2012 FIELD REPORT:

EVALUATION OF PINNIPED PREDATION ON ADULT SALMONIDS AND OTHER FISH IN THE BONNEVILLE DAM TAILRACE, 2012

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INTRODUCTION

The U.S. Army Corps of Engineers (USACE) has used surface observations since 2002 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*) in the Bonneville Dam tailrace (Stansell, 2004; Tackley, et al., 2008; Stansell, et al., 2010). This monitoring program is part of an ongoing effort to understand and manage pinniped predation on salmonids, particularly Endangered Species Act (ESA) listed Columbia River spring Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*) in the tailrace of the dam. The USACE and partnering agencies have used a variety of deterrents and barriers to prevent predation in and around fishways and to deter predation on salmonids and other fish in the tailrace.

This report is an annual 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 Oceanic and Atmospheric Administration Fisheries (NOAA), and the U.S. Department of Agriculture Wildlife Services (USDA). Although primarily covering 2012, data from 2002 to the present are also presented for comparison.

OBJECTIVES:

1. Estimate the number of adult salmonids (*Oncorhynchus* sp.), white sturgeon (*Acipenser transmontanus*), Pacific lamprey (*Entosphenus tridentatus*), 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 (CSL) and Steller sea lion (SSL) presence and predation activity when possible.
3. Evaluate the effectiveness of pinniped deterrents and barriers used at Bonneville Dam.
4. Evaluate the effect of the CSL removal program by ODFW and WDFW on the numbers of pinnipeds present and predation rates at Bonneville Dam.

METHODS

The methods used to collect data for developing pinniped predation estimates and pinniped abundance estimates have generally remained constant every year since 2002. Changes to procedures between years have involved the number of hours of observation made each year with a trend toward more detailed data collected on specific locations of predation events, and the species of predator and prey. Methods used for surface observations, predation and abundance estimates, and assumptions made are described in more detail in Stansell (2004), Tackley et al. (2008), and Stansell et al. (2010).

SURFACE OBSERVATIONS

While surface observations are a useful tool for assessing sea lion diet at Bonneville Dam, pinnipeds can consume smaller prey underwater, so all consumption estimates and associated impacts outlined in this report should be considered minimum estimates.

Observers were stationed at each of the three major tailrace areas of Bonneville Dam: Powerhouse one (PH1), Powerhouse two (PH2), and the spillway. They used binoculars to observe and record pinniped presence, identify and record fish catches, and identify individual CSL and SSL when possible. Prey species were identified when possible and size (for white sturgeon) was estimated. Individual pinnipeds were identified when possible by cataloging unique physical characteristics and/or unique brand numbers. Individual identification was used to generate abundance estimates and to track individual predation and other behavioral patterns both within and among years.

In 2012, regular observations began 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 and were factored into the equation for determining adjusted night estimates. Night vision binoculars, and thermal imaging scopes were used to assist in sea lion detection, counting (at haul out locations), and predation events at night. In 2012, as begun in 2010, each tailrace was divided into seven zones (Figure 1). The location of each predation event was then recorded by zone.

The primary study period was from January 1 to May 31 to focus on the spring Chinook salmon passage season at Bonneville Dam. Few pinniped sightings occurred outside this timeframe. However, observations were made between October 1 and December 31, 2011 to collect additional information on Steller sea lion consumption of white sturgeon and other fish in the Bonneville Dam tailrace. In 2012, regular observations began January 6 and ended May 31 and covered Mondays through Fridays. Data were interpolated for days and hours not observed. Limited observations were conducted in early January and into June but not factored into predation estimates.

