2009 FIELD REPORT:

EVALUATION OF PINNIPED PREDATION ON ADULT SALMONIDS AND OTHER FISH IN THE BONNEVILLE DAM TAILRACE

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INTRODUCTION

Since 2002, we have used surface observations to evaluate the seasonal presence, abundance, and predation activities of pinnipeds, including California sea lions (*Zalophus californianus*), Steller sea lions (*Eumetopias jubatus*), and Pacific harbor seals (*Phoca vitulina richardsi*) in the Bonneville Dam tailrace (Stansell, 2004; Tackley, et al., 2008a; Tackley et al., 2008b). This monitoring program is part of an ongoing effort to understand and appropriately manage pinniped predation on threatened and endangered and non-listed salmonids, including Columbia River spring Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*) in the tailrace of the dam. The U.S. Army Corps of Engineers (USACE) and partnering agencies have utilized a variety of deterrents and barriers to prevent predation in or around fishways and to deter predation on salmonids and other fish in the tailrace. This report is intended as a summary of monitoring and deterrence efforts implemented by, or coordinated with, the USACE. Agency partners included the Oregon Department of Fish and Wildlife (ODFW), the Washington Department of Fish and Wildlife (WDFW), the Columbia River Inter-Tribal Fish Commission (CRITFC), the National Marine Fisheries Service (NMFS), the U.S. Department of Agriculture (USDA) Wildlife Services, and Portland State University (PSU).

Objectives in 2009 were similar to those in previous years with one addition (Objective 4):

1. Estimate the number of adult salmonids and other fish consumed by pinnipeds in the Bonneville Dam tailrace and estimate the proportion of the adult salmonid run impacted.
2. Determine the seasonal timing and abundance of pinnipeds present at the Bonneville Dam tailrace, documenting individual California sea lion presence and predation activity when possible.
3. Evaluate the effectiveness of pinniped deterrents and barriers used at Bonneville Dam.
4. Evaluate the impact and effectiveness of the removal program of specific California sea lions by the states on the numbers of pinnipeds present and predation rates at Bonneville Dam.

The Pinniped/Fishery Interaction Task Force, established to advise and give guidance to NMFS for determining a course of action to reduce pinniped predation on endangered salmonids at Bonneville Dam, requires a check-in after three years to determine if the actions (particularly removal of select California sea lions) are having the desired affect. 2009 is only the second year where removals have occurred, however we have begun to address this objective by summarizing relevant data from our monitoring efforts.

METHODS

SURFACE OBSERVATIONS

Pinnipeds, including California and Steller sea lions, typically bring large prey items, such as salmon and sturgeon (*Acipenser transmontanus*), to the surface to ease handling and dismemberment (London et al., 2002). In nearshore environments in which the target prey species are large-bodied, terrestrial observation can be used effectively to evaluate pinniped diet (Brown and Mate, 1983; Roffe and Mate, 1984). Previous scatological studies confirmed that California sea lions at Bonneville Dam are primarily targeting adult salmonids (Wright et al., 2007) and that Steller sea lion scat collected at Bonneville Dam and Phoca Rock largely contained remains of white sturgeon (Susan Riemer, personal comm..). While surface observations are a useful tool for assessing sea lion diet at Bonneville Dam, all consumption estimates and associated impacts should be considered minimum estimates.

Observers stationed at each of the three major tailrace areas of the dam (Powerhouse One [PH1], Powerhouse Two [PH2], and the spillway) used binoculars to record pinniped presence, record and identify fish catches, and identify individual California and Steller sea lions when possible (see Appendix A for map). Other locations were observed briefly when time and resources allowed. In 2009, as in 2008, observers were instructed to assign a confidence rating of 1 (least confident) to 5 (most confident) to each identified fish catch. The category of "unidentified salmonid" was eliminated from observation forms, and observers were instructed to identify all salmonid catches as either Chinook or steelhead. Individual pinnipeds were identified by cataloging unique physical characteristics and (for previously trapped and tagged animals) unique brand numbers. Individual identification was used to generate abundance estimates and to track individual predation and use patterns, both within and among years. Regular observations began roughly the hour of sunrise and ended the hour of sunset with one hour breaks in the morning and afternoon (with the break hour changing each day). Observations were occasionally conducted at night or at other locations, as time allowed, but were not factored into the equation for determining expanded estimates. A night vision monocular, thermal imaging scopes, and spotlights were used to assist in sea lion detection, counting (at haul out locations), and predation events. Methods used in surface observations are described in detail in Tackley et al. (2008).

In 2009, regular observations began on January 14, Mondays through Fridays. Weekends were not covered this year but data were interpolated for days not observed. Regular observations ceased on May 29 but limited observations were continued into June. This study period encompassed the fish passage season from January 1 to May 31, with special attention paid to the spring Chinook salmon passage season at Bonneville Dam. Few pinniped sightings occurred outside this timeframe, although three California sea lions were observed between September and December 2008 and one California sea lion has been in the Bonneville Dam forebay through at least August 11, 2009. Steller sea lions were known to be catching and consuming white sturgeon in the Bonneville Dam tailrace and farther downstream as early as October, 2008.

PREDATION ESTIMATES

Expanded Consumption Estimates

Surface observations were used to estimate total consumption of Chinook salmon, steelhead, Pacific lamprey (*Lampetra tridentata*) and white sturgeon. Since observers were not present at all times we used interpolation and expansion at each of the tailrace areas (PH1, PH2, and spillway) to estimate adult salmonid, sturgeon, and lamprey consumption (Appendix B, Equations 1-3). Estimates for all three tailrace sub-areas were combined to calculate total daily estimated consumption for the Bonneville Dam tailrace. For days on which no observations were made, we used linear interpolation to fill in the gaps. All daily estimated consumption totals were added to get the total *expanded consumption estimate* for the year. The *minimum estimated impact* on salmonids passing during the observation period (expressed as percent of run) was calculated by dividing the expanded salmonid consumption estimate by the expanded salmonid consumption estimate plus the total salmonid passage count from Bonneville Dam for the January 1 through May 31 time period:

$$I_m = \frac{C_e}{(C_e + P)}$$

where

C_e is the expanded adult salmonid consumption estimate,

P is the salmonid passage count at Bonneville from January 1 through May 31, and

I_m is the minimum estimated impact on adult salmonids passing Bonneville from January 1 through May 31.

Expanded Chinook Consumption Estimates

We estimated Chinook salmon consumption and the minimum estimated impact on the Columbia River spring Chinook salmon run at Bonneville Dam from 2002 to 2009. For 2002 through 2007 data, we multiplied daily expanded salmonid consumption estimates by the percentage of identified salmonid catches recorded as Chinooks to estimate expanded Chinook consumption. Daily estimates were combined to calculate the total expanded Chinook consumption estimate for each year. In 2008 and 2009, observers were instructed to identify all salmonid catches as either Chinook or steelhead and assign a confidence rating to their identification. After reviewing the confidence rating distribution for 2008 and 2009, we determined that for these simple estimates, it was acceptable to assume that all catches identified as Chinook were indeed Chinook, regardless of confidence ratings. Therefore, for 2008 and 2009 data, we simply used the standard expanded estimate equation (Appendix B, Equation 3) to generate the expanded Chinook consumption estimate. For all years, the estimated impact on Chinook passing during the observation period (expressed as percent of run from January 1 through June 15) was calculated similar to overall salmonid impact estimates.

Adjusted Consumption Estimates

For a variety of reasons, observers were sometimes unable to identify the fish caught during a predation event. To provide more comprehensive adult salmonid and sturgeon consumption estimates, we used daily observed catch distributions, unique to each predator, to proportionally divide unidentified (or "unknown") catch (Appendix B, Equations 1,2). The daily observed catch distributions included adult salmonids, sturgeon, American shad (*Alosa sapidissima*), northern pikeminnow (*Ptychocheilus oregonensis*), and bass (Centrarchidae). Lamprey and smolt (juvenile salmonids) were excluded from this proportional allocation, as we determined that their distinctive sizes and shapes made them extremely unlikely to be recorded as unidentified fish. The proportionally split consumption totals for California sea lions and Steller sea lions were added to the expanded consumption estimates to calculate the adjusted consumption estimate (Appendix B, Equation 5).

DETERRENTS AND MANAGEMENT ACTIVITIES

We used and evaluated a variety of sea lion deterrents, from physical barriers and Acoustic Deterrent Devices (ADDs) to non-lethal harassment (hazing) techniques in 2009, as well as the removal program (2008, 2009). Sea lion exclusion devices (SLEDs) are large, barred, grate-like physical barriers that were installed at Bonneville Dam's twelve primary fishway entrances to prevent sea lions from entering the fishways. The SLEDs feature 15.38-in (39.05 cm) gaps that are designed to allow fish passage. In 2009, SLEDs were installed by January 30 and removed in early June. Floating orifice gates (FOGs) were equipped with bars with similar gap sizes as the SLEDs to prevent sea lions from entering the fishway collection channel running below the tailrace deck of PH2. These FOG barriers were installed the last week in January.

Airmar dB Plus II* acoustic deterrent devices (ADDs), which emit a 205 decibel sound in the 15 kHz range, were installed at fishway entrances by January 28. In late April and early May, an acoustic camera was installed at the north upstream entrance at PH2 and a block test for the impact of the acoustics on fish passage and effectiveness for deterring sea lions was conducted, so there were a few hours when no acoustic device was operating at that entrance.

Hazing involved a combination of acoustic, visual, and tactile non-lethal deterrents, including boat chasing, above-water pyrotechnics (cracker shells, screamer shells or rockets), rubber bullets, rubber buckshot, and beanbags. Boat-based crews also used underwater percussive devices known as seal bombs. Dam-based and boat-based crews coordinated with USACE personnel, including our observers, to ensure safety and to increase the effectiveness of hazing efforts. Dam-based hazing by USDA Wildlife Services agents began on March 2 and was conducted seven days per week through the end of May.

Boat-based hazing was conducted by personnel from ODFW, WDFW, and CRITFC from the first week in January through May 15. Boats operated from the Bonneville Dam tailrace (river mile 146) downstream to Navigation Marker 85 (river mile 139). Boats could not operate within 30 m of dam structures or within 50 m of fishway entrances. The use of seal bombs was

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prohibited within 100 m of fishways, collection channels, or fish outfalls for the PH2 corner collector and smolt monitoring facility, and ceased after adult salmonid passage exceeded 1,000 fish per day.

Personnel from ODFW and WDFW operated two to three floating sea lion traps along the PH2 corner collector from February 2 through May 15 and one trap briefly at the old navigation lock entrance. In accordance with the Marine Mammal Protecion Act (MMPA) Section 120 authority, animals captured after March 1 were either selected for transfer to holding facilities or euthanized. California sea lions that meet four conditions established by the Pinniped/Fisheries Interaction Task force are placed on the list for removal. The conditions are: 1) the California sea lion can be individually identified; 2) it has been observed in the Bonneville Dam tailrace on at least five days; 3) it has been observed to take at least one salmonid; and 4) it was present under active hazing conditions. Captured California sea lions that were unbranded and not on the list for removal were branded, fixed with an acoustic tag, and released. Any Steller sea lions captured were released on-site.

