EVALUATION OF PINNIPED PREDATION ON ADULT SALMONIDS AND OTHER FISH IN THE BONNEVILLE DAM TAILRACE, 2002-2004

By

Robert J. Stansell

U.S. Army Corps of Engineers
CENWP-OP-SRF

Bonneville Lock and Dam
Cascade Locks, OR. 97014
(541) 374-8801

September 30, 2004

EXECUTIVE SUMMARY

In the spring of 2002, 2003, and 2004 the Fisheries Field Unit (FFU) conducted evaluations of the seasonal presence and abundance of pinnipeds in the Bonneville Dam tailrace including surface observations of salmonid consumption. Individual pinnipeds were identified by cataloging unique physical characteristics, allowing us to make more accurate abundance estimates and track individuals returning both within and among years.

Incidental pinniped observations occurred across much of the year at Bonneville Dam; however, scheduled observations began when the pinnipeds' first arrived for consecutive days and last departed each year. This resulted in our study period including the fish passage season from 1 January to 31 May, but was primarily focused on the spring Chinook (*O. tshawytscha*) passage season at Bonneville Dam (March 15 through May 31). Few pinniped sightings occurred outside this timeframe.

An estimated 929 (0.3% of the run) adult salmonids were consumed by pinnipeds in the tailrace of Bonneville Dam during the 2002 1 January to 31 May fish passage season. An estimated 2,394 (1.1% of the run) adult salmonids were consumed during 2003, and an estimated 3,872 (2.0% of the run) adult salmonids were consumed during 2004. Additional salmonids were caught by pinnipeds but escaped and swam away with unknown levels of injuries (11.9%, 9.5%, and 1.8% of total salmonid catch in 2002, 2003, and 2004 respectively). Pinniped salmonid catch rates per hour in 2002, 2003, and 2004 were higher at Powerhouse Two (PH2) (0.23, 0.56 and 0.91, respectively) than at Powerhouse One (PH1) (0.13, 0.39, and 0.60 respectively) or the spillway (0.02, 0.05 and 0.08 respectively).

The highest number of salmon consumed by any one individual pinniped in a single day was 10 occurring in 2003, over a 12-hour period. The most salmon consumed by an individual during any season was 52, occurring over 18 days in 2003. This same individual consumed the most salmon in 2002: 51 salmon over 14 days, nine over a 15-hour period and this individual was not observed in 2004.

Pacific lamprey (*Lampetra tridentata*), American shad (*Alosa sapidissima*), yearling salmonids, centrarchids, and Northern Pikeminnow (*Ptychocheilus oregonensis*) were also consumed by pinnipeds on the surface. Although likely underestimated, lamprey comprised at least 4.6% to 13.1% of the total catch observed while shad comprised up to 3.3% of the total catch.

Thirty-one individual pinnipeds were identified in 2002, 111 in 2003, and 105 in 2004. The highest number of individuals observed at the project on any one day was 14 in 2002, 32 in 2003, and 37 in 2004. The mean number of pinnipeds observed per day during our study period was 4 in 2002, 13 in 2003, and 14 in 2004.

Observations using night-vision binoculars and spotlights indicate that pinnipeds were not actively feeding at night in the Bonneville Dam tailrace. Pinnipeds were never

observed at night in the tailrace of Bonneville down to Beacon Rock in 2002, but up to six were observed resting/playing at night in the tailrace area in 2003 on two occasions. In 2004 groups of 10 to 20 California sea lions were seen sleeping in the PH1 tailrace at night and up to 15 California sea lions at a time were seen hauled out on the concrete ogee of spill bay 17 for several nights and mornings before spill began. No pinnipeds were ever observed hauled out on land from Bonneville Dam down to Beacon Rock in 2002 or 2003.

In 2002, one Pacific harbor seal (*Phoca vitulina*) and at least 30 individual California sea lions (*Zalophus californianus*) were identified and documented in the Bonneville Dam tailrace during our study period. In 2003, at least 106 individual California sea lions, 3 individual Steller sea lions (*Eumetopias jubatus*), and 2 harbor seals were identified and documented. In 2004, at least 101 individual California sea lions, 2 individual Steller sea lions, and 2 harbor seals were identified and documented. We identified at least 12 individual California sea lions in 2003 as returns from 2002. We identified at least 36 individual California sea lions in 2004 as returns from 2003, 11 of those having been also seen in 2002.

Although the number of pinnipeds present and salmonids consumed increased from 2002 to 2004, salmon runs were relatively strong. Further evaluation during a low spring Chinook run year should be made to see if pinniped numbers stay high and salmon take is proportionate to the run. In order to put some perspective into pinniped impacts on Columbia River salmon runs, additional studies should be conducted from Astoria to below Bonneville.

TABLE OF CONTENTS

TABLE OF CONTENTS cont.

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

BACKGROUND

The presence of growing numbers of pinnipeds, protected by the Marine Mammal Protection Act (MMPA) of 1972, at Bonneville Dam on the Columbia River is a concern to fisheries managers. The pinnipeds are feeding on Columbia River salmon runs and the impacts to the Endangered Species Act (ESA) listed salmonid species is unknown. The National Marine Fisheries Servie (NMFS)(1997) reported a population of 300-500 California sea lions (*Zalophus californianus*) in the Columbia River from Astoria to Bonneville. The sea lions are present from late August to early June. Large groups (100-300) were seen at the mooring basin and fish processing plants, the mouths of the Cowlitz and Lewis Rivers (50-100), and at the mouth of the Willamette River (10-50). Harbor seals (*Phoca vitulina*) are observed at the mouth of the Columbia River year-round, but particularly in the spring and fall when large numbers of salmon are present and winter during smelt (*Thaleichthys pacificus*) migration. Historical records of the presence of pinnipeds in the Columbia River are few (Appendix H). One to two California sea lions in the tailrace of Bonneville Dam were reported during fishway inspections almost every year since the 1980's. However, in 2001, there were reports of up to six sea lions observed at one time at Bonneville Dam. Unfortunately, no systematic documentation of the timing of the sea lions arrival, the number of salmonids being consumed, nor the numbers of individuals involved exists.

The 2000 Federal Columbia River Power System Biological Opinion (section 9.6.1.5.3, action Item 106) called for an evaluation of marine mammal predation in the tailrace of Bonneville Dam. This document cited high rates of marine mammal tooth and claw abrasions on fish examined at the Lower Granite Dam adult trapping facility from 1990-1993. The injuries occurred on 14% to 19% of spring/summer chinook (*Oncorhynchus tshawytscha*) and 5%-14% of steelhead (*Oncorhynchus mykiss*)(Harmon et al., 1993). Approximately 5%-6% of chinook and 1%-6% of steelhead exhibited more severe open wounds. Fryer (1998) demonstrated an increase in pinniped abrasions from 2.8% in 1991 to 25.9% in 1996 for sockeye and 10.5% in 1991 to 31.8% in 1994 for Chinook, although only 3% of the injuries were considered severe enough to affect survival. In 2002, the University of Idaho reported that 37.6% of spring Chinook captured at Bonneville had marine mammal caused injuries and attributed 12% of those injuries to near Bonneville Dam (Steve Lee, personal comm.). The National Marine Fisheries Service (NMFS) believes that many fish injured by marine mammals may die before reaching Lower Granite Dam.

In April of 2001, after several pinnipeds had been seen for a month in the Bonneville Dam tailrace, the Fisheries Field Unit (FFU) was requested to document the numbers present and determine their departure date. We began observing on 11 April, and saw the last pinniped on May 13, 2001. The highest number of pinnipeds observed at any one time was six. Our work in 2002, 2003, and 2004 was directed toward determining when pinniped predation occurs in the Bonneville Dam tailrace, the numbers present, the number of individuals observed, and the number of salmonids (and the

proportion of the population passing Bonneville) consumed in the tailrace. The University of Idaho Cooperative Fish and Wildlife Research Unit radio telemetry program examined marine mammal injuries to adult salmonids captured at the Bonneville Dam trap. Injury was recorded before tagging and after recapture when tagged fish, released approximately 8 kilometers below the dam, returned to the trap on their way upriver. This allowed them to determine a rate of marine mammal incurred injuries near Bonneville Dam. Those results are currently not published.

OBJECTIVES

1. Estimate the number of adult salmonids and other fish consumed by pinnipeds in the Bonneville Dam tailrace and the proportion of the salmonid run impacted.
2. Determine the seasonal timing and numbers of pinnipeds present at the Bonneville Dam tailrace.
3. Determine how many different individuals are present at Bonneville Dam each year. Determine whether the same individuals return in subsequent years.

METHODS

GENERAL

Surface observation techniques similar to those described in London et al. (2002) were used for all study objectives. Pinnipeds must surface to breathe every few minutes. Also, for pinnipeds to feed on large prey, such as salmon, they must bring them to the surface repeatedly, tearing them into chunks that can be swallowed. Pinnipeds cannot eat large prey underwater because their teeth are not adapted for chewing. Therefore, surface observations of the number of pinnipeds present and number of adult salmonid prey consumed can be recorded with a high degree of success and accuracy. To provide the visual acumen necessary to identify unique individuals and the species level of identification of prey, we used 8x30 binoculars, 15x50 image stabilized binoculars, 16X-60X spotting scopes, night-vision binoculars (generation 1 and 3), a 2 million candle-power spotlight, a 35mm camera with 500mm lens and 2x extender, and digital video recorders with 12X optical zoom. The spotting scopes were used mainly when pinnipeds were far away and engaged in surface activities for extended periods, for example feeding or resting. Night-vision binoculars and spotlights were used from both shoreline and in a boat to observe pinniped activity at night. Video recorders and 35mm cameras were used to identify unique marks for each individual and to confirm individuals seen by multiple observers. Individual pinnipeds were identified by noting a combination of physical characteristics such as placement of cuts, scars, lumps, areas of differing color, size, maturity, tags (brands), and even behavior. These uniquely identifiable characteristics were noted, sketched, and recorded on videotape. Digital images were captured from video to create a catalogue of individuals and their unique physical characteristics. This cataloging aided in identification of individuals both within and among years.

Information recorded by observers included date, observation period (later converted to PST), location, number of individual pinnipeds observed, number of adult

salmonids, lamprey (*Lampetra tridentata*), or shad (*Alossa sapidissima*) eaten, or those caught then lost by individual pinnipeds. Descriptions of special physical characteristics or behavior that would help distinguish one pinniped from another were noted. When time permitted, video or photos of specific individuals were taken to document distinctive characteristics. Criteria were developed to determine whether a pinniped was a new individual or one already observed. The degree of certainty fell into three categories: 100% positive, 70%-90% "very sure", and 50% "maybe". These criterion are described in Appendix B. One observer was ensured that individual pinnipeds were correctly identified by covering all sites confirming identities and documenting new individuals. Video and still picture documentation was the major tool employed in verifying individuals.

SITE

Bonneville Dam is the first dam upstream from the mouth of the Columbia River river kilometer 235 (Figure 1). Construction of the Powerhouse One (PH1), the spillway (main dam), and navigation lock was completed by 1938. Powerhouse Two (PH2) was added in 1982, and a new navigation lock was completed in 1993. This created a tailrace that is broken up into three main areas separated by islands (Figure 2). Tanner Creek empties into the Columbia River along the Oregon shoreline about 2 km below the dam. Our study area in 2002 included the tailraces of PH1, the spillway, and PH2 as well as the navigation lock channel, the downstream tips of the islands, and the mouth of Tanner Creek. In 2003 we observed primarily at the powerhouse tailraces and the spillway. In 2004, we concentrated our observations at both powerhouse tailraces.

