19	Mar. 08, 1989	Captured Shilshole Bay, WA (520 lbs)
	Mar. 08, 1989	Released Klipsan Beach, WA
	Mar. 14, 1989	Resight (6 days) Shilshole Bay, WA
	Mar. 16-18,20-22, 1989	*Ballard Locks, WA
	Mar. 23, 1989	Shilshole Bay, WA
	Mar. 24-31, 1989	*Ballard Locks, WA
	Apr. 01-02, 1989	*Ballard Locks, WA
	Apr. 03, 1989	Everett, WA
	Apr. 05-12, 1989	Ballard Locks, WA
	Apr. 13, 1989	Shilshole Bay, WA
	Apr. 14, 1989	Ballard Locks, WA
	Apr. 17, 1989	Everett, WA
	Apr. 19,22,26, 1989	Ballard Locks, WA
	May 15, 1989	Ballard Locks, WA
	Jul. 16, 1989	San Miguel Is., CA
	Nov. 05, 1989	Ballard Locks, WA
	Dec. 01-02,09,22	Ballard Locks, WA
	Dec. 13, 1989	Everett, WA
	Jan. 03,09,10,30, 1990	Ballard Locks, WA
	Jan. 11, 1990	Everett, WA
	Feb. 06-8,12, 1990	Ballard Locks, WA
	Feb. 24,28 1990	Ballard Locks, WA
	Mar. 01-04,08,13, 1990	*Ballard Locks, WA
	Mar. 21-22,24-28, 1990	*Ballard Locks, WA
	Mar. 30, 1990	Ballard Locks, WA
	Mar. 07,15, 1990	Everett, WA
	Apr. 02-03,09,11, 1990	*Ballard Locks, WA.
	Apr. 12, 1990	Everett, WA
	Apr. 13,18-21, 1990	*Ballard Locks, WA
	Apr. 24-28, 1990	*Ballard Locks, WA
20	Mar. 08, 1989	Captured Shilshole Bay, WA (580 lbs)
	Mar. 08, 1989	Released Klipsan Beach, WA
	May 14, 1989	Tag Recovered in N. California
	Jan. 14, 1990	Everett, WA
21	Mar. 09, 1989	Captured Shilshole Bay, WA (565 lbs)
	Mar. 10, 1989	Released Klipsan Beach, WA
	Mar. 28, 1989	Resight (18 days) Everett, WA
	Mar. 30, 1989	Ballard Locks, WA
	Apr. 06, 1989	Recaptured Shilshole Bay, WA (640 lbs)
	Apr. 07, 1989	Released Klipsan Beach, WA
	Apr. 14, 1989	Resight (7 days) Shilshole Bay, WA
	Apr. 17, 1989	Everett, WA
	Apr. 26, 1989	Shilshole Bay, WA
	May 03, 1989	Shilshole Bay, WA
	Jan. 20, 1990	Everett, WA
	Feb. 24, 1990	Shilshole Bay, WA