IMPACT OF REMOVAL PROGRAM

We evaluated the impact of selected California sea lion removal in three ways:

1) Compared the annual salmonid consumption estimates and minimum estimated impact on salmonids of pre- and post-removal years (excluding Steller sea lion contributions);
2) Compared estimated total California sea lion abundance of pre- and post-removal years;
3) Compared the predation rates, daily presence, and other metrics of the removed animals with the "Bonneville" California sea lion population at large to assess the relative contribution of removed animals to salmonid consumption estimates.

Brown et al. (2009 Field Report, in prep.) used both a bioenergetics and a bootstrap method to estimate potential salmonids 'saved' as a result of the removal of selected California sea lions in 2008 and 2009. Both methods require many assumptions. The case for more or less potential predation primarily depends upon the assumptions one is willing to make. We continue to work with the States to develop the methodology and assumptions for their estimates.

DIDSON TEST DEPLOYMENTS

To determine if the acoustic deterrent devices (ADDs) installed at each of the major fishway entrances affected the behavior of migrating salmon and other fish in the vicinity of the entrances, a Didson* (**D**ual Frequency **Id**entification **So**nar) camera underwater acoustic camera was deployed at the PH2 tailrace, near the North Upstream fishway Entrance (NUE). The ADDs have been deployed for the last several years with the intent of keeping sea lions away from the fishway entrances. We conducted a test using a Didson underwater acoustic camera to assess possible adverse effects of ADDs on fish behavior. See Appendix C for more on the Didson and methods used to test ADDs.

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RESULTS AND DISCUSSION

PREDATION ACTIVITY

In 2009 (January 1 through May 31), observers completed 3,455 hours of observations. During this period, observers saw pinnipeds catch and consume 4,434 fish of several species. Adult salmonids were the primary prey item, comprising 67.2% (n=2,980) of observed catches. White sturgeon and Pacific lamprey were the second and third most commonly identified prey types, comprising 17.1% (n=758) and 1.4% (n=64) of total observed catch respectively. Observers were unable to identify 13.8% (n=610) of the fish caught and consumed by pinnipeds during this period. As in previous years, all consumption estimates should be treated as minimum estimates.

Three California sea lions were observed feeding on salmonids at Bonneville Dam between September and December 2008. Since observations were opportunistic and intermittent, expansions were not made for these catches. An individual branded as C265 was seen, often hauled out, on 41 of 46 observation days between September 18 and December 31. Observers noted 19 fall Chinook, 6 Coho (*Oncorhynchus kisutch*), 2 steelhead, and 5 unidentified fish catches by C265 during this period. C805 was observed on 9 of 46 days and was seen to catch and consume 4 fall Chinook and 1 unidentified fish. The third sea lion, C_57 (likely C657), was seen on one day and was observed consuming 2 fall Chinook. This was the first time California sea lions were reported at Bonneville Dam in the fall; if this behavior escalates and fall and winter salmonid runs are targeted by large numbers of sea lions, this could become a serious concern for the Corps and partnering agencies.

Predation on Adult Salmonids

In 2009, the expanded adult salmonid consumption estimate for the Bonneville Dam tailrace observation area was 4,489 or 2.4% of the adult salmonid run at Bonneville Dam from January 1 through May 31. Accounting for unidentified fish, the adjusted estimated consumption was 4,960 (or 2.7% of the run) (Table 1). California sea lions were the primary salmonid predator, accounting for 89.9% (n=2,680) of the 2,980 observed catches (Table 2). This percentage is lower than was seen in previous years, as observed salmonid catch by Steller sea lions increased from 0.3% (n=12) in 2007 and 3.8% (n=162) in 2008, to 10.1% (n=300) in 2009. This was also the fifth consecutive year showing atypical late arrival of the spring Chinook run (Figure 1). As in previous years, Chinook salmon that arrived at the early stage of the run were heavily targeted by sea lions (Figure 2).

Chinook salmon were the most commonly identified prey species, comprising 89.0% (n=2,652) of observed adult salmonid catch in 2009. The expanded Chinook consumption estimate for the Bonneville Dam tailrace observation area was 3,997 or 1.7% of the Chinook run (including jacks) at Bonneville Dam from January 1 through June 15 (Table 3). Note that this time period differs from the passage season used for total salmonid estimates. This period includes the defined Columbia River spring Chinook passage season at Bonneville Dam, which extends beyond the period during which sea lions are normally present. Steelhead comprised about 11.0% (n=328) of observed adult salmonid catch during the same period. Steelhead, which are present in the Bonneville Dam tailrace throughout the winter and spring months, comprised the majority of salmonid catches prior to the onset of the spring Chinook salmon run (Figure 2). This year and last, Steller sea lions were often observed swallowing steelhead whole, suggesting that they could consume steelhead and jack Chinook entirely below the surface. All consumption estimates provided are minimum estimates, but Steller sea lion predation may be significantly underestimated by surface observation techniques.

Table 1. Consumption of salmonids by California sea lions, Steller sea lions, and harbor seals at Bonneville Dam, from surface observations conducted between 2002 and 2009. Total salmonid passage counts include all adult salmonids that passed Bonneville Dam from January 1 through May 31.

Year	Bonneville Dam salmonid passage (Jan. 1-May 31)	Expanded salmonid consumption estimate		Adjusted salmonid consumption estimate	
		Estimated consumption	% of run (Jan. 1 to May 31)	Estimated consumption	% of run (Jan. 1 to May 31)
2002	284,733	1,010	0.4 %	-	-
2003	217,185	2,329	1.1 %	-	-
2004	186,804	3,533	1.9 %	-	-
2005	82,006	2,920	3.4 %	-	-
2006	105,063	3,023	2.8 %	3,401	3.1 %
2007	88,474	3,859	4.2 %	4,355	4.7 %
2008	147,543	4,466	2.9 %	4,927	3.2 %
2009	186,060	4,489	2.4 %	4,960	2.7 %

Table 2. California sea lion and Steller sea lion predation on adult salmonids at Bonneville Dam, from January 1 through May 31, 2009. Adjusted consumption estimates include expanded consumption estimates and likely additional catch.

Predator	Observed Salmonid Catch	Expanded Salmonid Consumption estimate		Adjusted Salmonid Consumption estimate	
	Observed Catch	Estimated consumption	*% of Run (1/1 to 5/31)*	Estimated consumptio n	*% of Run (1/1 to 5/31)*
California Sea Lions	2,680	4,014	*2.1%*	4,353	*2.4%*
Steller Sea Lions	300	475	*0.3%*	607	*0.3%*

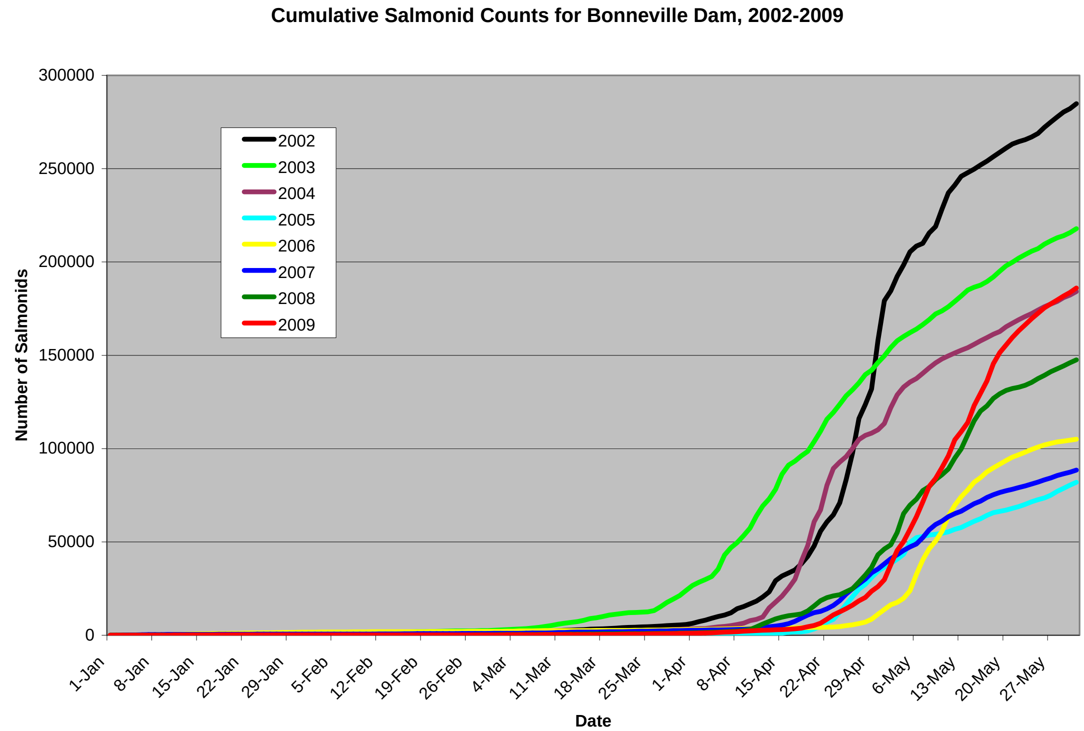

Figure 1. Cumulative daily counts of adult (including jacks) Chinook salmon and steelhead passing Bonneville Dam from 1 January through 31 May, 2002 to 2009.

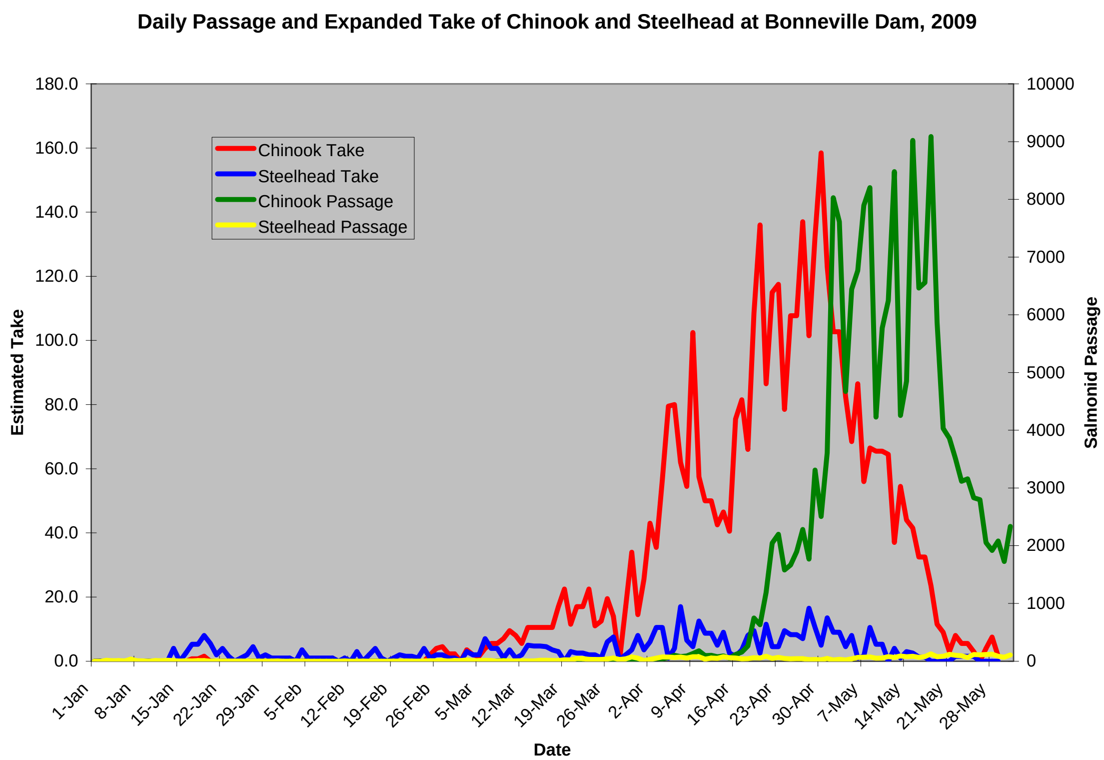

Figure 2. Daily salmonid passage and expanded consumption estimates by pinnipeds at Bonneville Dam, 2009.