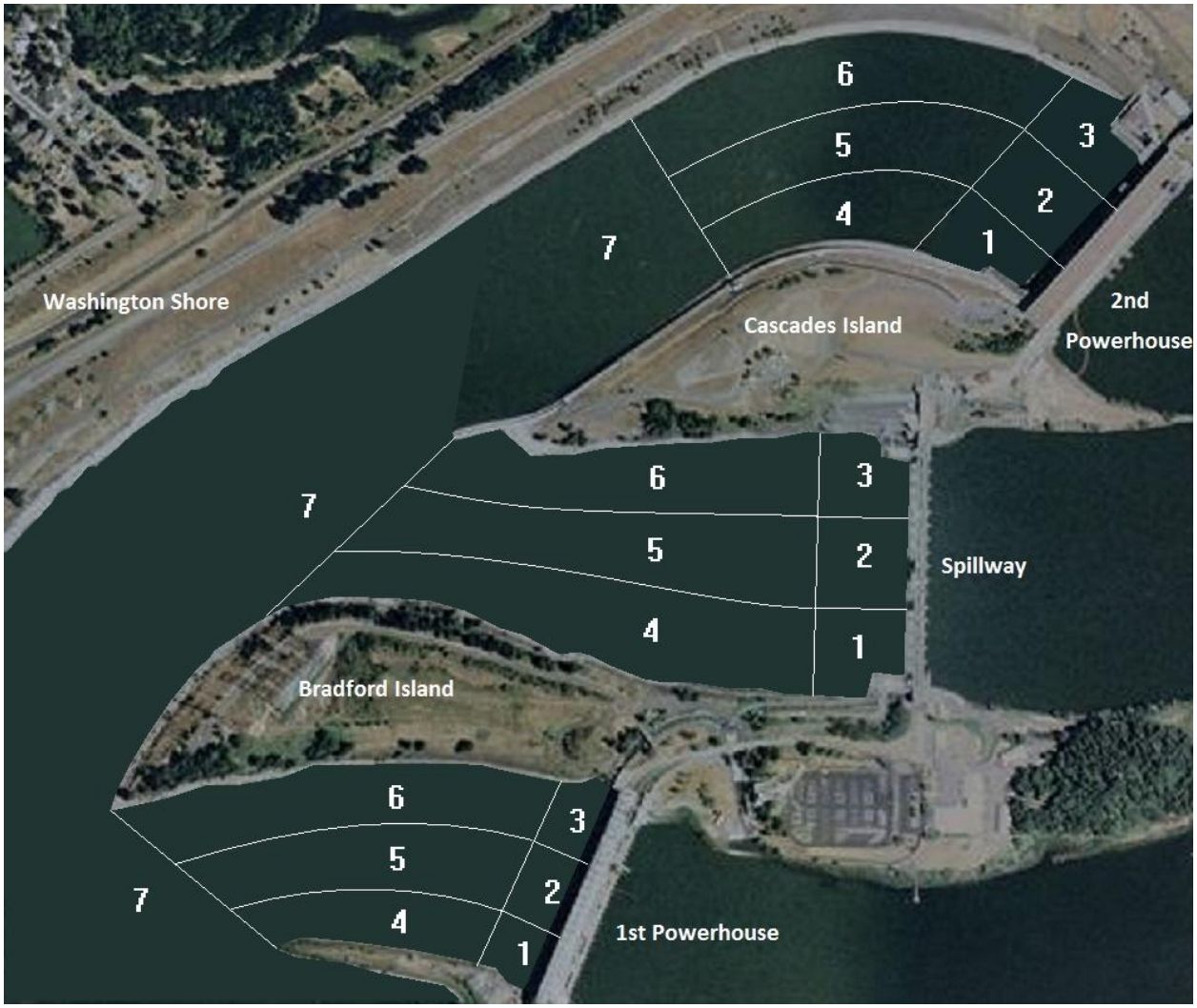

Figure 1. Primary study area and location of zones at Bonneville Dam, 2012.

PREDATION ESTIMATES

Expanded Consumption Estimates

Surface observations were used to estimate total consumption of Chinook salmon, steelhead, Pacific lamprey 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. 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 data 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.

Adjusted Consumption Estimates

Expanded consumption estimates were adjusted to include unknown catches and nighttime predation. For a variety of reasons, observers were occasionally unable to identify the fish caught by species during a predation event. We can make more realistic estimates of salmonid and sturgeon consumption beyond the total *expanded consumption estimate* by attributing "unknown" prey to specific species based on the proportion of known prey observed consumed by each pinniped species (Stansell et al., 2010, Appendix B, Equation 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 "unknowns" for CSL and SSL were added to the expanded consumption estimates to calculate the adjusted consumption estimate for each day. We also estimated nighttime consumption by increasing the daily estimate by 0.9% based on our night work in 2011 and 2012. This is less than the 3.5% observed in 2009 and also used for 2010 adjusted estimates (Stansell, et al., 2009). Little or no night time predation was observed prior to large-scale daytime hazing efforts, which began in 2006, and we felt there was some shift to nighttime predation once large-scale daytime hazing began.

INDIVIDUAL IDENTIFICATION

Identification of individual CSL and SSL was used to determine the number of sea lions present (daily and seasonally) and to track individual presence and predation activity. We used video and photos from digital HD video recorders equipped with 30X optical zoom lenses, field sketches, and observer notes to identify unique marks for individual CSL and SSL and to confirm identities of individuals seen by multiple observers. Individual pinnipeds were identified by noting a combination of physical characteristics such as brands, cuts, scars, lumps, color patterns, size, maturity, and also behavior. Since harbor seal presence was relatively minor at the dam, we did not attempt to identify and track individual harbor seals.