Not all of the tailrace in each of the three channels was visible from the dams, owing to curvatures of the islands and shorelines and the distances involved. Therefore, we defined the tailrace (near-dam impacts) as the area from the face of the powerhouses and spillway to a line about ¾ of the distance from where the tips of the islands cross with the opposite shorelines (Figure 2). Data collected from the areas around the tips of the islands and Tanner Creek were assumed far enough downstream from the dam to not directly affect the predation success of pinnipeds any more so than would lower stretches of the Columbia River. The vast majority of predation in our study area occurred within 0.2 km of the face of the dams.

Observation stations varied, but typically were at the face of the dams at tailrace deck level since it was best for identifying individuals. Occasionally a site high on top of the dam gave a good overall picture of activity in the tailrace when several pinnipeds were coming and going. At other times, the tips of the islands or various points along the shorelines were best for watching an individual pinnipeds.

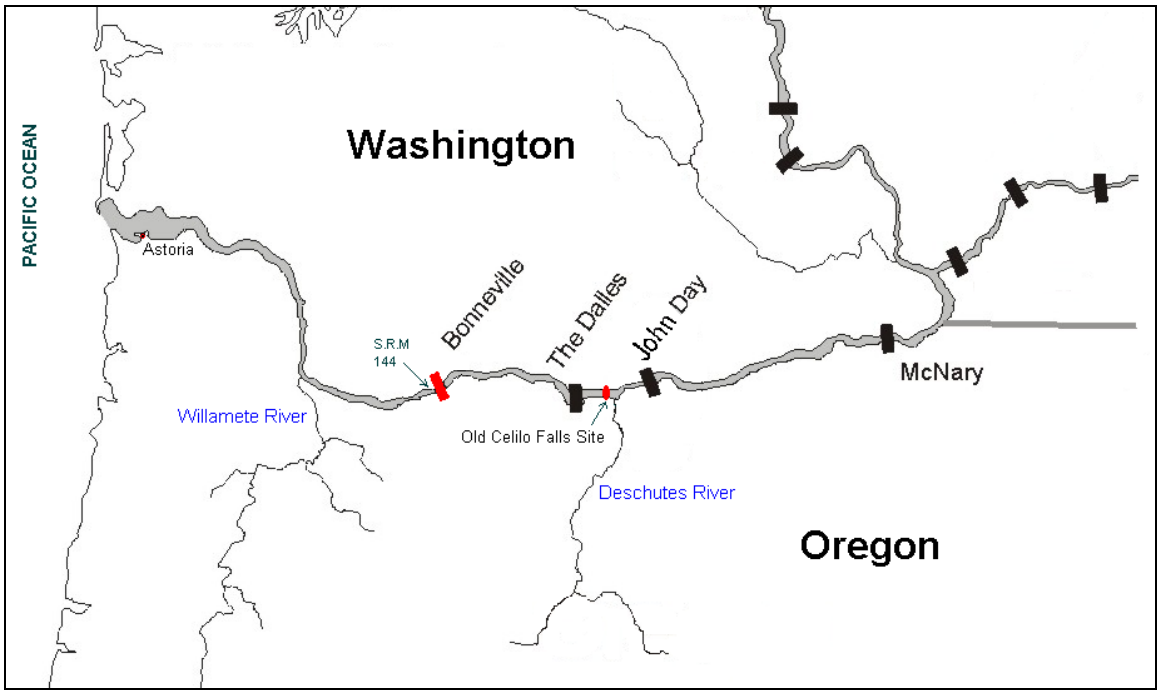

Figure 1. Overview of the Columbia River and location of Bonneville Dam.

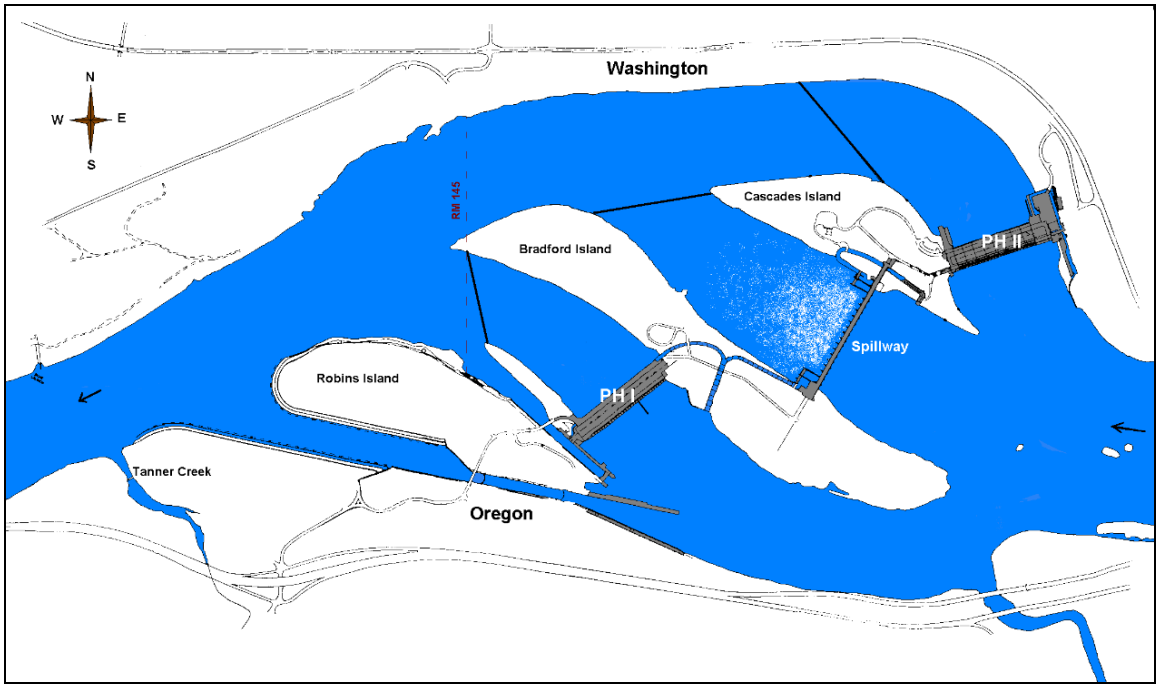

Figure 2. Diagram of pinniped study area at Bonneville Dam, 2002-2004.

2002 SAMPLING SCHEDULE

Incidental observations for the presence of pinnipeds at Bonneville occurs all year during other FFU and Bonneville Project personnel activities. A sea lion was reported by a fisherman at PH2 on 2 January. A sea lion was sighted on 6, 13 and 14 March, but not consistently until 20 March. FFU began scheduled observations on 21 March and ended on 17 May, when the pinnipeds were virtually gone (we observed until 24 May). Initially, observations were scheduled five randomly selected days per week. One person would observe for four hours between sunrise and noon, one hour at each location (PH1, PH2, spillway, Tanner Creek), and another for four hours between noon and sunset. A third observer would alternate between morning and afternoon and stay at one location where there were pinnipeds present for four hours. On one randomly selected day each week, one observer each would be at the four locations for the same four randomly selected hours. Additionally, one night a week was randomly selected. Hours of daylight were defined as approximately one hour before sunrise to one hour after sunset.

Three weeks into the 2002 season, we modified the observation schedule based on what we had learned, what was feasible, and what would give us meaningful data. First, three weekends were covered instead of the six originally scheduled. The weekend days eliminated from the original schedule were made up on other days during the week. Based on observations, it was highly unlikely that pinniped activity was different between weekdays and weekends. This was confirmed in 2003, Appendix F. Second, most of the pinnipeds were hunting in the powerhouse tailraces near the face of the dams. Observations made at other locations were primarily of pinnipeds moving into or out of the powerhouse tailraces. Spill began on 10 April and made viewing pinnipeds extremely difficult in the spillway tailrace. Consequently, we monitored more hours from sunrise to sunset at both powerhouses with additional observers checking other locations at a reduced period of time. This modified schedule was followed from 10 April on, with one of the powerhouses being observed from dawn to dusk, the other powerhouse observed for about half a day, and the remaining locations observed for a few random hours. In addition, we added one more location, “other”, which collectively encompassed the navigation locks, tips of the islands, and forebays. Last, we attempted to observe pinnipeds at night both from the shoreline and from a boat using spotlights and night-vision binoculars. After the first few unsuccessful nights we limited our hours of night observation to attempts at following pinnipeds after it became dark until we lost them or just before day break to see if they were present before daybreak. A list of the dates and total hours observed at each location can be seen in Appendix A. The dates of incidental observations can be seen in Appendix E.

2003 SAMPLING SCHEDULE

In 2003, we began pinniped observations on 3 March and ended on 2 June. We observed for at least two hours at each powerhouse tailrace Monday through Friday until we saw the first pinniped (14 March). After that, we attempted to sample from 6:00 to 18:00 (Pacific Standard Time, PST) on five randomly selected days per week at each powerhouse tailrace. This was supplemented with additional observations at the spillway

tailrace and on the other two days each week. There were a few days where the full 12 hours were not made due to lack of personnel to cover both powerhouses. Some period of observation was made every day from 17 March through 29 May. A list of the dates and total hours observed (excluding incidental observations) at each location can be seen in Appendix A. The dates of incidental observations can be seen in Appendix E.

2004 SAMPLING SCHEDULE

In 2004, we began pinniped observations on 24 February, sampling at least 4 hours at each powerhouse tailrace Mondays through Fridays. The spillway was monitored only a few times, usually for no more than an hour, when a group of pinnipeds was observed. Sampling ended on 30 May, since no pinnipeds were observed after 26 May. A list of the dates and total hours observed at each location can be seen in Appendix A. The dates of incidental observations can be seen in Appendix E.

EXPANDED ESTIMATES OF FISH CAUGHT

A number of assumptions were made to determined the number of individual pinnipeds present and to determined estimates of salmonids consumed by pinnipeds. These can be seen in Appendix G. Estimates of salmonids consumed were made by taking the actual number consumed at each location, each day and expanding for the hours of daylight not observed between January 1 and May 31 using the total project temporal catch distribution averaged for 2002, 2003 and 2004 combined (Figure 3). The temporal catch distribution was similar between PH1, PH2, and the spillway and was therefore, combined. The yearly catch distribution was also combined since the trend was similar each year even though the early and late hours were not monitored as much in 2003 and 2004. Days not monitored were accounted for by extrapolating estimated catch between the days observed (**(day1 + day3) / 2 = day2**). The percentage of the salmonid run taken by pinnipeds was determined by totaling the daily expanded catch estimate for both powerhouses, adding 5% for spillway tailrace catches (based upon the 2003 year results with unbiased spillway sampling), and dividing that number by the total of that same number plus the total number of salmonids passing Bonneville ladders during the same time period:

(((PH1+PH2) x 1.05) / ((PH1+PH2) x 1.05) + total salmonid count for Bonneville) x 100

We did not determine confidence limits for the percentage of salmonids taken as early season catch to passage values were very high and fish passing were not necessarily representative of those in the tailrace. This also applies to lamprey and shad, which are taken before they are seen passing the count windows. We also reported rates of predation (number of salmon caught per hour of observation) and calculated confidence limits for those rates.

Incidental observations, taken by Bonneville Project rangers, Oregon State Police Troopers (patrolling Bonneville Dam), and FFU personnel outside the more intense monitoring period, were also collected and are reported in Appendix E. These include date, time, location, number of pinnipeds observed, and the behavior observed. The

duration of most of these observations were for less than 10 minutes. Incidental observations were taken when pinnipeds were eating fish, events that are hard to miss if one is nearby. Therefore, these were not used in the expanded estimates of fish caught. Nevertheless, these observations do give us additional information concerning pinniped presence, their location, and their activity.