Table 3. Consumption of Chinook salmon by pinnipeds at Bonneville Dam between 2002 and 2009. Regular observations were not made at the spillway in 2004.

Year	Chinook salmon passage (Jan. 1 – June 15)	Expanded Chinook consumption estimate	Percent of Chinook run (Jan. 1 – June 15)
2002	316,468*	880‡	0.3 %
2003	247,059	2,313	0.9 %
2004	210,569	3,307	1.5 %
2005	102,741	2,742†	2.6 %
2006	130,014	2,580	1.9 %
2007	101,068	3,403	3.3 %
2008	174,247	4,115	2.3 %
2009	229,271	3,997	1.7 %

* Fish counts did not start until March 15 in 2002. Chinook passage from January 1 through March 15 was minimal in all other years.
‡ From March 15 through April 25, used fish passage count split between Chinook salmon and steelhead to estimate Chinook proportion of unidentified salmonid catch. Thereafter, used observed catch distribution to divide unidentified salmonid consumption.
† In 2005, regular observations did not start until March 18.

Predation on White Sturgeon

In 2009, the expanded white sturgeon consumption estimate for our study area was 1,241, continuing the upward trend in predation on sturgeon in the Bonneville Dam tailrace (Table 4). When unidentified catch was divided proportionally according to daily catch distributions and added to the expanded sturgeon consumption estimate, the adjusted consumption estimate was 1,710. White sturgeon were the most commonly observed prey for Steller sea lions, which made 95.1% (n=721) of the 758 observed sturgeon catches in 2009. Steller sea lions were known to be catching and consuming sturgeon in the vicinity of Bonneville Dam as early as October 2008, so observed and expanded catches represent minimum catch and do not include this predation outside our normal observation period. California sea lions took more sturgeon this year (37 observed) than last year (9). Most of these occurred well before the spring Chinook run when few salmonids were present, making the abundantly available sturgeon an easy, if not the preferred, prey target during this time. Predation on sturgeon, particularly by Steller sea lions, dropped off dramatically after the first week of April when spring Chinook began to show up and became the preferred prey (Figure 3).

When possible, observers estimated the total lengths of sturgeon caught by pinnipeds. The estimated total lengths of sturgeon caught in 2009 ranged from less than 2 ft (0.6 m) to over 7 ft (2.7 m), but 79.4% of sturgeon lengths (n=541) were 4 ft (1.2 m) or shorter (Figure 4).

Table 4. Consumption of white sturgeon and Pacific lamprey by pinnipeds at Bonneville Dam from 1 January through 31 May, 2002 to 2009.

Year	Total Hours Observed	Observed Sturgeon Catch	Expanded Sturgeon Consumption estimate	Adjusted Sturgeon Consumption estimate
2005	1,108	1	-	-
2006	3,647	265	315	413
2007	4,433	360	467	664
2008	5,131	606	792	1,139
2009	3,455	758	1,241	1,710

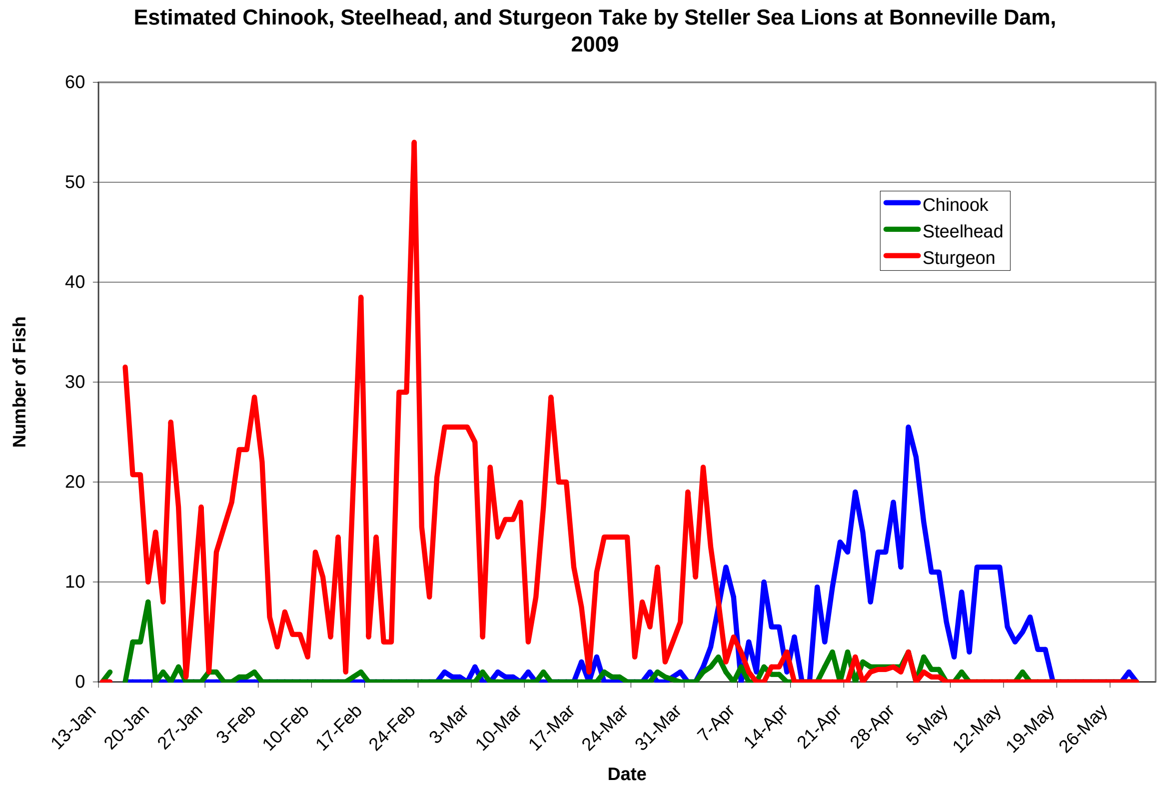

Figure 3. Daily expanded consumption of Chinook salmon, steelhead, and white sturgeon by Steller sea lions at Bonneville Dam from 1 January through 31 May 2009.

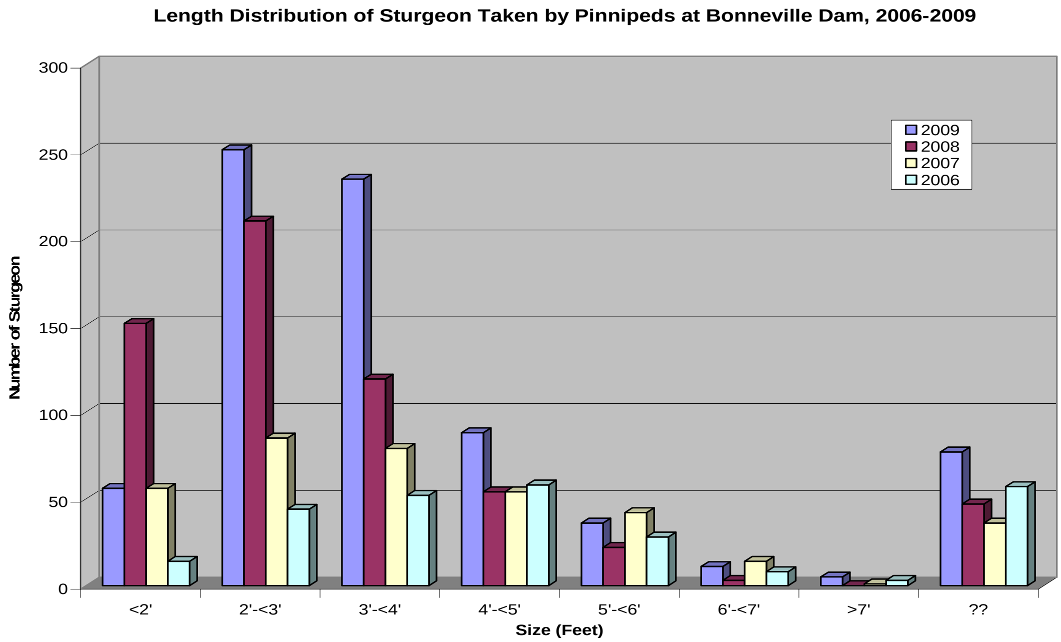

Figure 4. Estimated total lengths of sturgeon consumed by Steller sea lions and California sea lions at Bonneville Dam, from 1 January through 31 May, 2006 to 2009.

Predation on Pacific Lamprey

In 2009, the expanded Pacific lamprey consumption estimate was 102, fewer than the estimated 143 and 145 caught in 2007 and 2008, respectively (Table 5). Lamprey were once again the second most commonly observed prey item for California sea lions, which made 58 of the 64 observed lamprey catches in the Bonneville Dam observation area. However, lamprey catch comprised the lowest proportion of total observed catch (1.4%) since 2002. Most predation occurred in April and May, and catch rates were highest in the early morning hours. Due to the small body size and presumed vulnerability of lamprey to predation, our surface observation approach may significantly underestimate actual predation impacts on lamprey.

Table5. Consumption of Pacific lamprey by pinnipeds at Bonneville Dam from 1 January through 31 May, 2002 to 2009.