A catalog of photos and sketches of all individuals is kept and updated annually. More detailed description of the methods used to determine daily and annual pinniped abundance estimates can be found in Stansell et al., 2010.

DETERRENTS AND MANAGEMENT ACTIVITIES

In 2012, physical barriers (sea lion exclusion devices or SLEDs and floating orifice gate barriers or FOGs) were re-deployed to keep pinnipeds out of the fishways. The USDA (dam based) and CRITFC (boat based) continued non-lethal harassment (hazing) techniques. The states re-submitted a request to NOAA for authority for lethal removal of CSL under Section 120 of the Marine Mammal Protection Act after addressing issues that the 9th Circuit Court of Appeals felt required attention. NOAA granted the states a permit to continue the removal program in 2012 and beyond.

SLEDs and FOGs were installed at PH2 and Cascades Island on December 9, 2011 and removed on July 16, 2012. SLEDs were installed at the B branch entrance on February 16 and PH1 on February 22, and removed from those entrances on June 28. All were effective, and no pinnipeds entered the fishways during the 2012 season.

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 fired from shotguns. 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 Service agents began the first week in March and continued seven days per week through the end of May.

Boat-based hazing in 2012 was primarily conducted by personnel from CRITFC from the first week in March through mid-May. Boats operated primarily in the Bonneville Dam tailrace boat restricted zone (BRZ). Boats could not operate within 30 m of dam structures or within 50 m of fishway entrances. To minimize the impact to fish, the use of seal bombs was prohibited within 100 m of fishways, collection channels, or fish outfalls for the PH2 corner collector and smolt monitoring facility, and the use of seal bombs ceased completely in the tailrace after adult salmonid passage exceeded 1,000 fish per day at Bonneville Dam. More on boat hazing activities can be seen in Wright et al., 2007 and Brown et al., 2008, 2009, 2010, and 2011.

Personnel from ODFW and WDFW operated four floating sea lion traps (for details see Brown et al., 2008) at Bonneville Dam at various locations across the season. Traps were used to brand and/or put acoustic and/or GPS tags on several CSL and SSL and to remove specific CSL that qualified for removal under the permit issued to the states.

RESULTS AND DISCUSSION

PREDATION ACTIVITY

Between January 6 and May 31, 2012, observers completed over 3,404 hours of daytime observations. During this period, observers saw pinnipeds catch and consume 2,962 fish of several species. White sturgeon were the primary prey item, comprising 45.3% (n=1,342) of observed catches. Adult salmonids and Pacific Lamprey were the second and third most commonly identified prey types, comprising 41.4% (n=1,017) and 0.9% (n=40) of total observed catch respectively. This marks the first time adult salmonids were not the most preyed upon species by number. This is due to the increased presence of Steller sea lions earlier in the season, and the reduced presence and predation of California sea lions in 2012. Observers were unable to identify 10.9% (n=324) of the fish caught and consumed by pinnipeds during this period.

Between October 1 and December 31, 2011 we completed over 536 daytime hours observation. Only one CSL was observed at Bonneville Dam in the fall of 2011 for one day, and a harbor seal was observed on two separate days. However, at least 11 individual SSL were observed between October and December 2011. White sturgeon were the primary prey item, comprising 45.4% (212) of observed catches. Adult salmonids were the second most commonly observed prey type consumed, comprising 28.5% (133) of the catch. Observers were unable to identify 22.1% (103) of the fish caught and consumed by SSL. Identified salmonid species caught were 91 Chinook, 37 steelhead, 4 coho (*Oncorhynchus kisutch*), and 1 chum (*Oncorhynchus keta*). All predation observed was by SSL.