RESULTS

PINNIPED CONSUMPTION IMPACTS UPON FISH SPECIES CAUGHT

Pinnipeds were never observed feeding during our nighttime observations. We observed at night in 2002 and 2003 and never saw pinnipeds catching salmonids. In fact, we did not see any pinnipeds at night at the dam until 2003, and they were resting/playing, not hunting. Therefore, the expanded estimate data presented is for daylight hours only, which is defined as 1 hour before sunrise to 1 hour after sunset. Although not tabulated, the vast majority of fish caught were within 200 meters of the face of the powerhouse and fishway entrances. Determining the exact location of the catch was next to impossible as the pinnipeds hunted a large area, sometimes not surfacing with a fish until farther downstream; beginning to eat a caught fish occurred even farther downstream. We never observed pinnipeds feeding at the PH2 corner collector outfall at the tip of Cascades Island in 2004, even though it was in operation. We did see one pinniped presumably feeding on smolts at the PH2 outall in both 2003 and 2004.

Expanded Estimates of Salmonids Caught –

Expanded estimates were based on the temporal distribution of catches from all three years combined at all locations (PH1, PH2, and Spillway) combined (Figure 3). The estimate increased each year from 929 in 2002 to 3,872 in 2004 (Table 1). The number of salmonids passing Bonneville Dam from 1 January to 31 May decreased each year, therefore, the estimated percentage of the salmonid run taken by pinnipeds at Bonneville Dam each year increased from 0.3% to 2.0% (Table 1).

Table 1. Hours observed, salmonids caught, expanded estimate of salmonids caught, total salmonids passing Bonneville Dam and percentage of salmonids taken by pinnipeds from 1 January to 31 May, for 2002, 2003, and 2004.

Study Year	Total Hours Observed	Total Salmonids Caught	Expanded Estimate of Salmonids Caught	Total Salmonids Passing Bonneville	Percentage of Salmonid Run Taken by Pinnipeds
2002	734	452	929	284,733	0.3%
2003	1,440	1,538	2,394	217,185	1.1%
2004	553	838	3,872	186,804	2.0%

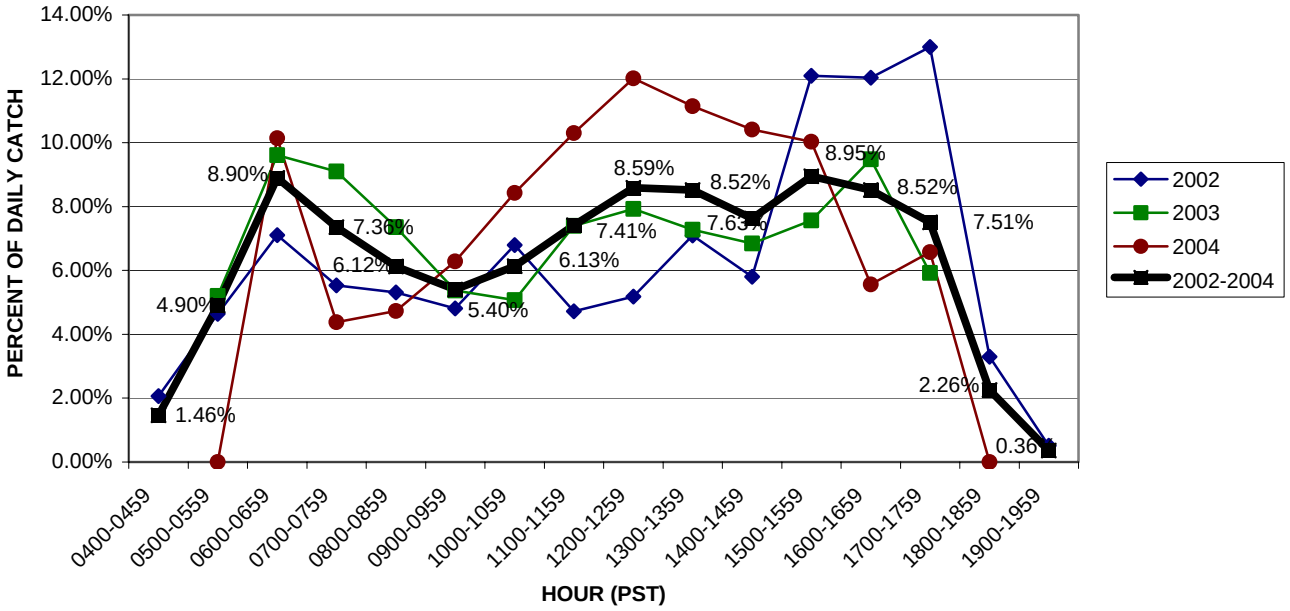

Figure 3. Diurnal salmonid catch distribution by pinnipeds over the entire Bonneville Project for each year and all years combined. The displayed percentages are for all years combined. These were the values used in expanding for hours not observed.

In addition, some salmonids caught by pinnipeds escaped and swam away. The unexpanded numbers of salmonids caught, then lost, by pinnipeds was 61 in 2002, 162 in 2003, and 15 in 2004. This resulted in a loss rate of 11.9% in 2002, 9.5% in 2003, and 1.8% in 2004. Both adult Chinook and steelhead were seen to escape. The degree of injury to salmon could not be ascertained.

Most salmonids caught by pinnipeds were from the PH2 tailrace, followed by PH1, the spillway, and "other" locations (Table 2). Numbers and percentage caught at these locations can be seen in Appendix C. Additional pinniped feeding behavior, such as pinnipeds stealing prey from each another, sharing prey, and losing partially eaten prey was seen and recorded, but occurred infrequently and are not presented here.

Rates of Salmonids Caught as per Surface Observations –

Rates of salmonids consumed per hour of observation at each site were calculated with 95% confidence limits. Predation rates basically followed the pattern of catch distribution (Figure 4). Table 3 shows the catch rate (using expanded estimates and daylight hours for the entire season) for both powerhouse tailrace locations increasing

each year from 2002 to 2004. Predation rates were always highest at PH2, followed by PH1, the spillway and "other" sites.

Table 2. Percentage of salmonids caught at each location in 2002, 2003, and 2004 based on expanded estimates at each site (excluding "other" sites).

	Percentage of Salmonids Caught by Location		
Location	**2002**	**2003**	**2004**
PH2	60.5%	56.3%	57.5%
PH1	34.7%	38.9%	37.8%
Spillway	4.8%	4.5%	4.8%

Note: 2002 and 2004 spillway based on PH1 plus PH2 totals times 5%

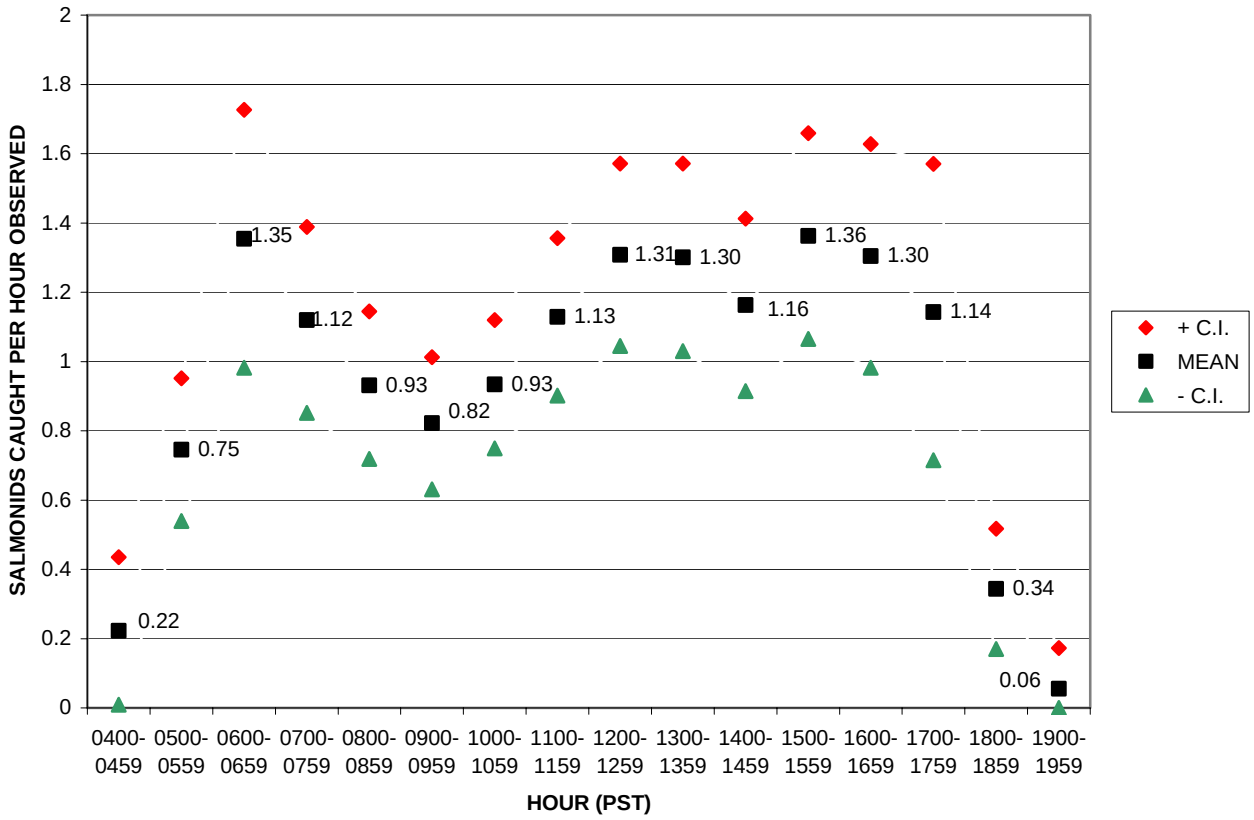

Figure 4. Diurnal salmonid catch rate by pinnipeds at Bonneville dam in 2002, 2003, and 2004 combined, with 95% confidence intervals.

Table 3. Rate of salmonids caught per hour (using expanded estimates and total season daylight hours) at various locations of Bonneville Dam for 2002, 2003, and 2004. The location "other" includes navigation lock channels, downstream tips of Cascades, Bradford, and Robins Islands and Tanner Creek. Total project excludes the "other" category.

	Salmonids Caught per Hour of Observation		
Location	**2002**	**2003**	**2004**
PH2	0.23	0.56	0.91
PH1	0.13	0.39	0.60
Spillway	0.02	0.05	0.08
Other	0.03	0.06	
Total Project	0.13	0.33	0.53

Over 65% of the time observations of fish caught were attributed to a specific individual pinniped. The mean and median number of salmonids caught per individual decreased each year (Table 4). The highest number of salmon any one individual pinniped was observed to consume at the dam in one day was 10 in a 12-hour period. The most salmon consumed by an individual over any season was 52 over 18 days in 2003. This same individual consumed the most salmon in 2002; 51 salmon over 14 days, nine over a 15-hour period and this individual was not observed at Bonneville in 2004. More than 50% of the individuals appear to take two or less salmon each season (Figure 5). However, since these are raw unexpanded numbers it is likely that some of those pinnipeds did take some salmonids but we could not identify the individual, or we were not observing at the time and did not document these catches. If we look at the the proportion of total salmonids caught by the 10 known individuals that caught the most salmonids in each year (2002 - 72%, 2003 - 41%, 2004 - 25%), it is evident that a few individuals account for the majority of fish caught.