Year	Total Hours Observed	Observed Pacific Lamprey Catch	Expanded Pacific Lamprey Consumption estimate	Percent of Total Observed Fish Catch
2002	662	34	47	5.6%
2003	1,356	283	317	11.3%
2004	553	120	816	12.8%
2005	1,108	613	810	25.1%
2006	3,647	374	424	9.8%
2007	4,433	119	143	2.6%
2008	5,131	111	145	2.0%
2009	3,455	64	102	1.4%

Night Observations

We conducted a total of 30 hours of additional observations on March 27, April 3, and April 11 between 2000h and 0500h. PH1 and PH2 tailrace locations were observed to determine whether predation was occurring at night. Given the obvious difficulties of detection (we tried night vision binoculars, monocular, scopes, thermal imaging, and high powered spot lights, all with less success than ambient light, binoculars, and listening), we were able to discern an average of 3.2 pinnipeds present and foraging per hour. Most were California sea lions, although a few Steller sea lions were also spotted, and one harbor seal was observed. At least 8 salmonid, 2 sturgeon, and 7 unidentified fish were caught during those hours. A rigorous expansion based on these observations was not attempted as it appeared take occurred primarily in the early night hours compared to later hours, which would involve dissimilar hourly expansion estimates. However, a cursory analysis estimated an average of 4 fish/night for two months during the peak period (mid-March to mid-May). This would indicate that up to 240 additional fish may be taken over the season, but this would make up only about 3.5% (240/6722) of current adjusted catch. Spot checks were made at the traps and haul out sites at the top of each hour, where the numbers grew steadily up to around midnight (Appendix E). Few hours were sampled, but these observations are supported by the large numbers of sea lions seen hauled-out in the early morning hours, with more animals becoming active and hunting as the morning progressed. Therefore, while hazing activities or social factors may have encouraged additional foraging toward the crepuscular hours, we saw little evidence of large-scale nocturnal predation.

Additional Observations

This year, students from PSU observed at Willamette Falls Locks so we do not have any data on catches downstream of Bonneville Dam as we did in 2008. PSU reported two branded California sea lions that we had last observed at Bonneville Dam in 2005 and 2006. We also observed one California sea lion in the forebay take a salmonid near the Bradford Island fishway exit on May 27. This animal, C697, had been trapped at the corner collector on April 1 and again on April 8 and was fitted with an acoustic tag. He had frequently been seen hauled out, but tracking data from ODFW/CRITFC (Brown et al., in prep.) showed he primarily left Bonneville in the morning and hunted around mile marker 85. On May 16, we received a report of a sea lion hitching a ride on the Kathryn B tug through the locks. C697 was subsequently observed on many days after that either in the near dam forebay near the Bradford Island fishway exit, the Bridge of the Gods, Stevenson, and even up at The Dalles Dam spillway area. As of the date of this report, the last reported sighting upstream of Bonneville was on October 19.

PINNIPED ACTIVITY

Daily pinniped abundance peaked in April (Figure 5). At 82 animals, the estimated number of individual pinnipeds observed at Bonneville Dam in 2009 was lower than estimates from all years except 2002 and 2007 (Table 6). California sea lion numbers decreased to 54 in 2009, the fewest since 2002, while Steller sea lion numbers increased. The 26 Steller sea lions observed on one day was more than we have seen previously, however, the decrease in California sea lion numbers is likely due to the removal of 11 individuals in 2008. As in previous years, hazing activity typically resulted in behavioral changes in the sea lions (more time below the water surface, less time with backs and unique markings exposed, etc) that made identification of individuals challenging. These estimates should be considered minimum estimates.

Table 5. Minimum estimated total number of pinnipeds observed at Bonneville Dam from 2002 to 2009.

	California sea lions	Steller sea lions	Harbor seals	*Total pinnipeds*
2002	30	0	1	31
2003	104	3	2	109
2004	99	2	2	103
2005*	81	4	1	86
2006	72	10	3	85
2007	71	9	2	82
2008	82	17	2	101
2009	54	26	2	82

* Regular observations did not begin until March 18 in 2005.

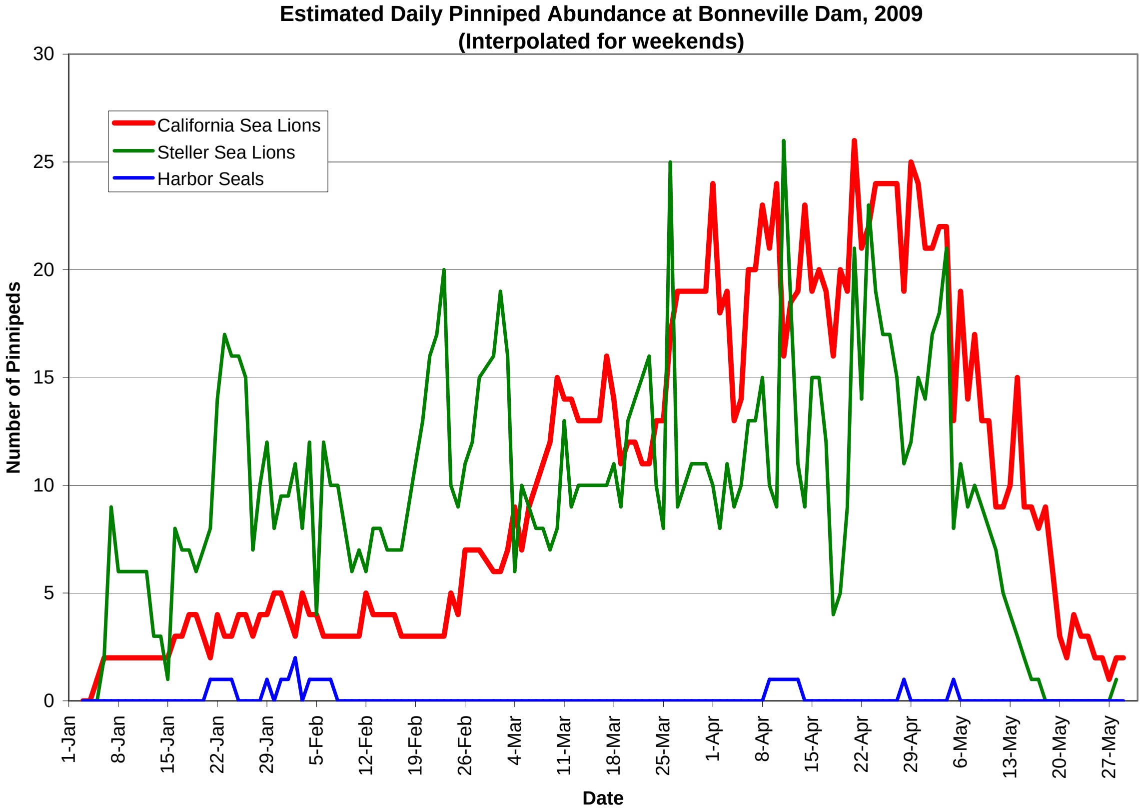

Figure 5. Daily abundance estimates for California sea lions, Steller sea lions, and harbor seals at Bonneville Dam from 1 January through 31 May 2009.

The highest number of pinnipeds counted on any one day was 47 (April 21), which was fewer than the previous two years (Figure 6). This is the first reduction in peak numbers since we began monitoring. Mean daily number of pinnipeds present was 19.5, similar to last year and higher than other previous years. The California sea lion component shows far fewer animals present daily on average than we have seen since 2004 and the maximum seen on any one day was fewer than any year since 2002 (Figure 7). However, the Steller sea lions were present in greater numbers in 2009 than any previous year and averaged 9.4 per day (Figure 8).

The most number of days an individual California sea lion was observed at Bonneville was 67 days in 2009, slightly fewer than the previous three years (Figure 9). However, this would have likely been higher had 14 individuals not been removed from the project by the states, in effect, shortening their number of days present.

California sea lions not previously identified continue to show up each year. Of the 53 highly identifiable animals observed in 2009, 16 (30.2%) were "new" additions to that category (5 branded and 2 more given brands while at Bonneville). The percentage of "new" California sea lions each year was 70.7%, 48.8%, 22.9%, 37.7%, 34.4%, and 33.8% for 2003 through 2008, respectively, so we did not see a great increase in new individuals in 2009 replacing the animals removed. In fact, 16 newly identified California sea lions was the fewest, matching 2005. Three sea lions have been observed all eight observation years.

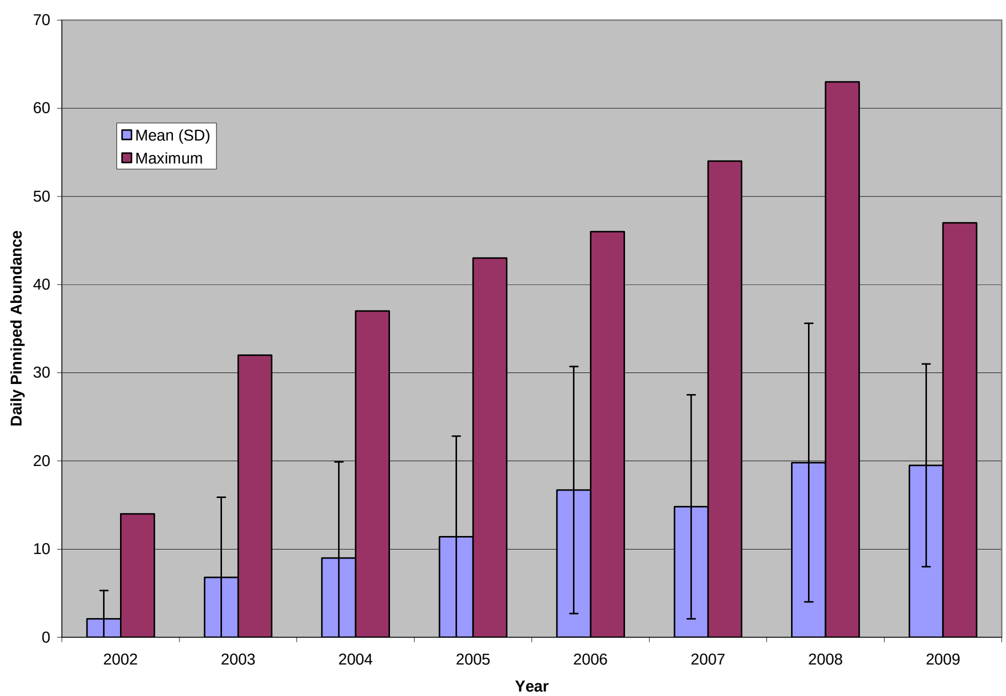

Figure 6. Mean (and standard deviation) and maximum daily estimated number of pinnipeds present at Bonneville Dam between 1 January and 31 May, 2002 to 2009.