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
	Mar. 12, 1990	Captured Shilshole Bay, WA (594 lbs)
	Mar. 21, 1990	Released at San Miguel Island, CA
	Mar. 22-24, 1990	San Miguel Is., CA
	May 04, 1990	Resight (41 days) Everett, WA
	May 05, 1990	Everett, WA
	Jun. 27, 1990	Resight (53 days) San Miguel Is., CA
	Jul. 23, 1990	San Miguel Is., CA
	Jan. 04, 1991	Everett, WA
22	Mar. 09, 1989	Captured Shilshole Bay, WA (550 lbs)
	Mar. 10, 1989	Released Klipsan Beach, WA
	Mar. 29, 1989	Recaptured (19 days) Shilshole (585 lbs)
	Mar. 30, 1989	Released Klipsan Beach, WA
	Jul. 04, 1989	San Nicolas Is. CA
	Dec. 11, 1989	Shilshole Bay, WA
	Mar. 12, 1990	Captured Shilshole Bay, WA (836 lbs)
	Mar. 21, 1990	Released at San Miguel Island, CA
	Mar. 22 - Apr 03, 1990	San Miguel Island, CA
	May 03, 1990	Resight (30 days) Alki Point, WA
	May 18, 1990	Tag Recovered at Rich Passage, WA
	Dec. 05, 1990	Shilshole Bay, WA
23	Mar. 09, 1989	Captured Shilshole Bay, WA (560 lbs)
	Mar. 10, 1989	Released Klipsan Beach, WA
	Mar. 22, 1989	Recaptured (12 days) Shilshole (540 lbs)
	Mar. 23, 1989	Released Klipsan Beach, WA
	Apr. 09,10, 1989	Shilshole Bay, WA
	Apr. 12, 1989	Three Tree Pt., WA
	Jul. 10, 1989	San Miguel Is., CA
	Dec. 07, 1989	Shilshole Bay, WA
	Dec. 18,28, 1989	Shilshole Bay, WA
	Jan. 18-21,30-31 1990	*Ballard Locks, WA
	Feb. 13-14,20-21 1990	*Ballard Locks, WA
	Feb. 24, 1990	Shilshole Bay, WA
	Mar. 03,07, 1990	Shilshole Bay, WA
	Apr. 24, 1990	Shilshole Bay, WA
	May 05, 1990	Everett, WA
	May 09, 1990	Shilshole Bay, WA
	Dec. 05, 1990	Shilshole Bay, WA
	Jan. 03, 1991	Shilshole Bay, WA
	Jan. 04,05,22, 1991	Everett, WA
24	Mar. 10, 1989	Captured Shilshole Bay, WA (675 lbs)
	Mar. 10, 1989	Released Klipsan Beach, WA
	Mar. 24, 1989	Recaptured (14 days) Shilshole (655 lbs)
	Mar. 24, 1989	Released Klipsan Beach, WA
	Apr. 01, 1989	Ballard Locks, WA
	Apr. 04, 1989	Shilshole Bay, WA

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
	Mar. 14, 1989	Released Klipsan Beach, WA
	Mar. 20, 1989	Resight (6 days) Race Rocks, B.C.
	Mar. 28, 1989	Everett, WA
	Apr. 10, 1989	Toliva Shoals, WA
	Apr. 12,18,24, 1989	Shilshole Bay, WA
	May 09, 1989	Shilshole Bay, WA
	Jan. 11, 1990	Everett, WA
	Feb. 22,24, 1990	Everett, WA
	Mar. 16, 1989	Everett, WA
	Apr. 09, 1990	Everett, WA
	May 09, 1990	Shilshole Bay, WA
	Feb. 06, 1991	Everett, WA
27	Mar. 22, 1989	Captured Shilshole Bay, WA (570 lbs)
	Mar. 23, 1989	Released Klipsan Beach, WA
	Apr. 13, 1989	Resight (21 days) Shilshole Bay, WA
	Apr. 19,24,28, 1989	Shilshole Bay, WA
28	Mar. 22, 1989	Captured Shilshole Bay, WA (590 lbs)
	Mar. 23, 1989	Released Klipsan Beach, WA
	Apr. 03, 1989	Resight (11 days) Shilshole Bay, WA
	Apr. 04, 1989	Shilshole Bay, WA
	Apr. 05, 1989	Ballard Locks, WA
	Apr. 7,17-19,24, 1989	Shilshole Bay, WA
	Apr. 28-29, 1989	Shilshole Bay, WA
	May 09,20, 1989	Shilshole Bay, WA
29	Mar. 24, 1989	Captured Shilshole Bay, WA (580 lbs)
	Mar. 24, 1989	Released Klipsan Beach, WA
	Apr. 03, 1989	Resight (10 days) Everett, WA
	Apr. 05, 1989	Ballard Locks, WA
	Apr. 13, 1989	Everett, WA
	Apr. 14,17, 1989	Shilshole Bay, WA
	May 02, 1989	Shilshole Bay, WA
	Jan. 20, 1990	Everett, WA
	Feb. 24, 1990	Everett, WA
	Mar. 15, 1990	Everett, WA
	Apr. 12, 1990	Everett, WA
	May 07, 1990	Everett, WA
	Dec. 06, 1990	Everett, WA
	Jan. 04,22, 1991	Everett, WA
	Jul. 04, 1991	San Miguel Is., CA
	Dec. 29-30, 1991	Everett, WA
30	Mar. 29, 1989	Captured Shilshole Bay, WA (485 lbs)
	Mar. 30, 1989	Released Klipsan Beach, WA
	Apr. 12,16-17, 1989	*Ballard Locks, WA
	Apr. 18, 1989	Shilshole Bay, WA