Table 4. Mean, median, and range of salmonid numbers consumed by individual pinnipeds at Bonneville over the study years.

NUMBER OF SALMONIDS CAUGHT BY INDIVIDUAL PINNIPEDS				
	2002	**2003**	**2004**	**Total**
Mean	10.2	8.2	3.9	7.0
Median	6.5	3.0	1.0	3.0
Range	0-51	0-52	0-35	0-52
% Taken by Known Individuals	81.3%	68.3%	52.6%	65.7%

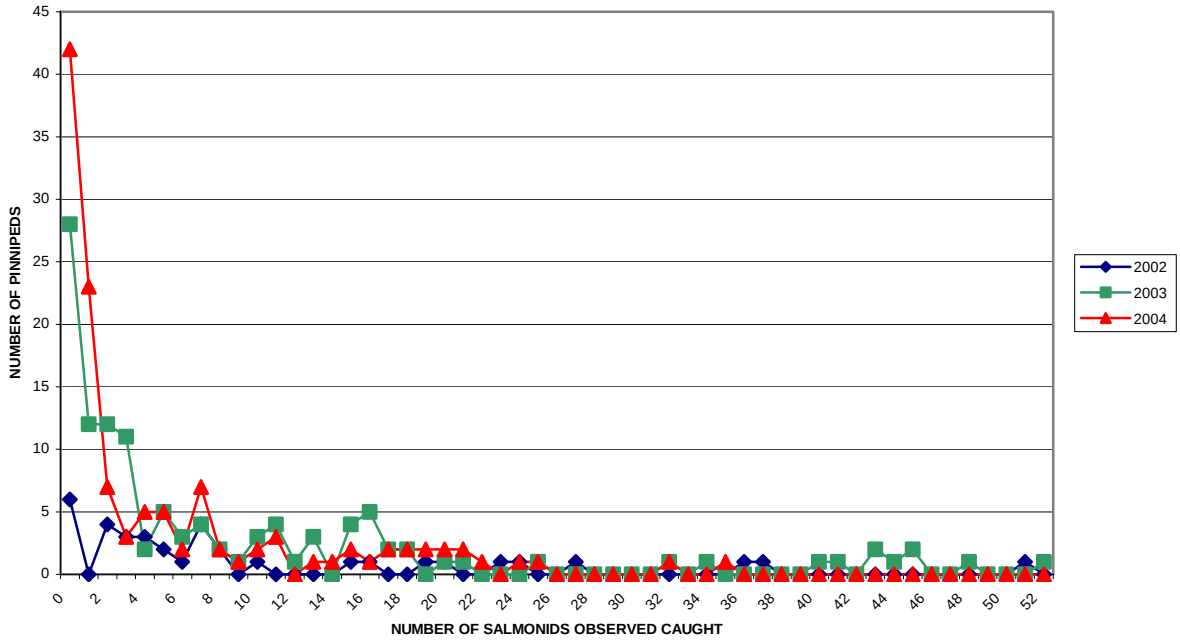

Figure 5. Number of salmonids caught by individual pinnipeds at Bonneville Dam during 2002, 2003, and 2004. Numbers are not expanded for times not observed. Roughly 35% of salmonids were caught by unidentified pinnipeds.

Observed Prey Species Caught –

Pinnipeds were observed catching additional prey species other than salmonids in the Bonneville Dam tailrace (Table 5). Lamprey were the next most common species caught after salmonids (5.4% to 12.1% of prey seen taken). Lamprey were seen taken as early as 3 March, well before lamprey are seen passing the count windows. They were eaten quickly, usually after a few bites to kill it, then swallowed whole, rarely being torn up. This action was so quick that when many pinnipeds were present, the activity could have easily gone unobserved. Also, lamprey may have been swallowed underwater. Shad were being taken beginning in May as the shad run began arriving at Bonneville and more so as shad numbers increased. Shad were not seen taken in 2002 although some smaller unidentified fish may have been shad. Therefore, observations and estimates of lamprey and shad taken are probably underestimated (Appendix J).

Steelhead made up from 0.7% to 7.4% of the salmonids caught, similar to the proportion of steelhead to Chinook counts at Bonneville from 15 March to 31 May (3.2% to 4.0%). Most of the salmonids not identified to species can be assumed to be Chinook. Few smolts were observed being eaten, however, considering that smolts are usually under 200mm, these can be swallowed whole underwater. Pinnipeds were seen at the PH2 outfall location and it can be assumed that many more smolts were taken but not observed.

Table 5. Unexpanded numbers of various prey species taken by pinnipeds in the Bonneville Dam tailrace in 2002, 2003, and 2004.

Species	2002	2003	2004
Salmonid sp.	361	53	352
Chinook	79	1470	451
Chinook Jack	2	4	10
Steelhead	6	10	25
Smolt	3	3	2
Lamprey	26	205	120
Shad	0	63	20
Centrarchid	0	1	1
Northern Pikeminnow	0	0	1
Unidentified	4	0	0
Total	481	1809	982

SEASONAL PRESENCE AND ABUNDANCE OF PINNIPEDS

Pinnipeds were reported at Bonneville on 2 January and 6 March of 2002 and were consistently present from 21 March to 17 May. One pinniped that was locked upstream into the forebay was seen near the upstream entrance to the navigation lock from 18 May to 22 May, when it was locked downstream. There were two additional sightings of pinnipeds reported, on 28 June and 16 July. Pinnipeds were first observed at Bonneville on 14 March of 2003 and were present continuously until 27 May. One additional sighting of a harbor seal was reported near the dam on 4 December. Pinnipeds were first observed at Bonneville on 22 February of 2004 and were present continuously until 26 May. No additional sightings were reported through 30 September.

Table 6 shows the number of identified individuals recorded for each species observed between 2002 and 2004 at Bonneville Dam. Several additional individuals were seen each year. However, these could not be identified either because they did not have unique physical markings or they did not come close enough to be viewed and recorded. The number of individuals increased dramatically from 2002 to 2003, with the numbers in 2004 being similar to those seen in 2003.

Table 6. Number of identified individual pinnipeds at Bonneville by species and the maximum, mean, and median number of pinnipeds per day each year.

Number of Identified Individual Pinnipeds			
	2002	2003	2004
California Sea Lions	30	106	101
Steller's Sea Lions	0	3	2
Harbor Seals	1	2	2
Total Pinnipeds Observed	31	111	105
Maximum in one day	14	32	37
Mean per day	4.4	13.3	13.7
Median per day	5.0	10.0	6.5

The maximum number of individual pinnipeds present in any one day increased each year, as did the mean per day (Table 6). However, the median number of pinnipeds present per day dropped in 2004, indicating more days of higher numbers of pinnipeds that skewed the mean. In 2002, pinnipeds were documented to be present on 58 of 151 days (38.4%) between 1 January and 31 May. Pinnipeds were present on 71 of 151 days (47.0%) in 2003 and 97 of 152 days (63.8%) in 2004.

DETERMINATION OF INDIVIDUAL PINNIPED BEHAVIOR WITHIN AND AMONG YEARS

Individual identification of the majority of pinnipeds was possible. Most of those observed were California sea lions and were identified within a given year and many pinnipeds had markings that made identification between years possible (including branded animals – See Appendix C).

Pinniped Behavior Within Year Near Bonneville Dam -

The mean and maximum number of days individual pinnipeds were observed at Bonneville Dam increased each year from 2002 to 2004 (Table 7). These days were typically not consecutive. In 2003, we monitored every day from 17 March to 29 May. Individual pinnipeds were present a mean of 7.4 consecutive days and averaged 7.3 days between sightings at Bonneville.

Table 7. Mean, median, and range of days individual pinnipeds were present at Bonneville Dam each year.

	Number of Days Individual Pinnipeds Present at Bonneville		
	2002	**2003**	**2004**
Mean	4.7	6.4	7.5
Median	3	4	4
Range	1-14	1-25	1-31

In 2003 and 2004 we kept track of several branded individuals as they moved between Astoria to Bonneville. Of 46 branded sea lions that were seen one or more times at both locations in 2003 and 2004, the shortest time was about 52 hours between the last sighting at Astoria and first sighting at Bonneville. We know of 29 one time trips that individuals made between Astoria and Bonneville Dam, 19 individuals made the trip at least twice, 14 made the trip three times, six made the trip four times, and two made the trip five times. The shortest time was about 21 hours between the last sighting at Bonneville and first sighting at Astoria.

Pinniped Behavior Between Years at Bonneville Dam -

Branded California sea lions and individuals with highly identifiable features enabled us to positively identify many individual California sea lions between years. Of

30 California sea lions identified in 2002, 16 possessed brands or highly discernable features. Of those 16, 12 (76%) were observed again in 2003 and 11 (69%) in 2004. Of 106 California sea lions identified in 2003, 72 possessed brands or highly discernable features. Of those 72, 36 (50%) were observed again in 2004. The numbers of pinnipeds seen between 2003 and 2004 were similar, yet roughly 50% of those were seen the previous year, making the other 50% new to Bonneville Dam in 2004. However, the number of repeats may actually be higher as we did not observe weekends in 2004 and several 2003 animals had marks that may not have been possible to match up in 2004. As can be seen in Figure 6, most pinnipeds were observed at Bonneville for only one day, and most others for less than four days.

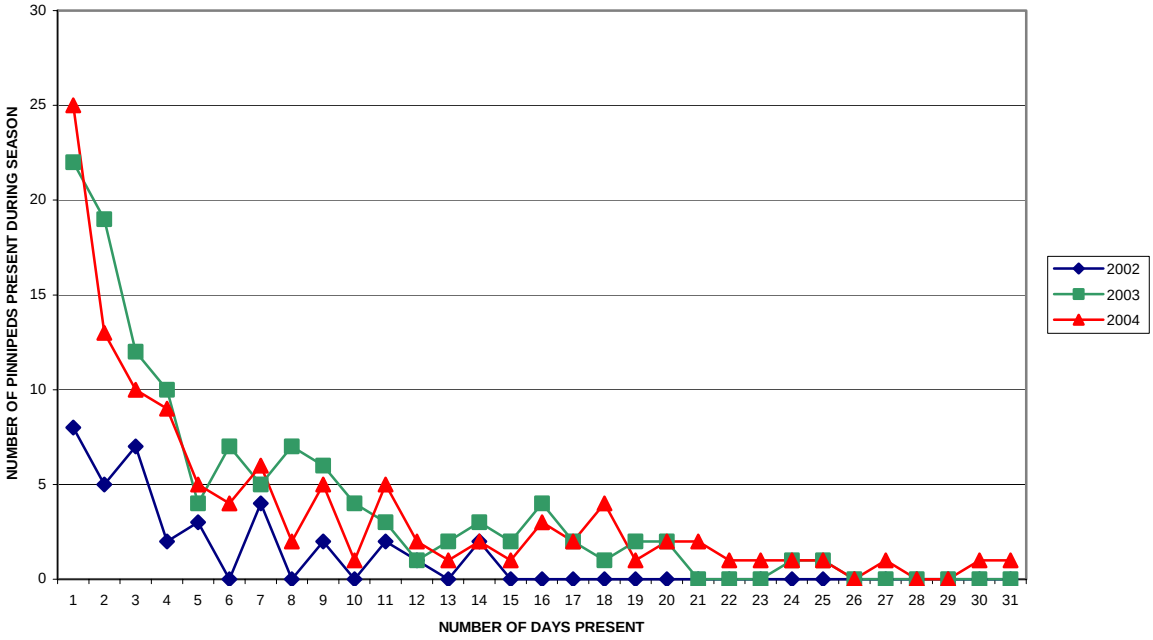

Figure 6. Number of days individual pinnipeds were observed at Bonneville Dam, 2002, 2003, and 2004.