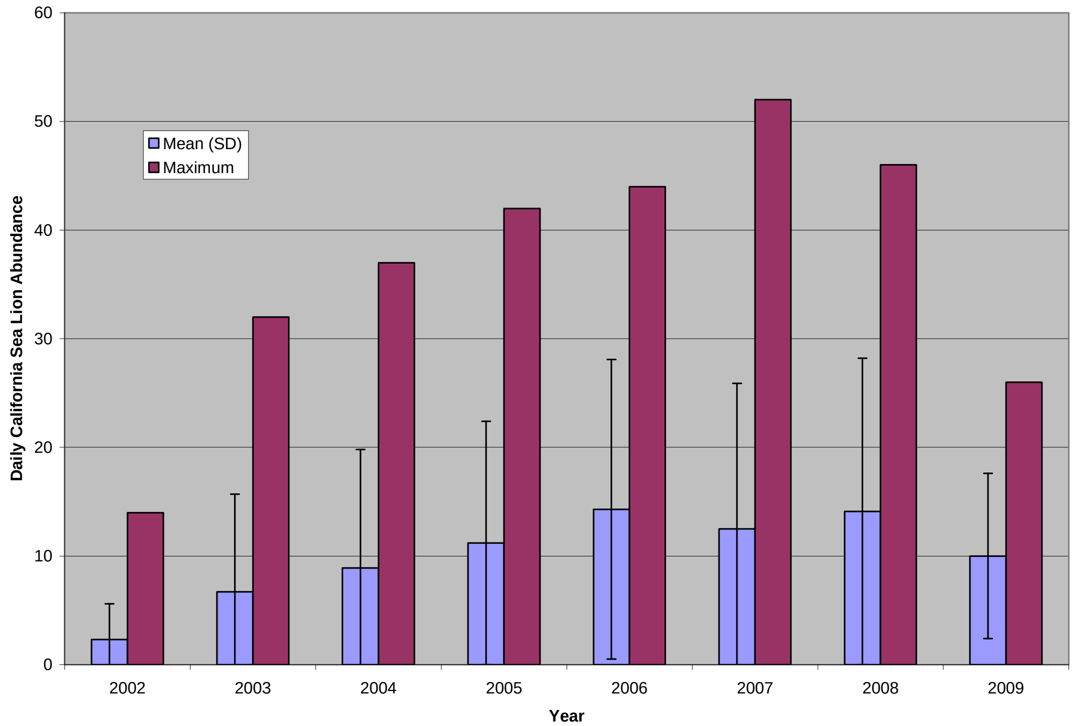

Figure 7. Mean (and standard deviation) and maximum daily estimated number of California sea lions present at Bonneville Dam between 1 January and 31 May, 2002 to 2009.

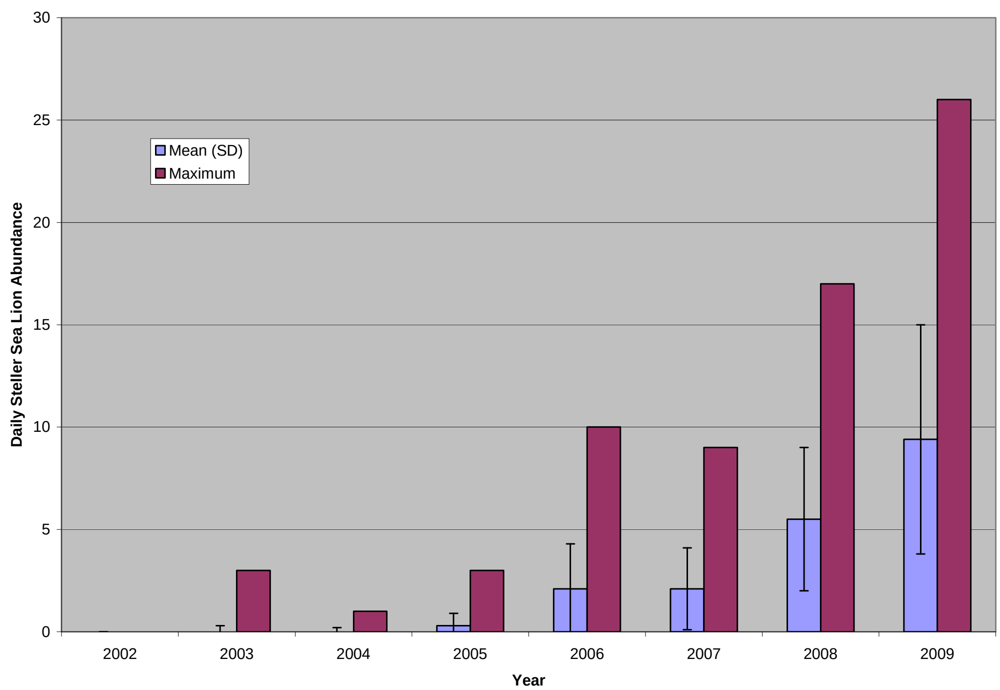

Figure 8. Mean (and standard deviation) and maximum daily estimated number of Steller Sea Lions present at Bonneville Dam between 1 January and 31 May, 2002-2009.

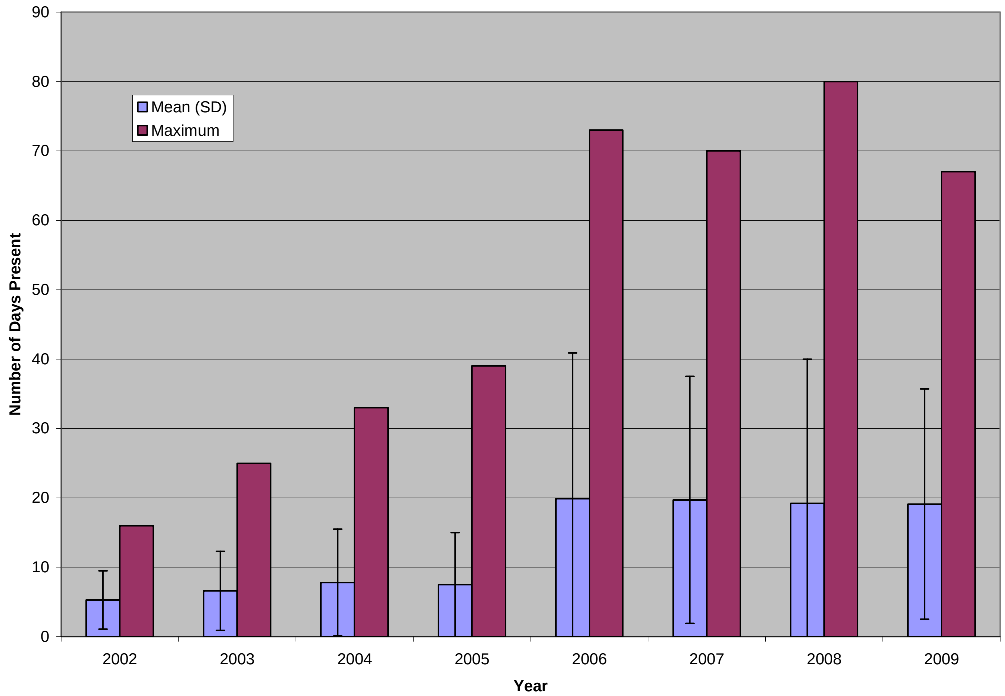

Figure 9. Mean (and standard deviation) and maximum number of days individually identified California sea lions were observed at Bonneville Dam between 1 January and 31 May, 2002-2009.

<u>DETERRENTS AND MANAGEMENT ACTIVITIES</u>

Physical Barriers

C265 was observed entering the PH2 fishway entrances on January 14. In response, the project crane crew installed the SLEDs on January 15, about 2 weeks earlier than normally required. SLEDs were installed at PH1 on January 30. On January 31 it was reported that there was a sea lion inside the fishway at PH1. C635, who had been observed present in the tailrace days earlier, had apparently entered the fishway before the SLEDs were placed and became trapped. The project crane crew was called in on the weekend to raise the SLED at the downstream-most entrance. C635 was then hazed with cracker shells to move him downstream toward the open fishway entrance and out into the tailrace. The SLED was replaced and C635 was subsequently observed swimming in the tailrace. Otherwise, there were no sea lions observed inside the fishways, nor did any observers note any sea lions attempting to get through the SLEDs or FOG barriers in 2009 despite significant predation activity near dam structures.

Acoustic Deterrent Devices and Test for Impacts to Salmonids

ADDs were again installed at all main fishway entrances. As in previous years, pinnipeds were observed swimming and eating fish within 20 ft of some of the ADDs, with no obvious deterrent effect observed. For results of the test of the ADDs impact to fish passage using the Didson, see Appendix C.

Non-Lethal Harassment

ODFW, WDFW, and CRITFC hazed from boats five days a week on most weeks between January and May, and their results will be presented in a separate report. USDA agents hazed from the dam on 90 days between March 3 and May 31. Table 7 shows the actual near dam hazing level for boat and dam based hazing (data excludes weekends and boat hazing downstream of the BRZ as our observers were not present to record this information). Of this time, active hazing (as opposed to the boat or dam hazer just being present at the site) occurred 70.1% of the time for boat hazing and 87.6% for dam hazing. These values are lower than those reported in 2008, as boat hazing crews became more actively involved in trapping activities in 2009, and later in the season the dam hazing crew combined pinniped and avian hazing activities and cut back to one 8-hr shift per day.

Table 7. Total hours of hazing activity in the Bonneville Dam tailrace observation area in 2009. Data excludes weekends as observers were not present.

Location	Number of Hours Hazers were Present at Least Once in Hour		Actual Total Time (Hours) Hazers were Present	
	Boat hazing	*Dam hazing*	*Boat hazing*	*Dam hazing*
Powerhouse 1	239	178	63.7	60.0
Powerhouse 2	191	209	41.7	62.5
Spillway	151	68	25.3	16.2
Total	*581*	*455*	*130.7*	*136.7*

As in previous years, hazing activity temporarily moved some sea lions out of tailrace areas, but the animals typically returned and resumed foraging shortly after hazers left the area. This can be shown by the slight shift in the diurnal predation activities before (2002-2005) and after (2006-2009) large scale active hazing occurred (Figure 10). A slight shift to more predation occurring in the first and last hour of light during the day can be seen, which corresponds to hazing activities start and end times. The high adult salmonid and sturgeon consumption estimates seen in 2009 suggest that, at best, hazing at the current level of intensity only slows the increase of predation.

Trapping and Removal

Personnel from ODFW and WDFW operated two to three floating sea lion traps along the PH2 corner collector from February 2 through May 15 and one trap briefly at the old navigation lock entrance. In accordance with the Marine Mammal Protection Act (MMPA) Section 120 authority, captured animals after March 1 were either selected for transfer to holding facilities or euthanized. Captured California sea lions that were unbranded were given brands, an acoustic tag, and released. Any Steller sea lions captured were released on-site.