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
	Apr. 10, 1989	Everett, WA
	Apr. 18,24,26, 1989	Shilshole Bay, WA
	Jun. 23, 1989	Found Shot, Eureka, CA
25	Dec. 28-29, 1988	*Ballard Locks, WA
	Jan. 08,14-15, 1989	Ballard Locks, WA
	Jan. 20-22,26, 1989	*Ballard Locks, WA
	Jan. 28-30, 1989	*Ballard Locks, WA
	Feb. 03,05,12,	Ballard Locks, WA
	Feb. 19,21,27 1989	Ballard Locks, WA
	Mar. 03-04,07,11, 1989	Ballard Locks, WA
	Mar. 13, 1989	Captured Shilshole Bay, WA (675 lbs)
	Mar. 14, 1989	Released Klipsan Beach, WA
	Mar. 20, 1989	Race Rocks, B.C.
	Mar. 28, 1989	Ballard Locks, WA
	Mar. 29, 1989	Lake Washington
	Mar. 30-31, 1989	*Ballard Locks, WA
	Apr. 01-11, 1989	*Ballard Locks, WA
	Apr. 13-16, 1989	Ballard Locks, WA
	Apr. 17, 1989	Shilshole Bay, WA
	Apr. 18-21, 1989	*Ballard Locks and Shilshole Bay, WA
	Apr. 24-29, 1989	*Ballard Locks, WA
	May 02,04,05, 1989	*Ballard Locks, WA
	Jul. 11, 1989	San Miguel Is., CA
	Nov. 05, 1989	Ballard Locks, WA
	Dec. 02,04,06,08, 1989	*Ballard Locks, WA
	Dec. 09,11-12, 1989	*Ballard Locks, WA
	Dec. 13, 1989	Everett, WA
	Dec. 14-15,22,26, 1989	*Ballard Locks, WA
	Dec. 29,31, 1989	*Ballard Locks, WA
	Jan. 01-06,09-13 1990	*Ballard Locks, WA
	Jan. 16-20,25-31, 1990	*Ballard Locks, WA
	Jan. 21, 1990	Everett, WA
	Feb. 01,03,05-06, 1990	*Ballard Locks, WA
	Feb. 08-12,16,20, 1990	*Ballard Locks, WA
	Feb. 21,24-27, 1990	*Ballard Locks, WA
	Feb. 22, 1990	Everett, WA
	Mar. 03-08,10-12, 1990	*Ballard Locks, WA
	Mar. 15, 1990	Everett, WA
	Mar. 16-17,19-22, 1990	*Ballard Locks, WA
	Mar. 26-30, 1990	*Ballard Locks, WA
	Apr. 01,05-06, 1990	*Ballard Locks, WA
	Apr. 09-10,12, 1990	*Ballard Locks, WA
	Apr. 12, 1990	Everett, WA; Ballard Locks, WA
	Apr. 16-17,26-28, 1990	*Ballard Locks, WA
	Nov. 29, 1990	Ballard Locks, WA
26	Mar. 13, 1989	Captured Shilshole Bay, WA (575 lbs)