DISCUSSION

The estimated numbers of salmonids caught by pinnipeds in the tailrace of Bonneville Dam between 2002 and 2004 increased from 929 (0.3% of run) in 2002 to 3,872 (2.0%) in 2004 (Table 1). Whether or not this increase will continue is not known. If 100 or more pinnipeds continue to show up each spring at Bonneville and take the same number of salmon, then the impact could be much larger in a year with relatively low fish passage. On the other hand, a small salmonid run may result in fewer pinnpeds at Bonneville Dam.

The California sea lion population along the West Coast has been on the increase since the implementation of the MMPA in 1972; they are now seen in areas where there was no documented historical occurrence (NMFS and WDFW, 1995). NMFS (1994) mention that between 1975 and 1993 pup counts in southern California increased overall 4.4% annually. Two years of major declines occurred in 1983 and 1992 due to El Nino events. Between 1976 and 1982 the annual rate of increase was 8.8% and between 1983 and 1993 the annual rate of increase was 10.8%. Bigg et al. (1990) noted an increased number of California sea lion males migrating into northern West Coast waters that coincide with an overall population increase. The number of sea lions in British Columbia increased by a factor of ten from 1972 to 1984. The increased numbers in British Columbia were greater than the increase for the breeding population, therefore Bigg believes a shift to a more northward migration has occurred. This may be the case for the Lower Columbia River as well as evidenced by the increasing numbers seen at Bonneville.

In the 1980's about 50 California sea lions would commonly be seen in the Columbia River (Beach et al., 1985), yet from 1991 to 1993 150-200 were counted annually (Matteson et al., 1993). NOAA (1997) reported a population of 300-500 California sea lions in the Columbia River from Astoria to Bonneville, 100-300 in Astoria, 50-100 near the mouths of the Cowlitz and Lewis Rivers, 10-50 at the mouth of the Willamette R. and 4-6 at Willamette Falls. Park (1993) stated that the Columbia River California sea lion herd was estimated to be at least 3,000 and the harbor seal herd to be around 3,600 animals.

Many West Coast areas have seen not only an increase in pinniped numbers but an increase in pinniped impacts to local prey. Bigg et al. (1990) reported California sea lions and harbor seals feeding on fall Chinook in Comox Harbor, British Columbia, estimating an impact to approximately 46% of the run. The well-known Ballard Locks study (NMFS, 1996) showed California sea lions to be taking between 42% and 65% of the winter steelhead run between 1986 and 1992. Brown and Mate (1983), reported harbor seals consuming 1.5% to 7.2% of the chum run entering Whiskey Creek on the Oregon coast. Harbor seals consumed up to 46% of fall Chinook entering the Puntledge River (Jurk et al., 1997). Park (1993), based on population estimates and salmon consumption data from other studies, estimated harbor seal take on the Columbia River spring Chinook could be as high as 22,558, of which 20%, or 4,500 could be listed Snake River Chinook, but he did not include California sea lion impacts in his estimates.

ODFW has examined California sea lion predation at the Willamette Falls Locks from 1995 and noted at least five sea lions at the locks and estimated them to have taken up to 300 salmonids (NMFS and ODFW, 1997). Between 0.3% to 2.7% of the winter steelhead population, 0.3% to 1.3% of the summer steelhead population, and 0.5% to 0.7% of the spring Chinook population passing the project was taken by California sea lions from 1996 to 2000 (Bryan Wright, ODFW, personal comm.).

Salmon are usually not the primary prey of pinnipeds except in specific locations and during specific times of the year. Roffe and Mate (1984) found that although pinnpeds were present and taking salmonids in the Rogue River, they were feeding primarily on lamprey. Everett et al. (1981) found that California sea lions in Puget Sound, Washington ate primarily Pacific Hake (*Merluccius productus*)(75.9%) and found no salmon remains while harbor seals were found to take salmonids as only 1.4% of their diet. Brown et al. (1995) documented that the diet of California sea lions at the mouth of the Columbia River (based on intestinal tract samples) consisted primarily of smelt (61% of samples), salmonids (28%), rockfish (22%) and lamprey and herring (17%). NMFS and the Oregon Department of Fish and Wildlife (ODFW) (1997) noted that the increased presence of California sea lions in the Lower Columbia River near the mouths of the Cowlitz, Elochoman, and Lewis rivers was in response to the smelt migration. At Bonneville, we found that lamprey made up at least 5.4% to 12.1% of the prey taken by pinnipeds while shad made up to at least 3.3% of the prey taken. Lamprey are in the tailrace of Bonneville Dam at least as early as March, since they have been observed being eaten, but do not show up in the count windows until early May. Lamprey and shad become a higher proportion of the fish caught from early May, with some individual pinnipeds appearing to concentrate primarily upon lamprey and/or shad as prey. Other individuals seemed to remain focused on salmon. It is highly likely that other prey species may have been consumed mostly underwater and we do not know whether the consumption of smolts is insignificant since we do not know how many are being consumed.

Sport and commercial fisheries were allowed to take 2% of the upriver spring Chinook run each year between 2002 and 2004. Tribal catch limits of about 9%-10% were allowed each year for spring Chinook above Bonneville Dam. The 0.3% to 2.0% of salmon taken by pinnipeds at Bonneville between 2002 and 2004 does not seem huge compared to reports in some studies, although this does represent a large number of adult salmonids, many of which likely were listed species. If the large number of pinnipeds seen at Bonneville continues, it could become a significant impact, particularly during a low run year.

The increase in pinniped abundance at Bonneville Dam from at least 31 individuals in 2002 to over 100 in 2003 and 2004 is alarming. Moreover, there appears to be a trend toward earlier and more protracted presence of pinnipeds during our study. In 2004 we observed one California sea lion repeatedly enter a fishway, several California sea lions hauling out at the dam, and large groups sleeping in slack-water areas of the dam at night. These behaviors were not observed in previous years, other than a few

individuals that were seen to sleep in slack-water areas at night in 2003. These observations, in addition to the pinnipeds being present in higher numbers than in the recent past, that salmonids and lamprey were taken in increasing numbers each year, and that pinnipeds appear to be staying longer at the dam, are of concern if the problem continues.

The problem of a California sea lion getting into the fishway is of particular concern for the Corps of Engineers. A solution may be to install trash rack-type barriers in the bulkhead slots to the main fishway entrances at least in the spring. These could be removed mid-to late May to allow sturgeon passage and reduce any debris accumulation. Similar action was taken at Willamette Falls Locks to prevent pinnipeds from entering one of their fishways (NMFS and ODFW, 1997). However, the trash rack may slow or impede salmonid passage, making the predation situation worse at the entrance to the fishway. This would have to be evaluated to show it does not impact salmonid passage or increase pinniped predation success.

Preventing predation in the tailrace area is a problem with no easy solution. It should be noted that harbor seals were seen up to Celilo Falls feeding on fall salmon runs before the dams were built (Thwaites, 1969). Therefore, the dams were not necessarily the first obstruction for fish navigating the Columbia River that allowed pinnipeds to prey upon them as they worked their way upstream. The Environmental Assessment report on protecting winter steelhead runs from California sea lions in Lake Washington ship Canal (NMFS and WDFW, 1995) described using several non-lethal deterrents, including aversion conditioning, acoustic barriers, translocation, captive holding, physical barriers, electrical barriers and others. None of these strategies proved effective at deterring the presence of pinnipeds (Appendix I). In more recent years, an electrical barrier has shown some promise in keeping new/nieve California sea lions away from the concentrations of salmonids at the Lake Washington ship Canal (pers. Comm., Steve Jeffries, WDFW).

Because none of the non-lethal methods tried in the Ballard Locks study proved feasible or effective in deterring pinniped predation on salmonids, WDFW applied for and received authority from NMFS to lethally take individually identified California sea lions that were proven to have a significant negative impact on the recovery of the winter steelhead population. However, Sea World offered to take the five identified animals. Three of these were successfully trapped and sent to Sea World, one never hauled out on the trap, and one was seen briefly the following year but was assumed killed, incidental to the tribal coho fishery as it was not seen since (NMFS, 1996). If the predation of ESA-listed salmon stocks by pinnipeds at Bonneville Dam and/or the Lower Columbia River is determined to be negatively affecting the recovery of these species, it will be very difficult to protect the salmon under the ESA and not compromise the MMPA requirements. Proof of individual pinnipeds having a significant negative impact to ESA-listed salmon stocks is required before beginning the process to request a waiver to the MMPA and allow lethal take on those specific individual animals. This process is difficult, complex, lengthy, and has only occurred once, as previously mentioned, after exhaustive attempts at non-lethal measures were tried and failed. New non-lethal techniques may become feasible, such as acoustic pingers used to reduce pinniped

bycatch in the California drift gill net fishery (Barlow, 2003), and should be tried as technology progresses and new information becomes available.

We strongly suggests a continued monitoring program to see if the trend in increased salmonid take continues at Bonneville Dam. At the very least, monitoring should occur when the population of spring Chinook is predicted to be lower than average. In addition, information is needed on the population and fish taken by California sea lions and other pinnipeds between Astoria and Bonneville Dam in order to obtain a larger perspective of the impacts pinnipeds may have on the salmon runs of the Columbia River. Studies could be undertaken to gather this information by having observers on commercial vessels, at popular sport fishing locations, and at the mouths of major rivers where pinnipeds are known to congregate and feed on salmon. These types of studies are out of the jurisdiction of the Corps of Engineers but would greatly enhance the general knowledge of pinniped predation on Columbia River salmon runs beyond the site specific information presented in this report.

ACKNOWLEDGEMENTS

We would like to thank all the observers who each put in hundreds of hours observing pinnipeds at Bonneville Dam under often cold, wet, and windy conditions. They include John Dalen, Marie Kopka, Sallie Jones, Andrew Lembrick, Bill Nagy, and Gretchen Starke, all of the Fisheries Field Unit. In addition, incidental observations were supplied by the Oregon State Police while conducting surveillance of fisherman at Bonneville Dam and by the Bonneville Dam ranger staff during their activities around the project. Special thanks go to Matt Tennis of Oregon Department of Fish and Wildlife ODFW) for his cooperation, help, and willingness to share data concerning sightings of branded California sea lions observed at Astoria and other locations, as well as radio- and satellite-tagging a couple of individuals known to visit Bonneville Dam. More thanks go to Robin Brown and Rick Boatner of ODFW for the loan of their radio telemetry receiver and antenna, which allowed us to track one of the radio-tagged individuals during a couple of nights at Bonneville Dam. Additional thanks go to Pat Gearin, NOAA, for information concerning a California sea lion branded in the Puget Sound and observed at Bonneville. Finally, thanks go to Steve Lee and his crew from University of Idaho Cooperative Fish and Wildlife Research Unit for supplying additional incidental observations of pinnipeds during their radio tracking activities in the tailrace of Bonneville Dam.

REFERENCES

Barlow, J. and G. Cameron. 2003. Field experiments show that acoustic pingers reduce marine mammal bycatch in the California drift net fishery. Marine Mammal Science. 19(2):265-283.

Beach, R., A. Geiger, S. Jefferies, S. Treacy and B. Troutman. 1985. Marine mammals and their interactions with fisheries of the Columbia River and adjacent waters, 1980-1982. NMFS/NWAFC Processed Report. 85-04. 316 pp.

Bigg, M., G. Ellis, P. Cottrell, and L. Milette. 1990. Predation by harbour seals and sea lions on adult salmon in Comox Harbour and Cowichan Bay, British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. No. 1769. 31 pp.