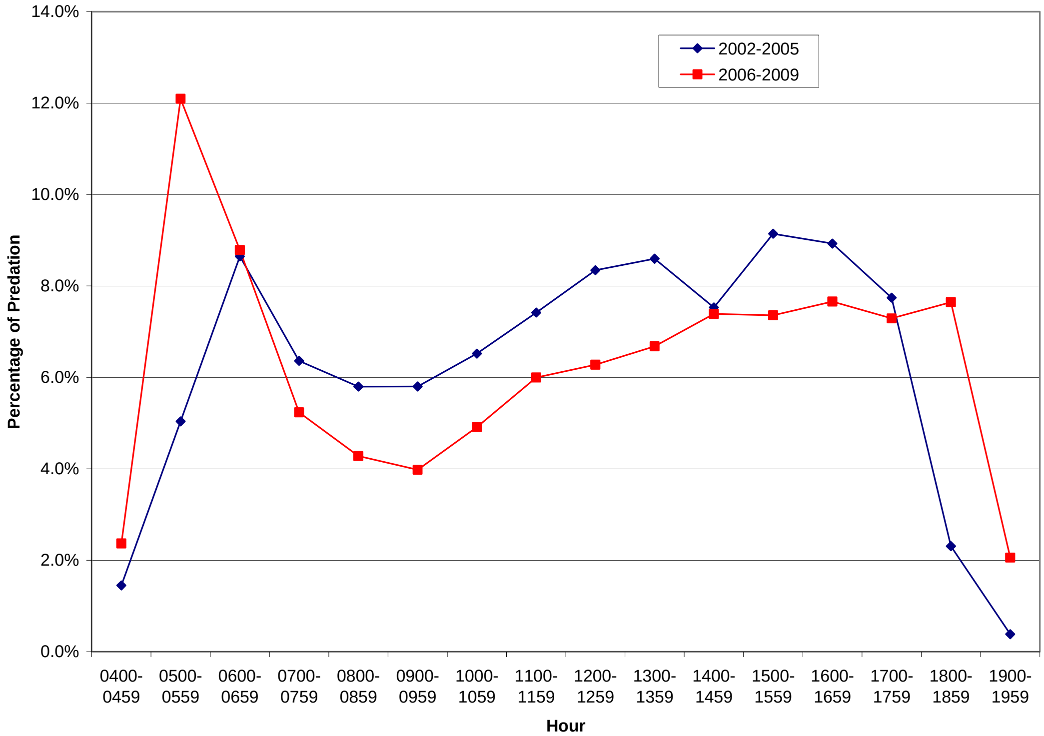

Figure 10. Diurnal distribution of predation events at Bonneville Dam before (2002 to 2005) and after (2006 to 2009) large-scale sea lion harassment efforts began.

Successful trapping events occurred on March 10, 11, 17, 18, April 1, 8, 16, and May 11, 13, and 14 (Appendix D). A total of 20 different California sea lions were captured (two were captured twice, and one Steller sea lion was captured but immediately released). Of those 20, 5 were given brands and acoustic tags, one was already branded but given an acoustic tag. Four were on the list for removal and relocated to Gladys Porter Zoo (2) and Shedd Aquarium (2). The remaining 10 were on the list for removal and were euthanized after the preliminary health screening showed them to have conditions that made them undesirable for zoos or aquariums, where they could have spread their diseases to other animals at the facilities. Acoustic tracking data will be presented by ODFW and CRITFC in a separate report (Brown et al., in prep). Of the 6 animals released, 5 were seen at Bonneville again on subsequent days and the sixth was captured and released on May 14, when most of the California sea lions begin leaving the area.

Impact of the Removal of Selected California Sea Lions

In 2008, 11 California sea lions were effectively removed from the population of “Bonneville” animals, and in 2009, 14 were removed (Appendix D). As mentioned in the Methods section, the impact the removal of these animals had on salmonid predation were summarized using three metrics: 1) Estimated total annual salmonid predation, 2) California sea lion abundance, 3) Salmonid consumption and days present for removed individuals over the years.

Estimated total annual salmonid take

The 2009 salmonid consumption estimate was higher than in any other year (Table 1), while the estimated percentage of the run consumed was the fourth lowest (2009 saw the fourth largest spring Chinook run size since 2002). The salmonid consumption estimate for California sea lions was down from 2008, while Steller sea lion take continued to increase (Table 8) The estimated number of salmonids consumed per California sea lion increased in 2009 (Table 8). A closer examination of individually identified California sea lions that were seen to take salmon over the years also shows the highest maximum number of salmonids caught for an individual sea lion this year compared to previous years (Table 9).

Table 8. Consumption of adult (including jacks) salmonids by California and Steller sea lions at Bonneville Dam from 1 January through 31 May, 2002 to 2009.

	California sea lions			Steller sea lions		
Year	Expanded salmonid consumption	Salmonid consumption per capita	% of run (1 Jan – 31 May)	Estimated salmonid consumption	Salmonid consumption per capita	% of run (1 Jan – 31 May)
2002	1,010	33.7	0.4%	0	0	0.0 %
2003	2,329	22.4	1.1%	0	0	0.0 %
2004	3,516	35.1	1.9%	13	7	0.0 %
2005	2,904	35.9	3.4%	16	4	0.0 %
2006	2,944	40.9	2.7%	76	8	0.1 %
2007	3,846	54.2	4.2%	13	1	0.0 %
2008	4,294	52.4	2.8%	176	10	0.1 %
2009	4,014	74.3	2.1%	475	18	0.3 %

Table 9. Maximum number of salmonids observed consumed by identified California sea lions (CSL) at Bonneville Dam from 1 January through 31 May, 2002 to 2009.

Year	Maximum number of salmonids caught by individual California sea lions	Percentage of salmonid catches attributed to individual California sea lions
2002	51	58.6%
2003	52	67.7%
2004	35	54.3%
2005*	11*	8.9%*
2006	79	43.0%
2007	64	28.1%
2008	107	42.6%
2009	157	62.1%

* Began observation season late and did not have opportunity to train new observers on individual California sea lion identification.

California sea lion abundance

The numbers of California sea lions identified in 2009 (54 including the 14 removed this year) was the lowest since 2002, when our study began (Table 6). This was also reflected in the mean and maximum number of California sea lions present per day (Table 10 and Figure 8). The increase in the number of Steller sea lions observed in 2009 (26) offset the reduction for California sea lion numbers seen (Table 10 and Figure 9). This, in combination with the consumption data, indicates that fewer California sea lions are present, but they caught more salmon per individual.

Table 10. Mean and maximum daily number of California and Steller sea lions observed at Bonneville Dam, from 1 January through 31 May, 2002 to 2009. Linear interpolation was used to estimate the number of animals present on days for which observations were not recorded.

Year	California sea lions		Steller sea lions	
	Mean daily count	Maximum daily count	Mean daily count	Maximum daily count
2002	2.3	14	0.0	0
2003	6.7	32	0.0	3
2004	8.9	47	0.0	1
2005	11.2	42	0.3	3
2006	14.3	44	2.1	10
2007	12.5	52	2.1	9
2008	14.1	46	5.5	17
2009	10.0	26	9.4	26

Salmonid consumption and days present for removed individuals over the years

The removal of 25 California sea lions between 2008 and 2009 failed to reduce overall salmonid consumption estimate. However, those same 25 California sea lions account for only about 7% (25 of 355) of the sea lions identified over the years, but they accounted for 22% of all the salmonid catch events attributed to specific individuals. These 25 individuals were present more days and consumed more salmonids per capita each year when compared to the rest of the California sea lions identified (Table 11). This indicates that the removal program has indeed targeted those animals most likely to stay for a long time and consume many salmonids. Consumption estimates and presence metrics for 2008 and 2009 undoubtedly would have been higher for the removed animals, had they not been removed. Any animals removed in 2010 that were observed in 2009 will alter the current figures for 2009. Of the 66 individuals remaining on the list, 25 have not been seen for two years and 11 (of 12) have not been seen for one year, leaving an estimated 30 individuals on the list that could likely be removed in 2010 and beyond (excluding new animals that would qualify for listing).

While there has yet to be a marked decline in the number of salmonids taken by California sea lions, the numbers of California sea lions are definitely lower, and the full impact of the removal of 14 animals this year should become more evident after next years monitoring program. Had the 25 animals not been removed in 2008 and 2009, the consumption estimates would likely have been much higher, perhaps by as much as 1,000 or more over the past two years (Brown et al., in prep.), and this does not even address the issue of fall salmonid predation by some California sea lions. None of the salmon 'saved' estimates take into account the potential impact of C265 and C657, had they not been removed and returned in the fall as they had in 2008 to prey on fall Chinook, Coho, and steelhead. As of this report, C805, the other documented California sea lion to have been seen at Bonneville Dam in the fall, was seen at the dam on two days in September and two days in October. The removal program appears to have targeted many of the multi-year individuals showing up at Bonneville Dam (Table 12). We would expect the results from the 2010 season to show a steep decline in California sea lion numbers, which should also result in reduced salmonid predation by California sea lions.

Table 11. Observed number of days present and salmonids taken for all removed California sea lions compared to all other individual California sea lions identified at Bonneville Dam, from 2002 to 2009.

Year	Per capita salmonid consumption		Per capita days present	
	Removed California sea lions	All other California sea lions	Removed California sea lions	All other California sea lions
2002	12.5	9.9	6.3	5.2
2003	28.5	8.4	15.5	6.3
2004	7.1	4.0	10.1	7.6
2005	2.6	1.6	10.9	7.1
2006	23.8	12.4	28.3	18.2
2007	18.6	12.4	28.5	16.6
2008	30.9	17.9	38.8	14.4
2009	9.2	36.4	15.4	21.1

Table 12. Number of years individually identified California sea lions present at Bonneville Dam between 2002 and 2009 and the number that have been removed. Individuals present for less than one year were animals identified in 2009.

Number of years present	All identified California sea lions	Removal list California sea lions	Removed California sea lions
8	3	3	3
7	4	4	1
6	3	3	0
5	16	16	5
4	17	13	2
3	31	15	5
2	45	21	5
1	218	8	3
>1	18	8	1

However, the increasing presence and salmon predation by Steller sea lions at Bonneville Dam could continue to complicate the issue, if current trends persist. For example, the increase in Steller sea lion numbers can affect our determining the impact of the California sea lion removal program. This can be seen by examining the rate of clepto-parasitism (taking prey from others) from California sea lions by Steller sea lions. Steller sea lions were observed to take 183 salmonid prey from California sea lions in 2009, a 45% increase from last year (126), requiring the "victims" to find more fish. In contrast, the California sea lions took 86 salmonid prey from each other this year, a 43% reduction over last years high of 150. It appears Steller sea lions are learning that taking salmonid prey from the smaller California sea lions is an easy way to obtain salmonids, as this now accounts for 66% of observed clepto-parasitism interactions, whereas previously, California sea lions taking from other California sea lions was predominant. As more Steller sea lions arrive and take salmon prey from fewer California sea lions, this may inflate the number of salmonids observed caught by California sea lions, but not necessarily consumed in whole.