Predation on Adult Salmonids

In 2012, the expanded adult salmonid consumption estimate for the Bonneville Dam tailrace observation area was 2,107 or 1.3% of the adult salmonid run at Bonneville Dam from January 1 through May 31. Accounting for unidentified fish, the adjusted estimated consumption was 2,360 (or 1.4% of the run) (Table 1). A progressive series of tables, broken out for CSL and SSL, showing estimated salmonid consumption (interpolated for hours and days not observed), adjusted salmonid consumption (factoring in unidentified fish caught), and finally adding a nighttime consumption factor after hazing began (in 2006) is presented in Appendix A. The estimated number of adult salmonids consumed increased each year since 2005 until a decline in 2011 and 2012 which has the lowest predation estimate since 2002 (Figure 2). The estimated percent of the run consumed has declined each year since a high of 4.2% in 2007, reflecting an increase in the run size each year since 2007 until 2011 and 2012 (Figure 3). SSL were the primary predator of salmonids in 2012, accounting for 53.3% (n=648) of the 1,216 observed catches (Table 2). CSL accounted for 46.7% of the salmonid catches. This percentage is lower than was seen in any previous year, and observed salmonid catch by SSL increased from 0.3% (n=12) in 2007, 3.8% (n=162) in 2008, 10.1% (n=300) in 2009, 16.2% (n=634) in 2010, and 29.1% (n=636) in 2011 to 53.3% in 2012. The drop in CSL salmonid predation in 2011 and 2012 relative to previous years and the continuing rise in SSL salmonid predation each year can be seen in Figure 4.

Table 1. Consumption of salmonids by CSL, SSL, and harbor seals at Bonneville Dam tailrace, from surface observations conducted between 2002 and 2012. 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	284,732	1,010	0.4 %	N/A	N/A
2003	217,934	2,329	1.1 %	N/A	N/A
2004	186,771	3,533	1.9 %	N/A	N/A
2005	81,252	2,920	3.4 %	N/A	N/A
2006	105,063	3,023	2.8 %	3,401	3.1 %
2007	88,474	3,859	4.2 %	4,355	4.7 %
2008	147,558	4,466	2.9 %	4,927	3.2 %
2009	186,056	4,489	2.4 %	4,960	2.7 %
2010	267,167	6,081	2.2 %	6,321	2.4 %
2011	223,380	3,557	1.6%	3,970	1.8%
2012	171,665	2,107	1.2%	2,360	1.4%

Table 2. CSL and SSL predation on adult salmonids at Bonneville Dam, from January 1 through May 31, 2012.

Predator		Expanded Salmonid Consumption estimate		Adjusted Salmonid Consumption estimate	
	Observed Salmonid Catch	Estimated consumption	% of Run (1/1 to 5/31)	Estimated consumption	% of Run (1/1 to 5/31)
CSL	579	998	0.6 %	1,067	0.6 %
SSL	648	1,009	0.7 %	1,293	0.8 %

The 2012 spring Chinook salmon run was one of the later runs, as was the case in 2011, 2009, and 2006 (Figure 3). Chinook salmon were the second most commonly identified prey species, comprising 82.9% (n=1,017) of observed adult salmonid catch in 2012. The expanded Chinook salmon consumption estimate for the Bonneville Dam tailrace in 2012 was 1,750 or 0.9% of the Chinook salmon run (including jacks) from January 1 through June 15 (Table 3). Note that this time period includes the defined Columbia River spring Chinook salmon passage season at Bonneville Dam (through June 15), which extends beyond the period during which sea lions are normally present. Keefer et al. (2012) used radio-telemetry and our observational data between 2002 and 2010 to identify specific salmonid populations at risk due to predation on early-timed passage of upriver stocks. Those populations identified with the highest risk included endangered/threatened stocks from the Clearwater and Salmon rivers, the Umatilla and Deschutes rivers, and the Icicle River. The higher proportional impact to the early passing Chinook salmon stocks by CSL seen averaged over the past 10 years (Figure 5) does not seem to have been the case in 2012 (Figure 6).