Brown, R. F. and Mate, B. R. 1983. Abundance, movements and feeding habits of Harbor Seals, *Phoca, vitulina*, at Netarts and Tillamook Bays, Oregon. Seattle, Washington: Fishery Bulletin 81(2):291-300.

Brown, R., S. Riemer, and S. Jeffries. 1995. Food of pinnipeds collected during the Columbia River area salmon gillnet observation program, 1991-1994. Oregon Department of Fish and Wildlife, Wildlife Diversity Program, Technical Report #95601. 16 pp.

COE. 1959. Annual Fish Passage Report, North Pacific Division, Bonneville, The Dalles, and McNary Dams, Columbia River, Oregon and Washington, 1960. U.S. Army Engineer Districts Portland and Walla Walla, Corp of Engineers. 44 pp.

Everett, R. D. , P. J. Gearin, J. S. Skidmore and R. L. De Long. 1981. Prey items of harbor seals and California sea lions in Puget Sound, Washington. Murrelet 62:(3) 83-86.

Fryer, Jeffrey K. 1998. Frequency of pinniped-caused scars and wounds on adult spring-summer Chinook and sockeye salmon returning to the Columbia River. North American Journal of Fisheries Management, 18(1): 46-51.

Gearin, P., B. Pfeifer, S. Jeffries. 1986. Control of California sea lion predation of winter-run Steelhead at the Hiram M. Chittenden Locks, Seattle, December 1985 – April 1986 with observations on sea lion abundance and distribution in Puget Sound. Mill Creek, Washington: Washington Department of Game.

Harmon, J., B. Sandford, K. Thomas, N. Paasch, K. McIntyre, and G. Matthews. 1993. Research related to transportation of juvenile salmonids on the Columbia and Snake Rivers, 1992. Annual Report of Research to USACE contract #DACW68-84-H0034. 23 pp.

Jurk, H., A. Trites, C. Wilson, G. Ellis, and J. Ford. 1997. Reducing predation of salmonids caused by harbour seals (*Phoca vitulina*) in the Puntledge River. Part 2: adult summer Chinook – June and July 1996. Report to University of British Columbia, Department of Fisheries and Oceans, Pacific Region, Ottawa.

London, J., M. Lance, and S. Jefferies. 2002. Observations of harbor seal predation on Hood Canal salmonids from 1998 to 2000. Final Report Studies of expanding pinniped populations. NOAA grant number NA17FX1603. 19 pp.

Lyman, R., J. Harpole, C. Darwent, and R. Church. 2002. Prehistoric occurrence of pinnipeds in the Lower Columbia River. Northwestern Naturalist. 83:1-6.

Matteson, K., W. Barnett and J. Langton. 1993. Summary report on the 1993 winter Columbia River salmon gillnet fishery. Progress report to NMFS under Award #NA90AA-H-FM714. 27 pp.

NMFS. 1994. Environmental assessment on reducing California sea lion predation on wild winter-run steelhead in the Lake Washington Ship Canal. NMFS/WDW Environmental Assessment Report. Seattle, WA. 57 pp.

NMFS. 1996. Environmental assessment for lethal removal of California sea lions at the Ballard Locks to protect winter steelhead. NMFS Environmental Assessment Report, Seattle, WA. 81 pp.

NMFS. 1997. Investigation of scientific information on impacts of California sea lions and Pacific harbor seals on salmonids and on the coastal ecosystem of Washington, Oregon, and California. U.S. Deparment of Commerce, NOAA Tech. Memo NMFS-NWFSC-28.

NMFS. 2000. Federal Columbia River Power System Biological Opinion (section 9.6.1.5.3, action Item 106). Seattle, WA.

NMFS and ODFW. 1997. Environmental assessment on preventing California sea lion foraging and predation on salmonids at Willamette Falls, Oregon. Seattle, Washington: National Marine Fisheries Service and Oregon Department of Fish and Wildlife.

NMFS and WDFW. 1995. Environmental assessment on protecting winter-run wild steelhead from predation by California sea lions in the Lake Washington Ship Canal, Seattle, Washington. NMFS/WDW Environ. Assess. Report. Seattle, WA 122 pp.

Park, D. 1993. Effects of marine mammals on Columbia River salmon listed under the Endangered Species Act. Report to Bonneville Power Administration, Contract DEAM993BP99654, 16 pp.

Roffe, T. and B. Mate. 1984. Abundance and feeding habits of pinnipeds in the Rogue River, OR. J. Wildl. Management 48(4):1262-1274.

State Board of Fish Commissioners. 1889. First and second annual reports of the State Board of Fish Commissioners to the Governor, 1887-1888.

Thwaites, R. 1969. Original Journals of the Lewis and Clark Expedition, 1804-1806. Arno Press.

APPENDICES

Appendix A. List of dates and hours of pinniped observations at each site for 2002, 2003, and 2004. Dates do not include incidental observations.

DATE	PH1	PH2	SPILL	T.C.	OTHER	ALL	TOTAL
3/7/2002	0:30	0:30	0:30	0:30			2:00
3/11/2002	0:30	0:30	0:30	0:30			2:00
3/12/2002	0:30	0:30	0:30	0:30			2:00
3/18/2002	0:30	0:30	0:30	0:30			2:00
3/19/2002	0:30	0:30	0:30	0:30			2:00
3/20/2002				0:30			0:30
3/21/2002	1:42	1:10					2:52
3/22/2002		1:29					1:29
3/25/2002	1:00	7:03	1:32	1:25			11:00
3/26/2002	1:50	4:05	1:50	1:40			9:25
3/27/2002	2:30	3:00	1:45	3:45		4:30	15:30
3/28/2002	4:39	9:39	3:20	1:35	0:57	2:30	22:40
3/29/2002	3:03	9:23	1:20	1:05			14:51
3/31/2002	5:45	3:50	2:15	1:45			13:35
4/1/2002	3:35	7:59	4:05	3:44			19:23
4/2/2002	6:02	5:09	2:25	1:40		1:05	16:21
4/3/2002	5:03	4:10	1:10	1:05	1:30		12:58
4/4/2002	3:15	4:00			1:05		8:20
4/5/2002	4:28	4:50	3:22	1:20			14:00
4/8/2002	7:35	6:40	2:00	1:15		2:00	19:30
4/9/2002	8:45	14:28		2:53	0:16		26:22
4/10/2002		4:40					4:40
4/11/2002		4:43					4:43
4/12/2002	4:10	9:17	2:55	3:58		0:40	21:00
4/13/2002		14:03					14:03
4/15/2002	3:30	12:35	2:00	0:42	0:47		19:34
4/16/2002	4:24	6:53	2:00	1:00			14:17
4/17/2002	2:27	4:37	1:34	3:20			11:58
4/18/2002	6:48	2:25	1:51	0:50			11:54
4/19/2002	6:50	6:51					13:41
4/22/2002	8:47	10:00					18:47
4/23/2002	10:30	12:57		0:30	0:58		24:55
4/24/2002	13:20	6:18	0:53		0:50	2:30	23:51
4/25/2002	5:13	8:10			0:46		14:09
4/26/2002	9:15	14:18	0:15	1:05	1:01		25:54
4/28/2002	15:50	15:15					31:05
4/29/2002	7:28	14:05					21:33
4/30/2002	9:30	6:53		0:15			16:38
5/1/2002	7:10	4:00		1:00			12:10
5/2/2002	15:36	8:05	0:15	0:15	0:30		24:41
5/6/2002	9:10	14:05		0:30	5:56		29:41
5/7/2002	4:19	10:28		0:40	1:09		16:36

DATE	PH1	PH2	SPILL	T.C.	OTHER	ALL	TOTAL
5/8/2002	5:58	5:05	0:15	0:32	0:39		12:29
5/9/2002	5:16	8:01	0:50				14:07
5/10/2002	2:51	15:25			0:42		18:58
5/13/2002	6:56	12:28	0:30				19:54
5/14/2002	13:28	7:49			0:16		21:33
5/15/2002	7:45	10:39			1:45		20:09
5/16/2002	8:15	12:04	2:30		1:30		24:19
5/17/2002	3:50	14:17					18:07
5/20/2002	3:15	3:15	1:55	0:15	0:15		8:55
5/21/2002	1:49	2:17	1:05	0:40	1:35		7:26
5/22/2002	1:05	0:30	0:28		1:12		3:15
5/23/2002					0:15		0:15
5/24/2002	0:30	0:25			1:20		2:15

DATE	PH1	PH2	SPILL	T.C.	OTHER	TOTAL
3/3/2003	3:00	3:00				6:00
3/4/2003	3:00	3:00				6:00
3/5/2003	2:00	2:00				4:00
3/6/2003	2:00	2:00				4:00
3/7/2003	3:00	3:00				6:00
3/10/2003	3:00	3:00				6:00
3/11/2003	2:00	2:00				4:00
3/12/2003	2:00	2:00				4:00
3/13/2003	2:00	2:00				4:00
3/14/2003	4:15	2:00				6:15
3/15/2003	0:00	0:00				0:00
3/16/2003	0:00	0:00				0:00
3/17/2003	7:43	2:20				10:00
3/18/2003	9:55	2:00	0:30			12:25
3/19/2003	7:57	3:15				11:12
3/20/2003	10:45	10:40	2:25			23:50
3/21/2003	11:10	8:45	0:30		1:00	21:25
3/22/2003	4:52	2:00	1:55			8:47
3/23/2003	1:30	1:15	0:45			3:30
3/24/2003	11:15	11:40	3:30		0:30	26:55
3/25/2003	11:30	12:33	1:00			25:03
3/26/2003	5:43	2:02	0:30			8:15
3/27/2003	12:15	12:00				24:15
3/28/2003	10:03	10:25	2:15			22:43
3/29/2003	1:00	1:00	0:30			2:30
3/30/2003	1:00	1:00				2:0
3/31/2003	12:00	12:10				24:10
4/1/2003	12:00	12:00				24:00
4/2/2003	5:50	4:50				10:40
4/3/2003	12:00	12:15				24:15
4/4/2003	11:15	11:41			0:15	23:11
4/5/2003	7:55	8:05				16:00
4/6/2003	0:55	3:20				4:15
4/7/2003	12:00	12:00	2:00	0:15		26:15
4/8/2003	12:30	12:00	7:41	1:00	0:30	33:41
4/9/2003	12:00	12:00	3:30	0:30	1:51	29:51
4/10/2003	8:00	8:15	0:30	0:15		17:00
4/11/2003	12:00	12:00	4:30	0:30		29:00
4/12/2003	1:45	1:15	0:15	0:45		4:00
4/13/2003	1:15	1:15	0:45	0:45	1:00	5:00
4/14/2003	12:00	12:00		0:15		24:15
4/15/2003	12:35	12:00	5:50	0:25	0:30	31:20