RECOMMENDATIONS

1. In light of continuing increases in estimated adult salmonid and white sturgeon catch, the earlier and more protracted presence (if not total seasonal abundance) of California and Steller sea lions from January through May in the Bonneville Dam tailrace, and potential management actions by wildlife management agencies, we strongly suggest a continuation of this monitoring program. The full impact of removal of specific individual California sea lions can not be fully measured until the subsequent years' monitoring is completed.
2. The Corps should continue to coordinate with agency partners performing observations in the area downstream of our study area, such as PSU and CRITFC.
3. SLEDs and FOG barriers have proved effective and should continue to be used to prevent sea lions from entering the fishways of Bonneville Dam. If presence of sea lions in the fall becomes a regular occurrence, the Corps should consider installing these barriers in the fall, or leaving them in all fish passage season, if approval by the fisheries agencies is gained.
4. The Corps should consider discontinuing the use of acoustic deterrent devices (ADDs), as this device has demonstrated little or no usefulness as a sea lion deterrent at fishway entrances. Alternatively, based on recommendations from the International Marine Animal Trainers Association, ADDs could be operated on a more random basis to prevent acclimation by pinnipeds.
5. Deployments of a Didson camera near the fishway entrances with current opportunistic mounts available did not cover the primary area of potential ADD effect on fish passage. An alternative deployment configuration could more directly measure this effect, however, we feel there is already enough information to show there does not seem to be a negative impact to fish passage, and therefore do not recommend pursuing this objective further.
6. The Corps should continue to assist in the pursuit and evaluation of potential non-lethal deterrent technologies as part of a long-term strategy to reduce pinniped predation on adult salmonids, sturgeon, and lamprey in the Bonneville Dam tailrace.
7. The Corps and States should continue to work together to develop and refine the best methodology for measuring the potential salmon "saved" by the removal program, using the most reasonable assumptions and the best bioenergetics and observational data available to us.
8. Members of the International Marine Animal Trainers' Association (IMATA) came out to the dam and wrote up a list of recommendations to the States, dated September 1, 2009, which might increase the effectiveness of the deterrent/harassment program. The Corps should work with the States and IMATA to determine if any of these recommendations could be implemented, pending funding and reasonable expectations of positive results.
9. The Corps should provide funding and resources to develop means to physically deter sea lions from hauling out near the dam, particularly along the PH2 Corner Collector. This would serve both to increase the likely rate of capture on floating traps and perhaps deter animals from residing and resting so long at Bonneville Dam each spring.

ACKNOWLEDGEMENTS

We would like to thank all who continue to help us provide the most accurate information on pinniped predation at Bonneville Lock and Dam. The Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, NOAA National Marine Fisheries Service, Pacific States Marine Fisheries Commission, and the Columbia River Inter-Tribal Fish Commission all contributed personnel and equipment to conduct the boat-based hazing program, while the USDA Wildlife Services continues to conduct the dam-based hazing program. Special thanks to Robin Brown (ODFW), Steve Jeffries (WDFW), Matt Tennis (PSMFC), and Bryan Wright (ODFW) for their advice, input, and cooperation. David Clugston and Bernard Klatte (USACE) helped with study objectives, funding, and program support. Just as in 2008, the Bonneville Lock and Dam rigging crew should be commended for successfully deploying and removing SLEDs, and for assisting with sea lion trapping efforts in 2009.

We thank Nathan Zorich for taking the time and energy to help manage the often challenging Didson test deployment.

A very big thank you goes to all the observers who collected valuable data for us this year. Observers from our own staff at the Fisheries Field Unit form the core of our observation team. Interns from the Student Conservation Association (SCA) did a great job of assisting with observations and data management. Erika Dittmar, Jennifer Watson, Meng Vue, William Ward, Heather Benedict, and Thomas Glazer endured particularly harsh winter and spring weather and performed admirably.

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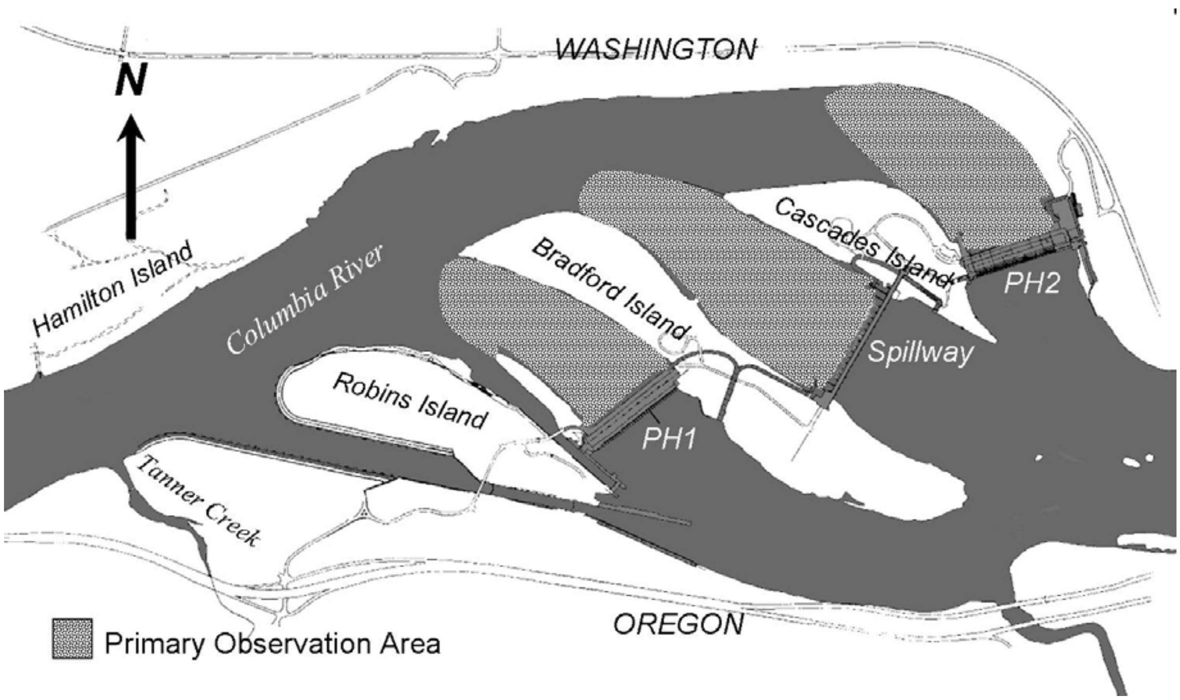
Appendix A. Map (A.1) of Bonneville Lock and Dam and vicinity, with observation areas highlighted.



A.1.

Appendix B. Equations used to calculate predation estimates.

Equation 1. Likely additional consumption by California (A_c) and Steller sea lions (A_s)

Observers were not always able to identify the species of fish being caught and consumed. Such catches were recorded as "unidentified" fish. The daily *identified* fish consumption distribution was used to calculate daily proportional allocation of *unidentified* catch. These daily totals were then added together to get the likely additional consumption for the season. The observed diets and catch rates of California and Steller sea lions differed substantially, with California sea lion diet dominated by adult salmonids and Steller sea lion diet dominated by sturgeon. To provide more accurate estimates, we estimated additional consumption separately by predator species.

For example, on April 7, 2008, California sea lions caught and consumed an estimated 82 adult salmonids (X_j), 1 lamprey, and an estimated 3 unidentified fish. When the single lamprey catch was excluded, 100% of identified catches (X_j divided by Z_j) were adult salmonids. This proportion was multiplied by the daily expanded unidentified consumption estimate for California sea lions (U_j), which was 3. So for April 7, we estimated that California sea lions likely consumed at least 3 additional adult salmonids, given that 100% of identified catches were adult salmonids. This same calculation was made for all days of the season and for both sea lion species, producing an additional catch estimate of 397 adult salmonids for California sea lions (A_c) and 64 salmonids for Steller sea lions (A_s). Thus:

$$A_c = \sum_{j=1}^{N} \left(\frac{X_j}{Z_j} \right) \cdot U_j \qquad (4)$$

where

N is the last day of regular sea lion observations,

X_j is the daily expanded (salmonid *or* sturgeon) catch, calculated by dividing observed daily (salmonid or sturgeon) catch (by California *or* Steller) by a predator species-specific (California *or* Steller) daily expansion factor (K_j) for each tailrace,

Z_j is total daily identified fish consumption (excludes Pacific lamprey and smolts) by California sea lions *or* Steller sea lions, and

U_j is the daily expanded unidentified consumption estimate for California sea lions *or* Steller sea lions.

Equation 2. Adjusted consumption estimates (C_a)

Adjusted consumption estimates include both the expanded (adult salmonid *or* sturgeon) consumption estimate (C_e) and the likely additional (adult salmonid *or* sturgeon) consumption by California sea lions (A_c) and Steller sea lions (A_s). The likely additional consumption is determined by multiplying the observed percentage of salmonid or sturgeon in the diet of each predator by the number of unidentified fish caught each day.

For example, in 2008 the expanded adult salmonid consumption estimate (C_e) was 4,466 fish. California sea lions (A_c) likely caught an additional 397 salmonids, and Steller sea lions (A_s) likely caught an additional 64 salmonids. This brings the adjusted consumption estimate (C_a) up to 4,927 fish. Thus:

$$C_a = C_e + A_c + A_s \qquad (5)$$

where

C_e is the expanded salmonid *or* sturgeon consumption estimate,

A_c is the likely additional salmonid *or* sturgeon consumption by California sea lions, and

A_s is the likely additional salmonid *or* sturgeon consumption by Steller sea lions.

Appendix C. Methodology, schedule, and results for Didson test of ADDs impact to salmon.

Methods

The Didson (**D**ual Frequency **Id**entification **So**nar) is manufactured by Sound Metrics Corp.* of Lake Forest Park, WA. It is a multi-beam sonar that uses a lens system to form the individual beams. One of its virtues is its ability to see further through turbid water than conventional video cameras that rely on ambient or artificial light. The Didson had no difficulty seeing out to 11.25 meters which was the maximum range used in this study. A disadvantage of the Didson compared to conventional video is its lower resolution. This was not a problem for this study. We only needed to distinguish fish from non-fish in the Didson movies and echograms, and this was not difficult because the fish could be distinguished by their behavior. The field of view of the Didson is built up from 96 individual fan beams (high resolution mode). Each fan beam is approximately 1/3 degree wide by 10 degrees deep. Thus the field of view is approximately 30 degrees wide by 10 degrees deep (Didson looking horizontally). The range window was 2.25 meters to 11.25 meters. This meant that with this deployment, the Didson was effectively blind in the immediate vicinity of the fishway entrance (more on this in the Discussion section).

On both sides of each major fishway entrance, an I-beam is attached vertically to the bulkhead wall and extends from the tailrace deck down into the water. A small trolley carries the ADD down the I-beam. We conducted our test on the ADD deployed at the upstream side of the north upstream entrance. We mounted the Didson camera to a second, larger trolley and lowered it down the same I-beam. During data collection the camera was lowered so that it was about two feet below the water surface and a short distance above the ADD. The mount that attached the camera to the trolley allowed us to adjust for pan and tilt in order to aim the camera. Initially the camera was aimed to point horizontally (but tilted slightly down so that the beam did not catch the water surface) so that the acoustic axis was pointing in the same direction as the outflow from the fishway entrance. With this aiming, the downstream edge of the beam barely caught the upstream edge of the turbulent outflow.