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
	Apr. 19,22-24, 1989	*Ballard Locks, WA
	Apr. 29, 1989	*Ballard Locks, WA
	May 09-11, 1989	*Ballard Locks, WA
	Jul. 17, 1989	San Miguel Is., CA
	Apr. 5,11-12, 1990	Ballard Locks, WA
	Apr. 14,17-18, 1990	*Ballard Locks, WA
	Apr. 28-29, 1990	*Ballard Locks, WA
	Mar. 27, 1991	Everett, WA
	Apr. 8,16,29,30, 1991	*Ballard Locks, WA
31	Mar. 29, 1989	Captured Shilshole Bay, WA (667 lbs)
	Mar. 30, 1989	Released Klipsan Beach, WA
	Apr. 10, 1989	Resight (11 days) Shilshole Bay, WA
	Apr. 11-14,18, 1989	Shilshole Bay, WA
	Apr. 19, 1989	Recaptured Shilshole Bay,WA (no weight)
	Apr. 19, 1989	Released Klipsan Beach, WA
	Jul. 14, 1989	San Miguel Is., CA
	Mar. 28, 1990	Ballard Locks, WA
	Apr. 19,24, 1990	Shilshole Bay, WA
	Mar. 27, 1991	Everett, WA
32	Mar. 29, 1989	Captured Shilshole Bay, WA (787 lbs)
	Mar. 30, 1989	Released Klipsan Beach, WA
	Apr. 07-08, 1989	Resight (8 days) Shilshole Bay, WA
	Apr. 11, 1989	Ballard Locks, WA
	Apr. 12,14, 1989	Shilshole Bay, WA
	Apr. 17,19,22, 1989	Shilshole Bay, WA
	Apr. 24, 1989	am- Shilshole Bay, WA, pm-Burien, WA
	Apr. 26, 1989	West Seattle, WA
	Apr. 28, 1990	Shilshole Bay, WA
	Jan. 14, 1990	*Ballard Locks, WA
	Mar. 15, 1990	Everett, WA
	Apr. 12,16, 1990	Ballard Locks, WA
	Apr. 12, 1991	Shilshole Bay, WA
	Nov. 15, 1993	Ballard LOcks, WA
	Jan. 05, 1994	Shilshole Bay, WA
	March 10,15,22, 1994	Shilshole Marina, Dock A
	Apr. 04-05,14,17, 1994	Shilshole Marina, Dock A
	Apr. 19, 1994	Captured Shilshole Bay, WA (688 lbs)
	Apr. 27, 1994	Released at Santa Cruz Island, CA
33	Apr. 06, 1989	Captured Shilshole Bay, WA (545 lbs)
	Apr. 07, 1989	Released Klipsan Beach, Wa
	Apr. 16, 1991	Resight (9 days) Everett, WA
	Mar. 28, 1994	Everett, WA
34	Apr. 06, 1989	Captured Shilshole Bay, WA (440 lbs)
	Apr. 07, 1989	Released Klipsan Beach, WA

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
	Apr. 16, 1989	Resight (9 days) Ballard Locks, WA
	Apr. 17, 1989	Ballard Locks, WA
	Apr. 18, 1989	Everett, WA
	Apr. 19,30, 1989	Ballard Locks, WA
	May 12, 1989	Everett, WA
35	Apr. 18, 1989	Captured Shilshole Bay, WA (no weight)
	Apr. 19, 1989	Released Klipsan Beach, WA
	Apr. 09, 1990	Everett, WA
	Apr. 24, 1990	Shilshole Bay, WA
	May 05, 1990	Everett, WA
	Jul. 21, 1990	San Miguel Is., CA
36	Apr. 18, 1989	Captured Shilshole Bay, WA (765 lbs)
	Apr. 19, 1989	Released Klipsan Beach, WA
37	Apr. 18, 1989	Captured Shilshole Bay, WA (672 lbs)
	Apr. 19, 1989	Released Klipsan Beach, WA
	Aug. 08, 1989	Año Nuevo Is., CA
	Feb. 27, 1993	Everett, WA
	May 09, 1994	Shilshole Bay, WA
38	Jan. 15, 1989	*Ballard Locks, WA
	Jan. 22,26, 1989	*Ballard Locks, WA
	Jan. 27, 1989	Dart tag, Shilshole Bay, WA
	Feb. 01,12,25-26, 1989	*Ballard Locks, WA
	Mar. 03,11,14-16, 1989	*Ballard Locks, WA
	Mar. 18-19,21-24, 1989	*Ballard Locks, WA
	Mar. 26-27, 1989	*Ballard Locks, WA
	Mar. 28, 1989	Dart tag, Ballard Locks
	Mar. 28-31, 1989	*Ballard Locks, WA
	Apr. 01-18, 1989	*Ballard Locks, WA
	Apr. 18, 1989	Captured Shilshole Bay, WA (915 lbs)
	Apr. 19, 1989	Released Klipsan Beach, WA
	May 23, 1989	Resight (34 days) San Miguel Is., CA
	May 24-31, 1989	San Miguel Is., CA
	Jun. 01, 1989	San Miguel Is., CA
39	Apr. 18, 1989	Captured Shilshole Bay, WA (875 lbs)
	Apr. 19, 1989	Released Klipsan Beach, WA
	Feb. 22, 1990	Everett, WA
	Mar. 15, 1990	Everett, WA
	Dec. 06, 1990	Everett, WA
	Jan. 22, 1991	Everett, WA
	Feb. 06, 1991	Everett, WA
	Mar. 20,27, 1991	Everett, WA