DATE	PH1	PH2	SPILL	T.C.	OTHER	TOTAL
4/16/2003	12:00	12:00	2:50	3:05		29:55
4/17/2003	5:00	8:30	0:15			13:45
4/18/2003	12:00	12:30	3:00	3:55		31:25
4/19/2003	8:00	8:00		0:45		16:45
4/20/2003	2:00	7:00	0:15		0:15	9:30
4/21/2003	12:00	12:00				24:00
4/22/2003	12:00	12:08	5:30	2:30		32:08
4/23/2003	0:45	9:25				10:10
4/24/2003	12:00	12:10	6:00			30:10
4/25/2003	12:30	12:00	6:00	3:30	0:15	34:15
4/26/2003	1:00	8:00				9:00
4/27/2003	1:30	2:00			0:30	4:00
4/28/2003	12:00	11:15				23:15
4/29/2003	12:00	12:30	4:30	1:30		30:30
4/30/2003	12:05	12:00	7:20	0:40		32:05
5/1/2003	5:30	12:00				17:30
5/2/2003	12:00	12:00	5:00	2:00		31:00
5/3/2003	9:00	6:40		0:45		16:25
5/4/2003	2:45	7:15				10:00
5/5/2003	11:50	12:00	0:15			24:05
5/6/2003	12:00	12:15	8:00			32:15
5/7/2003	6:40	10:20	0:10		0:15	17:25
5/8/2003	12:00	12:00	5:30	0:30		30:00
5/9/2003	12:00	12:00	4:56			28:56
5/10/2003	1:00	1:00	0:30			2:30
5/11/2003	5:15	6:00				11:15
5/12/2003	12:00	12:00				24:00
5/13/2003	12:00	12:00	3:30	2:00		29:30
5/14/2003	10:40	11:30				22:10
5/15/2003	12:00	12:40	7:00	0:45		32:25
5/16/2003	12:00	12:00	5:00		0:15	29:15
5/17/2003	5:15	3:15				8:30
5/18/2003	2:30	2:00				4:30
5/19/2003	6:45	8:00				14:45
5/20/2003	12:00	12:00	1:45			25:45
5/21/2003	12:00	12:00	7:00			31:00
5/22/2003	12:00	11:30	3:55		0:05	27:30
5/23/2003	6:31	6:30	2:30			15:31
5/24/2003	0:30	0:30				1:00
5/25/2003	0:30	0:30				1:00
5/26/2003	0:30	0:30				1:00
5/27/2003	6:55	5:40	0:40			13:15
5/28/2003	5:55	5:45				11:40

DATE	PH1	PH2	SPILL	T.C.	OTHER	TOTAL
5/29/2003	3:30	5:00	1:00			9:30
5/30/2003	0:00	0:00				0:00
5/31/2003	0:00	0:00				0:00
6/1/2003	0:00	0:00				0:00
6/2/2003	0:30	0:30				1:00

DATE	PH1	PH2	SPILL	TOTAL
2/24/04	0:00	2:00		2:00
2/25/04	4:00	4:00		8:00
2/26/04	3:00	4:00		7:00
2/27/04	0:00	1:00		1:00
3/1/04	4:00	4:00		8:00
3/2/04	4:00	4:00		8:00
3/3/04	4:00	6:00		10:00
3/4/04	4:00	5:00		9:00
3/5/04	4:00	5:00	1:00	10:00
3/8/04	4:00	4:00		8:00
3/9/04	4:00	4:00		8:00
3/10/04	4:00	4:00		8:00
3/11/04	4:00	4:00		8:00
3/12/04	3:00	4:00		8:00
3/15/04	4:00	5:00		9:00
3/16/04	4:00	4:00		8:00
3/17/04	4:00	4:00		8:00
3/18/04	4:00	5:00		9:00
3/19/04	4:00	4:00		8:00
3/22/04	4:00	4:00		8:00
3/23/04	4:00	4:00		8:00
3/24/04	5:00	4:00		8:00
3/25/04	4:00	4:00		8:00
3/26/04	4:00	4:00		8:00
3/29/04	4:00	4:00		8:00
3/30/04	4:00	4:00		8:00
3/31/04	4:00	4:00		8:00
4/1/04	4:00	4:00		8:00
4/2/04	4:00	4:00		8:00
4/5/04	4:00	4:00		8:00
4/6/04	4:00	4:00		8:00
4/7/04	4:00	4:00		8:00
4/8/04	5:00	4:00	1:00	9:00
4/9/04	4:00	4:00	2:00	10:00
4/12/04	4:00	4:00	1:00	9:00
4/13/04	4:00	4:00		8:00
4/14/04	4:00	5:00		9:00
4/15/04	4:00	4:00		8:00
4/16/04	4:00	4:00		8:00
4/19/04	4:00	4:00		8:00
4/20/04	4:00	5:00		9:00
4/21/04	4:00	4:00		8:00

DATE	PH1	PH2	SPILL	TOTAL
4/22/04	4:00	4:00		8:00
4/23/04	4:00	4:00		8:00
4/24/04	0:00	1:00		1:00
4/26/04	4:00	4:00		8:00
4/27/04	4:00	4:00		8:00
4/28/04	4:00	4:00		8:00
4/29/04	4:00	4:00		8:00
4/30/04	5:00	4:00		9:00
5/3/04	4:00	4:00		8:00
5/4/04	4:00	4:00		8:00
5/5/04	4:00	4:00		8:00
5/6/04	4:00	4:00		8:00
5/7/04	4:00	5:00		9:00
5/10/04	4:00	5:00		9:00
5/11/04	4:00	4:00		8:00
5/12/04	4:00	4:00		8:00
5/13/04	4:00	4:00		8:00
5/14/04	4:00	4:00		8:00
5/15/04	1:00	4:00	1:00	9:00
5/17/04	4:00	4:00		8:00
5/18/04	4:00	4:00		8:00
5/19/04	4:00	4:00		8:00
5/20/04	4:00	4:00		8:00
5/21/04	4:00	4:00		8:00
5/23/04	4:00	4:00		8:00
5/24/04	3:00	3:00		6:00
5/25/04	4:00	4:00		8:00
5/26/04	2:00	2:00		4:00
5/27/04	3:00	3:00		6:00
5/28/04	2:00	2:00		4:00
5/29/04	1:00	1:00		2:00

Appendix B. Criteria for categorizing the degree of certainty for individual pinniped identification.

100% - Must have clear video of unique feature or features documented.
90% - Poor but distinquishable video of unique feature or two separate observers identify and describe the same markings or brand.
80% - A single sighting by one observer but described a definite unique feature.
70% - Clear video of common or difficult to see features or features that could be mistaken for another individual if seen only briefly.
50% - Individual with few or no distinguishable marks but timing or coloration or some other feature made identification possible from others at least within a day.

We are confident that individuals assigned a 70% or greater degree of certainty were separate individuals. Ones assigned 50% were considered likely new individuals, but we weren't sure enough to count them in the total number of individuals identified.

Appendix C. List of branded California sea lions observed at Bonneville Dam in 2002, 2003, and 2004.

	2004	2003	2002	
818	X	X		
3341	X			
3696		X		
4140	X			
C?28	X			
C147	X	X	X	
C192	X	X		
C193	X			
C225		X	X	
C226		X		
C235	X			
C236	X	X	X	
C247	X	X		
C248	X			
C251	X	X		
C257	X	X	X	
C258	X	X	X	
C259	X	X		
C265/MR ED	X	X	X	
C275	X	X		
C301	X	X		Branded after spring 2002
C304	X			
C309/(lumpy 2002)	X	X	X	Branded after spring 2002
C311	X	X		Branded after spring 2002
C319(patch 2002)	X	X	X	Branded after spring 2002
C322	X	X		Branded after spring 2002
C327	X	X		Branded after spring 2002
C334	X	X		Branded after spring 2002
C335	X			
C361	X	X		Branded after spring 2002
C364	X			
C396		X		Branded after spring 2002
C398	X	X		Branded after spring 2002
C404	X	X		Branded after spring 2002
C417	X			
C426	X	X		Branded after spring 2002
C440	X			
C441		X		Branded after spring 2002
C442	X	X		Branded after spring 2002
C443	X			

	2004	2003	2002	
C444	X	X		Branded after spring 2002
C445		X		Branded after spring 2002
C449	X	X		Branded after spring 2002
C494	X			
C507	X			

Branding of California sea lions has occurred since 1997 at Astoria by the Oregon Department of Fish and Wildlife (ODFW). NMFS has also branded some California sea lions in the Puget Sound area, and pup branding occurs on San Miguel Island in southern California. In 2003, a California sea lion that was known to be at Bonneville in 2002 was captured early in the spring of 2003 and fitted with a radio-transmitter by ODFW personnel and tracked at Astoria and Bonneville Dam. In 2004, two California sea lions were captured and fitted with both radio-transmitters and satellite tags by ODFW personnel. Both animals were observed at Bonneville Dam in 2004. Data from these tags are yet to be published.

Appendix D. Table of raw numbers of salmonids caught, number of hours observed, and rates and percentage of salmonids caught per location.

Location	Salmon Caught 2002	Hours Observed 2002	Seasonal Rate of Fish Caught Per Hour ** 2002	Expanded Estimate of Salmonids Caught 2002	Percentage Caught Per Location 2002
PH2	305	363	0.23	562.34	60.5%
PH1	119	258	0.13	322.80	34.7%
Spillway	9	41	0.02	44.26	4.8% *
Other	19	72	0.03		
Total Project	433	662	0.13	929	

Location	Salmon Caught 2003	Hours Observed 2003	Seasonal Rate of Fish Caught Per Hour ** 2003	Expanded Estimate of Salmonids Caught 2003	Percentage Caught Per Location 2003
PH2	941	618	0.56	1348.54	56.3%
PH1	559	607	0.39	931.02	38.9%
Spillway	27	131	0.05	114.00	4.5%
Other	11	35	0.06		
Total Project	1527	1356	0.33	2394	

Location	Salmon Caught 2004	Hours Observed 2004	Seasonal Rate of Fish Caught Per Hour ** 2004	Expanded Estimate of Salmonids Caught 2004	Percentage Caught Per Location 2004
PH2	503	283	0.91	2224.63	57.5%
PH1	335	265	0.60	1463.33	37.8%
Spillway	1	5	0.08	184.40	4.8% *
Other	NA	NA			
Total Project	839	553	0.53	3872	

***** - Actual spill estimates for 2003 totaled 108.40 and 4.5% of location. This figure was rounded up to 5% and used for all years at the spillway, including 2003, for making final expanded estimates. 2003 was the best year to use spill estimates for as we monitored based upon scheduled times and not predominantly when pinnipeds were present. The 'spillway' category for 2002 and the 'other' category for 2002 and 2003 are biased as we tended to sample these locations only when pinnipeds were present, thus skewing towards a higher catch rate than in reality since we did not observe long when pinnipeds were not present.
** - Rate of fish caught is calculated by dividing the expanded estimate of salmonids caught by the total hours of daylight for the season (2416 for 2002 and 2003, 2432 for 2004). This equalizes across years and for any bias in hours actually observed.

Appendix E. Dates and information on incidental pinniped observations at and near Bonneville Dam, 2002, 2003 and 2004.