The tests were conducted on fourteen days between April 23 and May 14, 2009. On each test day Didson movies were collected for six hours between approximately noon and 1800h. We used a randomized block design. In each of the seven blocks, the ADD was on one day and off the other day. The order of on vs. off was selected using a random number table. During non-test times the ADD was on. On an ADD-off day the ADD was turned off at the start of the test and turned back on at the end. After the first three blocks, the Didson camera was re-aimed to point slightly upstream so that it no longer caught the turbulent outflow from the entrance. The test schedule is tabulated in Appendix Table C1.

For the first four blocks, the entire six hours of Didson data were inspected for fish for each day. For the last three blocks, there was a dramatic increase in the number of fish, and a single hour (1600h – 1700h) was selected for fish detection.

* Does not imply endorsement by the U.S. Army Corps of Engineers

Appendix Table C1. Schedule for ADD activation.

Date	Block	Unit	ADD treatment
4/23/09	1	1	On
4/24/09	1	2	Off
4/28/09	2	1	Off
4/29/09	2	2	On
5/1/09	3	1	On
5/2/09	3	2	Off
5/4/09	4	1	Off
5/5/09	4	2	On
5/7/09	5	1	On
5/8/09	5	2	Off
5/11/09	6	1	Off
5/12/09	6	2	On
5/13/09	7	1	Off
5/14/09	7	2	On

As a measure of a possible adverse effect of the ADDs on fish passage, we looked at the range distributions of fish detected by the Didson. Because the ADD and the Didson camera were approximately collocated, the range indicated by the Didson was very nearly equivalent to range from the ADD. The assumption is that if the ADD is repulsive to the fish, then the range distribution will be shifted to longer ranges on days when the ADD was on. At first, the fish were detected by visual observation of the Didson movie played back at double speed. If a fish was seen, the movie was paused and the range recorded by hand. After looking at the first few days, it was decided that this was too cumbersome and time consuming. Subsequently, we started over and used the echogram feature of the Didson software to record the ranges for detected fish. The range was automatically recorded to a file by clicking with the mouse on the mid range of a fish trace. This worked well, but care and consistency were required when setting up the intensity and threshold of the echogram display.

Results and Discussion

The deployment of the Didson to test for affects of the ADDs on fish went well. The mean ranges for detected fish for each test day can be seen in Appendix Table C2. The differences in the last column are ‘On’ minus ‘Off’ for each block. A positive difference would be expected if fish are repelled by the ADD.

The mean range for May 12 appeared anomalous. A reexamination of the Didson echograms used for that date did indeed reveal few fish targets at the longest ranges, where most of fish detections were typically recorded. However, the echograms for May 11 differed from all the other dates in another way in that background noise was significantly reduced. It is possible that conditions in the PH2 tailrace near the north upstream entrance were different due to different powerhouse operations at that time. Dropping block 6, the mean difference in range (On minus Off) for the remaining six blocks was -0.01 meters.

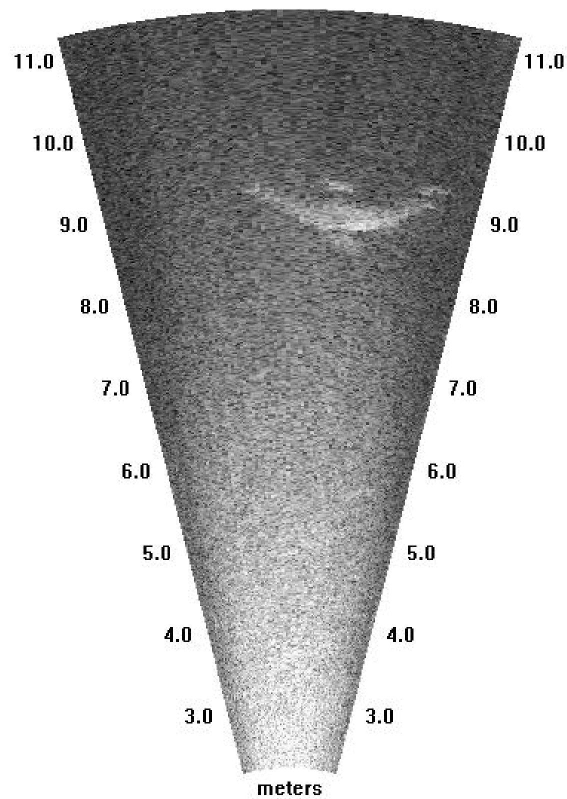
Appendix Table C2. Results of fish detections by Didson near ADD at PH2, 2009.

Date	ADD treatment	Fish Detections	Mean Range (M)	Difference
4/23/09	On	31	7.63	
4/24/09	Off	37	7.83	-0.20
4/28/09	Off	101	7.50	
4/29/09	On	134	7.54	0.04
5/1/09	On	243	8.38	
5/2/09	Off	225	7.72	0.66
5/4/09	Off	42	7.86	
5/5/09	On	200	8.45	0.59
5/7/09	On	134	8.63	
5/8/09	Off	258	9.22	-0.59
5/11/09	Off	105	6.28	
5/12/09	On	111	9.00	2.72
5/13/09	Off	93	9.06	
5/14/09	On	239	8.53	-0.53

In the Didson movies examined, no direct interaction of sea lion and fish was detected, however when a sea lion was actively foraging near the north upstream fishway entrance, it was occasionally detected by the Didson. Because of the somewhat unusual geometry involved in Didson imaging, and because the sea lion when detected was usually only partly in the beam, the image seen in the movie typically consisted of a shapeless mass. However, on rare occasions, decent images of the sea lion were recorded (Appendix Figure C1). In the Didson movies that have been examined so far, no direct interaction of sea lion and fish has been detected.

We conclude, based on the block test results, that there is no indication of an adverse effect of ADD operation on fish behavior. However, for reasons elaborated below, this result should not be considered definitive.

The Didson was deployed using the same I-beam as the ADD. It was located close to the ADD and looking out from the fishway entrance into the tailrace. This simplified computation because range determined by the Didson was roughly equivalent to distance from the ADD. There are, however, some serious disadvantages to this deployment. The sample volume was smallest close to the entrance and ADD (the Didson was actually blind out to 2.25 meters, but the sample volume at such short ranges is so small as to be useless anyway). Also, the noise near the entrance was much greater due to the turbulence and entrained air of the discharge. Because of the difference in sample volume and noise with range, fish were much more readily detected at far ranges than at short ranges. Any effect of the ADD on fish behavior is much more likely to occur close to the entrance where the ADD is located. It may be that we did not see an effect from the ADD because we were not looking in the right place. That is why the results above should not be taken as definitive.



Appendix Figure C1. Single frame image of Didson acoustic camera movie showing a California sea lion in the beam. The range of the sea lion target was approximately 9 m.

Appendix D. List of California sea lions trapped at Bonneville Dam in 2008 and 2009. (Yellow shading denotes animals removed from population known to visit Bonneville Dam)

Sea lion ID	Capture date	On removal list?	Passed health exam?	Action	Additional information
C319/B239	4/24/08	Yes	Yes	Relocated	Relocated to Sea World
C606	4/24/08	Yes	Yes	Relocated	Relocated to Sea World
C739/B136	4/24/08	Yes	Yes	Relocated	Relocated to Sea World
C795/B291	4/24/08	No	-	Released	Branded and released
C796	4/24/08	No	-	Released	Branded and released
C797	4/24/08	No	-	Released	Branded and released
C640/B241	4/28/08	Yes	Yes	Relocated	Relocated to Sea World
C668/B244	4/28/08	Yes	Yes	Relocated	Relocated to Sea World
C805/B208	4/28/08	Yes	-	Released	Branded and released
B66	4/28/08	Yes	Yes	Relocated	Relocated to Sea World
B198	4/28/08	Yes	No	Died	Died while under anesthetic, did not recover
C347	5/4/08	Yes	-	Died	Died from heat exhaustion on trap
C672	5/4/08	No	-	Died	Died from heat exhaustion on trap
B252	5/4/08	No	-	Died	Died from heat exhaustion on trap
B275	5/4/08	No, but qualified	-	Died	Died from heat exhaustion on trap
C265/B237	3/10/09	Yes	No	Euthanized	Failed health examination and unsuited for zoos/aquariums
C635/B240	3/11/09	Yes	No	Euthanized	Failed health examination and unsuited for zoos/aquariums
C643/B242	3/17/09	Yes	No	Euthanized	Failed health examination and unsuited for zoos/aquariums
C507/B145	3/18/09	Yes	Yes	Relocated	Relocated to Shedd Aquarium (Chicago, IL)
C700/B247	3/18/09	Yes	Yes	Relocated	Relocated to Shedd Aquarium (Chicago, IL)
C554	4/1/09	Yes	No	Euthanized	Failed health examination and unsuited for zoos/aquariums
C578	4/1/09	Yes	No	Euthanized	Failed health examination and unsuited for zoos/aquariums
C579	4/1/09	Yes	No	Euthanized	Failed health examination and unsuited for zoos/aquariums
C586	4/1/09	Yes	Yes	Relocated	Relocated to Gladys Porter Zoo, Texas
C657/B127	4/1/09	Yes	Yes	Relocated	Relocated to Gladys Porter Zoo, Texas
C669/B110	4/1/09	Yes	No	Euthanized	Failed health examination and unsuited for zoos/aquariums
C697	4/1/09	No	-	Released	Tagged with acoustic transmitter for research (ODFW/CRITFC)
C697	4/8/09	No	-	Released	
C926/B278	4/1/09	Yes (09)	-	Released	Tagged with acoustic transmitter for research (ODFW), branded C926
C927/B283	4/8/09	No	-	Released	Tagged with acoustic transmitter for research (ODFW), branded C927
C927/B283	4/16/09	No	-	Released	
C928	4/16/09	No	-	Released	Tagged with acoustic transmitter for research (ODFW), branded C928
C858	5/11/09	Yes (09)	No	Euthanized	Failed health examination and unsuited for zoos/aquariums
C645	5/13/09	Yes	No	Euthanized	Failed health examination and unsuited for zoos/aquariums
C674	5/14/09	Yes	No	Euthanized	Failed health examination and unsuited for zoos/aquariums
C934/B300	5/14/09	No	-	Released	Tagged with acoustic transmitter for research (ODFW), branded C934
C935	5/14/09	No	-	Released	Tagged with acoustic transmitter for research (ODFW), branded C935

Appendix E. Night time pinniped abundance data at the PH2 corner collector and traps haul out location.

The larger number at 0630h on April 11 was the result of a large group of Steller sea lions that recently arrived. They likely came from down river somewhere, as few were seen in the tailraces of PH1 or PH2, although they could have been resting or hunting in the spillway tailrace area undetected.

Hour (PST)	March 27, 2009	April 3, 2009	Hour (PST)	April 11, 2009
1930	7	6	0030	20
2030	9	17	0130	20
2130	23	25	0230	27
2230	29	25	0330	27
2330	36	27	0430	27
0030	36	26	0530	27
0130	NA	31	0630	40