*40 (This brand number was used on a harbor seal that was captured in the

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
	floating trap at the Locks on 3/24/94. The seal was released in Hood Canal on 3/25/94 and was observed at the Locks 44 days later on 5/7/94)	
41	Feb. 16,22,26 1990	*Ballard Locks, WA
	Mar. 10, 1990	*Ballard Locks, WA
	Mar. 12, 1990	Captured Shilshole Bay, WA (394 lbs)
	Mar. 21, 1990	Released San Miguel Island, CA
	Mar. 22-26, 1990	San Miguel Is., CA
	May 04, 1990	Resight (39 days) Everett, WA
	May 20, 1990	Everett, WA
	Dec. 26, 1990	Ballard Locks, WA
	Jan. 2,22, 1991	Ballard Locks, WA
	Feb. 4-7,11-15, 1991	*Ballard Locks, WA
	Feb. 22,26-28, 1991	*Ballard Locks, WA
	Mar. 1,4,7,8, 1991	*Ballard Locks, WA
	Mar. 13,14, 1991	Ballard Locks, WA
	Mar. 20,21,25,26, 1991	Ballard Locks, WA
	Mar. 27, 1991	Everett, WA
	Apr. 1-3,5,11, 1991	Ballard Locks, WA
	Apr. 12,15-16,19, 1991	*Ballard Locks, WA
	Apr. 23, 1991	Ballard Locks, WA
	Nov. 16, 1993	Everett, WA
	Dec. ?, 1993	Everett, WA
	Nov. 14, 1994	Everett, WA
42	Jan. 03-31, 1990	*Ballard Locks, WA
	Feb. 01-28, 1990	*Ballard Locks, WA
	Mar. 01-11, 1990	*Ballard Locks, WA
	Mar. 12, 1990	Captured Shilshole Bay, WA (915 lbs)
	Mar. 21, 1990	Released at San Miguel Island, CA
	Mar. 22-31, 1990	San Miguel Is., CA
	Apr. 01, 1990	San Miguel Is., CA
	Apr. 06, 1990	Grimes Point, CA
	Jun. 02,03, 1990	San Miguel Is., CA
	Dec. 05, 1990	Shilshole Bay, WA
	Dec. 13, 1990	Ballard Locks, WA
	Jan. 04,17,25, 1991	*Ballard Locks, WA
	Feb. 12-14, 1991	*Ballard Locks, WA
	Apr. 02,16,17, 1991	*Ballard Locks, WA
43	Mar. 13, 1990	Captured Shilshole Bay, WA (715 lbs)
	Mar. 21, 1990	Released at San Miguel Island, CA
	Mar. 22-24, 1990	San Miguel Is., CA
	May 08, 1990	Resight (45 days) Columbia River, OR
	May 09-11, 1990	Columbia River (Astoria, OR)
	Dec. 29, 1991	Everett, WA