2002 DATE	TIME	# S.L. OBS.	LOCATION	# SALMON EATEN	BEHAVIOR
1/2/2002		1	PH2 TR		FISHERMAN REPORT
3/6/2002	7:30	1	PH2 TR		SWIMMING
3/13/2002	?am?	1	PH2 OUTFALL	1	
3/14/2002		1	TIP BI		
3/21/2002	9:00	1		0	
3/21/2002	10:00	1		1	
3/22/2002	9:00	2		1	
3/25/2002		2	PH2	0	
3/27/2002		2	PH2	0	
3/27/2002		1	PH1 TR	0	
3/30/2002	9:00	3	PH2	0	
3/31/2002	18:00	12	Pierce/Ives Is.		
4/4/2002	19:00	1	Pierce/Ives Is.		
4/5/2002	10:00	1	PH1 TR	0	
4/5/2002	13:00	1	Spillway	1	Spillway near ci entrance
4/5/2002	15:35	1	NL	1	New NL near tip RI
4/6/2002	6:18	1	Spillway	0	
4/6/2002	9:00	1	Tip RI	0	
4/9/2002	7:50	1	RI	0	Swimming
4/9/2002	8:46	1	PH1 TR	1	eating
4/10/2002	16:15	3	Spillway	0	
4/11/2002	8:55	1	Tip BI	1	
4/11/2002	10:15	1	TC mouth	0	
4/11/2002	14:10	1	SMF outfall	1	
4/18/2002		1	PH1 TR	1	
4/18/2002	17:10	1	BI-RI	0	
4/18/2002	19:30	1	NL	1	
4/20/2002	6:30	1	Wash shore	1	
4/21/2002	19:00	2	PH1 TR	0	
4/21/2002	19:00	1	Spillway	1	tossing fish
4/24/2002	14:10	1	BI-RI	1	
4/30/2002	7:26	1	RI	1	Eating
5/2/2002	13:50	1	TC mouth	1	
5/2/2002	15:50	2	Spillway	0	
5/2/2002	18:00	1	CI tip	1	
5/3/2002	10:30	1	Spillway	0	
5/3/2002	18:41	2	PH1 TR	0	
5/4/2002	6:30	1	Spillway	0	
5/4/2002	11:00	1	TC mouth	0	
5/6/2002	12:00	1	TC mouth	0	

2003 DATE	TIME	# S.L. OBS.	LOCATION	# SALMON EATEN	BEHAVIOR
5/6/2002	17:00	1	TC mouth	0	
5/16/2002	0:00	1	Nav. Lock	0	
5/18/2002	afternoon	1	Mouth Wind River	0	
5/20/2002	15:30	1	Stevenson Boat Dock	0	
5/15/2002	17:15	1	RI TIP	1	
5/16/2002	11:36	1	Spillway	0	
5/17/2002	9:19	1	RI TIP	1	
5/22/2002	19:20	1	UP NL GATE	0	
6/28/2002	19:00	1	Spillway	0	
6/28/2002	19:15	1	RI TIP	0	
3/14/2003	10:00	1	PH2		swimming
3/15/2003	10:00	1	Tip Ham Isl		swimming
3/23/2003	9:15	2	RI TIP		swimming
3/24/2003	10:00	2	T.C.		swimming
4/12/2003	18:20	1	RI TIP		swimming
4/16/2003	14:33	2	CI TIP		Feeding
4/19/2003	18:00	1	PH1		Feeding
4/25/2003	13:00	2	CI TIP		Feeding
4/25/2003	16:45	2	Tip Ives Isl		swimming
4/25/2003	16:55	1	Tip Ham Isl		Feeding
4/25/2003	16:57	1	Tip SMF Outfall		Swimming
12/4/2003		1	Ham. Isl. B.R.		Harbor seal pup seen multiple times
2/22/2004		1	PH2	1	Feeding
2/23/2004		1	PH2		Swimming
2/24/2004	9:30	1	PH1	1	Feeding
3/18/2004		1	PH2		Hunting in NDE fishway, c404
3/31/2004	24:00	1	Spillway		Hauled out on bay 17 ogee
4/8/2004	11:00	1	Spillway		Hauled out on bay 17 ogee
4/24/2004	6:00	1	P2 JBS Outfall		Hunting outfall area
4/27/2004		1	Drano L.	1	Hunting/feeding
5/4/2004		1	Forebay		Hauled out on rock island
5/5/2004	8:30	1	T. C.		Hunting
5/17/2004		1	Drano L.		
5/22/2004		1	PH2		Hunting
5/23/2004		1	PH2		Hunting
5/23/2004		2	PH1		Hunting

Appendix F. Comparison of weekday and weekend pinniped observations in 2003.

	Weekday Catch/Hour Rate	Weekend Catch/Hour Rate
N	53	20
Mean	1.03	1.15
Median	0.98	1.27
Minimum	0	0
Maximum	2.47	3.26
Standard Error	0.67	0.94

	Weekday Number of Pinnipeds	Weekend Number of Pinnipeds
N	53	20
Mean	11.0	9.3
Median	11.0	11.0
Minimum	0	0
Maximum	24	19
Standard Error	0.89	1.3

Appendix G. Assumptions made to determine the number of individual pinnipeds present and to determine estimates of salmonids consumed by pinnipeds.

- Catch rates and the hourly distribution of catches for hours and days not observed were assumed to be similar to the mean temporal catch distribution for 2002 through 2004 given in Figure 3.

- All adult salmonids caught by pinnipeds were assumed brought to the surface to be torn up and consumed. Some pinnipeds were observed apparently eating large chunks underwater and others dragged fish downstream, both at the surface and underwater great distances before beginning to eat the fish. This behavior may have contributed to an underestimate of the number of salmonids caught, but we feel this occurred less than 1% of the time. Overestimates may have occurred when several pinnipeds were present. A pinniped would catch a fish and take a long time before eating it. Towards the end of the season, after they had consumed many fish, this behavior could sometimes make it appear as if another pinniped had caught a fish, particularly if the individual that caught the fish was not identified. Pinnipeds stealing a fish from one another were usually identifiable. However, stealing behavior may have been counted as a new fish being taken if the amount of fish originally consumed was not carefully monitored. Overall, these conditions were rare and did not significantly affect the expanded estimates.

- Lamprey were eaten quickly and mature adults would not always shake or throw lamprey but rather swallow them whole, head first, after a few quick bites to kill them. We likely underestimated the number of lamprey caught as the action was quick and distances involved made seeing a lamprey being eaten difficult. Adult shad were eaten quickly and some may have been missed. Harbor seals (*Phoca vitulina*) were present on a few occasions but only one was seen catching a salmon. Seals may have targeted lamprey, which could have been consumed underwater. Roffe and Mate, (1984) found that lamprey were the primary prey consumed by harbor seals on the Rogue River after analyzing stomach contents.

- Observations were assumed equally successful at all locations, each observer had equal ability to detect the presence of pinnipeds and when fish were caught, and weather and lighting did not significantly affect these observations. However, when spill occurred, it was very difficult to see pinnipeds and if they had caught fish, so our detection and catch rate there may be biased low. Heavy rain reduced visibility at times and distant events may have gone unnoticed.

- The chance of underestimating the numbers of pinniped present was assumed equal to the chance of overestimating the numbers when large groups were present. The behavior of hunting California sea lions was to stay submerged for several minutes and only briefly surface to breathe. This made it difficult to know if a head or nose seen five minutes apart was from the same individual or a different individual. Some individuals would hunt in predictable patterns while

others would appear to randomly search and surface. When more than five or six pinnipeds were in a tailrace, it became very difficult to keep track of the number present, identify individuals, record all fish caught, and detect new arrivals and departures. We prioritized our effort as such: 1) ensure all fish caught are seen and recorded, 2) record and document individuals, and 3) determine the number of pinnipeds present and record when they arrive and when they leave the tailrace.

- The presence of observers on the tailrace deck was assumed to not affect the presence of pinnipeds in the area or their ability to catch prey.

Appendix H. Summary of historical documentation of pinniped presence in the Columbia River.

Historically, harbor seals were present in the Columbia River as far east as Celilo Falls. Lewis and Clark reported in their journals (Thwaites, 1969) seeing "Great numbers of sea otters in the river below the falls" (Celilo Falls). Additional reports of "sea otters", later correctly identified to have been harbor seals, were observed around the Cascade Rapids, Beacon Rock, and off the mouth of the Washougal River in the fall of 1805. In fact, the Washougal River was once called Seal River (Thwaites, 1969), which implies the presence of seals in the area. Also, Phoca rock, named for harbor seals, is situated between Multnomah Falls and Rooster Rock. According to the 1888 Report to the Oregon State Board of Commissioners (1889) "Hundreds of seals can be seen in the month of July at The Dalles, 200 miles distant from the mouth of the river…". Once Bonneville Dam was built, pinnipeds were blocked from swimming up to Celilo Falls to feed on the salmon concentrated there. The 1959 Corps of Engineers (COE) Annual Fish Passage Report (AFPR) stated that seals and sea lions were observed more frequently in previous years, some being caught in the McCord and Corbett Point fishwheels and mentions a large bull sea lion about five miles below Bonneville Dam seen in 1959. Doug Arndt, Corps of Engineers Fish Biologist (retired), reported seeing California sea lions hauled out at Bonneville Dam's Bradford Island (lower end of Bonneville Dam tailrace) in the early 1970's (pers. comm.). Lyman et al. (2002) conducted a thorough review of reports documenting archeological phocid remains at several sites in the Lower Columbia River up to Celilo Falls, but not above it. Steller sea lions (*Eumetopias jubatus*) were taken by hunters 70 km upstream of the mouth in the early 1800's. However, California sea lions specifically were not documented.

California sea lions typically breed in southern California in June to August. The males then migrate up the coast and begin arriving around Astoria in late August and September. However, they do not seem to migrate very far up the Columbia River during the fall Chinook run, as there have are no recent sightings of pinnipeds at Bonneville during this time. Much of their winter food is smelt (pers. comm., Matt Tennis). In late February and March the male sea lions begin migrating up the Columbia River, and this is when they first appear at Bonneville Dam. By late May to June the males begin their migration to the southern California breeding grounds. Virtually all males make the trip, although only the large breeding age males will claim a territory for mating.

Appendix I. Summary of pinniped deterrent methods and results from the Ballard Lock study.

The NMFS and WDFW (1995) and Gearin et al. (1986) reports give a good account of the predation control efforts used at the Ballard Locks area. Firecrackers were used intermittently to chase sea lions away from fishways. An acoustic harassment tool was then used to initial success, but after a short time, the sea lions became accustomed to the noise and were not deterred. Underwater firecrackers were used from shore and boat to remove sea lions from the lock area with some success initially, but in subsequent years they did not prove successful. Taste aversion methods with lithium chloride were unsuccessful. Boat chasing, hazing, and rubber bullets were also used with no success. A physical barrier was installed but the sea lions foraged at the face of the barrier at an increased rate and it was felt this impeded fish passage and the predation rate actually increased. A radio-controlled boat was ineffective at hazing the pinnipeds. Later, a capture and release program was used, initially moving the sea lions caught from Shilshole Bay to Klipsan Beach on the Coast. Of the 37 transported animals, 29 returned to the Puget Sound, ranging from 4 to 45 days and averaging 15 days. Capture and release to southern California breeding grounds was tried next with 6 sea lions. Three returned in 30 to 45 days. A fourth returned to the Columbia River in about 45 days. Rubber tipped arrows were tried and found to be ineffective. An acoustic barrier did appear to at least reduce predation in one year as no predation was seen, but the wild steelhead run was only 76 that year. Predator models, giving the sea lions alternative food, shock collars, hormonal injections, and more were discussed. Only lethal take or capture and removal to zoos appeared to be the successful solutions. However, Ballard Locks did not have the numbers of sea lions we are seeing at Bonneville Dam, reporting 40-60 in Shilshole Bay area and about 26 near the Locks. Twelve of those were seen to prey on steelhead, although most steelhead were taken by three to six individuals returning each year between January and May.

Appendix J. Expanded estimates for lamprey and shad caught at Bonneville Dam for each year and the percent of observed catch each species made up of the total.

Year	Total Hours Observed	Total Lamprey Observed Caught	Expanded Estimate of Lamprey Caught	Percentage of Catch That are Lamprey
2002	734	26	45	4.6%
2003	1440	205	275	10.0%
2004	553	120	600	13.1%

Year	Total Hours Observed	Total Shad Observed Caught	Expanded Estimate of Shad Caught	Percentage of Catch That are Shad
2002	734	0	0	0.0%
2003	1440	63	90	3.3%
2004	553	20	112	2.4%