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
44	Apr. 11, 1994	Captured Shilshole Bay, WA
	Apr. 12, 1994	Released Klipsan Beach, WA
45	Dec. 20-21,31, 1993	Ballard Locks, WA
	Jan. 03,10,13, 1994	Ballard Locks, WA
	Mar. 12, 1994	Ballard Locks, WA
	Apr. 19, 1994	Captured Shilshole Bay, WA (639 lbs)
	Apr. 27, 1994	Released at Santa Cruz Island, CA
	Jun. 04, 1994	San Miguel Is., CA
	Oct. 14, 1994	Shilshole Bay, WA
	Nov. 21, 1994	Recapture, Shilshole Bay, WA (575 lbs)
	Nov. 21, 1994	Release, Shilshole Bay, WA
	Nov. 23, 1994	Everett, WA
	Dec. 13, 1994	Everett, WA
46	Apr. 22, 1994	Captured Shilshole Bay, WA (568 lbs)
	Apr. 27, 1994	Released at Santa Cruz Island, CA
47	Oct. 28, 1994	Captured Shilshole Bay, WA
48	Oct. 28, 1994	Captured Shilshole Bay, WA
49	Oct. 28, 1994	Captured Shilshole Bay, WA
50	Oct. 28, 1994	Captured Shilshole Bay, WA
51	Oct. 28, 1994	Captured Shilshole Bay, WA
52	Oct. 28, 1994	Captured Shilshole Bay, WA
53	Oct. 28, 1994	Captured Shilshole Bay, WA
54	Oct. 28, 1994	Captured Shilshole Bay, WA
55	Oct. 28, 1994	Captured Shilshole Bay, WA
56	Oct. 28, 1994	Captured Shilshole Bay, WA
57	Oct. 28, 1994	Captured Shilshole Bay, WA
58	Nov. 10, 1994	Captured Shilshole Bay, WA (545 lbs)
59	Nov. 10, 1994	Captured Shilshole Bay, WA (180 lbs)
60	Nov. 10, 1994	Captured Shilshole Bay, WA (360 lbs)
61	Nov. 10, 1994	Captured Shilshole Bay, WA (430 lbs)

*Ballard - indicates a steelhead predation event was observed.

BRAND NUMBER	CAPTURE/RESIGHT DATE	LOCATION
62	Nov. 10, 1994	Captured Shilshole Bay, WA (645 lbs)
63	Nov. 10, 1994	Captured Shilshole Bay, WA (480 lbs)
64	Nov. 10, 1994	Captured Shilshole Bay, WA (345 lbs)
65	Nov. 10, 1994	Captured Shilshole Bay, WA (420 lbs)
66	Nov. 10, 1994	Captured Shilshole Bay, WA (395 lbs)
67	Nov. 10, 1994	Captured Shilshole Bay, WA (295 lbs)
68	Nov. 21, 1994	Captured Shilshole Bay, WA (617 lbs)
69	Dec. 05, 1994	Captured Shilshole Bay, WA (530 lbs)
70	Dec. 05, 1994	Captured Shilshole Bay, WA (450 lbs)
71	Dec. 22, 1994	Captured Shilshole Bay, WA (205 lbs)
72	Dec. 22, 1994	Captured Shilshole Bay, WA (315 lbs)
73	Dec. 22, 1994	Captured Shilshole Bay, WA (250 lbs)
74	Dec. 22, 1994	Captured Shilshole Bay, WA (415 lbs)
75	Dec. 22, 1994	Captured Shilshole Bay, WA (225 lbs)
76	Dec. 22, 1994	Captured Shilshole Bay, WA (265 lbs)
77	Dec. 22, 1994	Captured Shilshole Bay, WA (365 lbs)
78	Dec. 22, 1994	Captured Shilshole Bay, WA (385 lbs)
79	Dec. 22, 1994	Captured Shilshole Bay, WA (295 lbs)
80	Dec. 22, 1994	Captured Shilshole Bay, WA (555 lbs)
81	Dec. 22, 1994	Captured Shilshole Bay, WA (410 lbs)
82	Dec. 29, 1994	Captured Shilshole Bay, WA
83	Dec. 29, 1994	Captured Shilshole Bay, WA

*Ballard - indicates a steelhead predation event was observed.