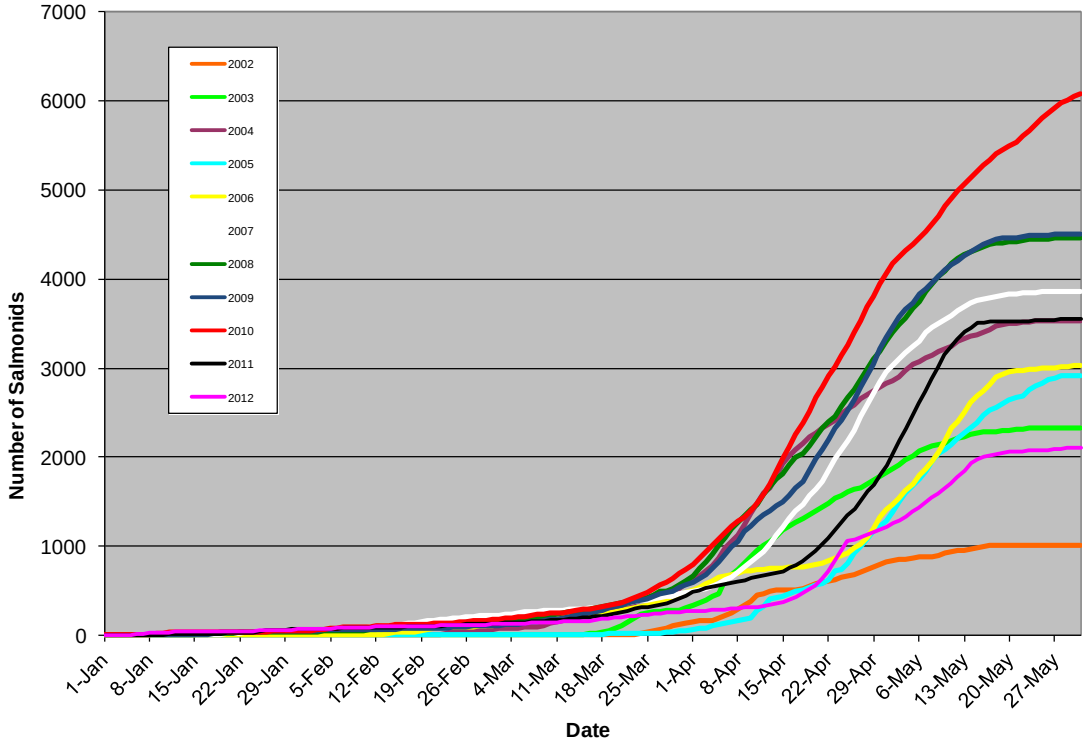

Figure 2. Cumulative salmonid catch by pinnipeds at Bonneville Dam, 2002 to 2012.

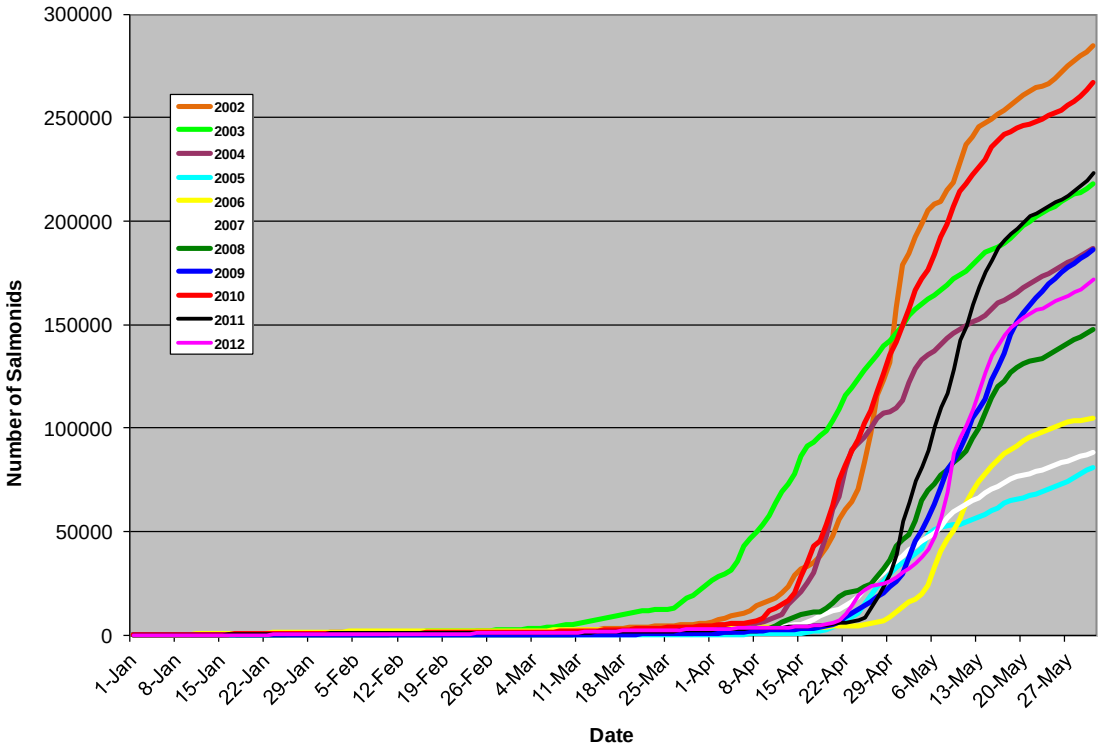

Figure 3. Cumulative daily counts of adult (including jacks) Chinook salmon and steelhead passing Bonneville Dam, 2002 to 2012.

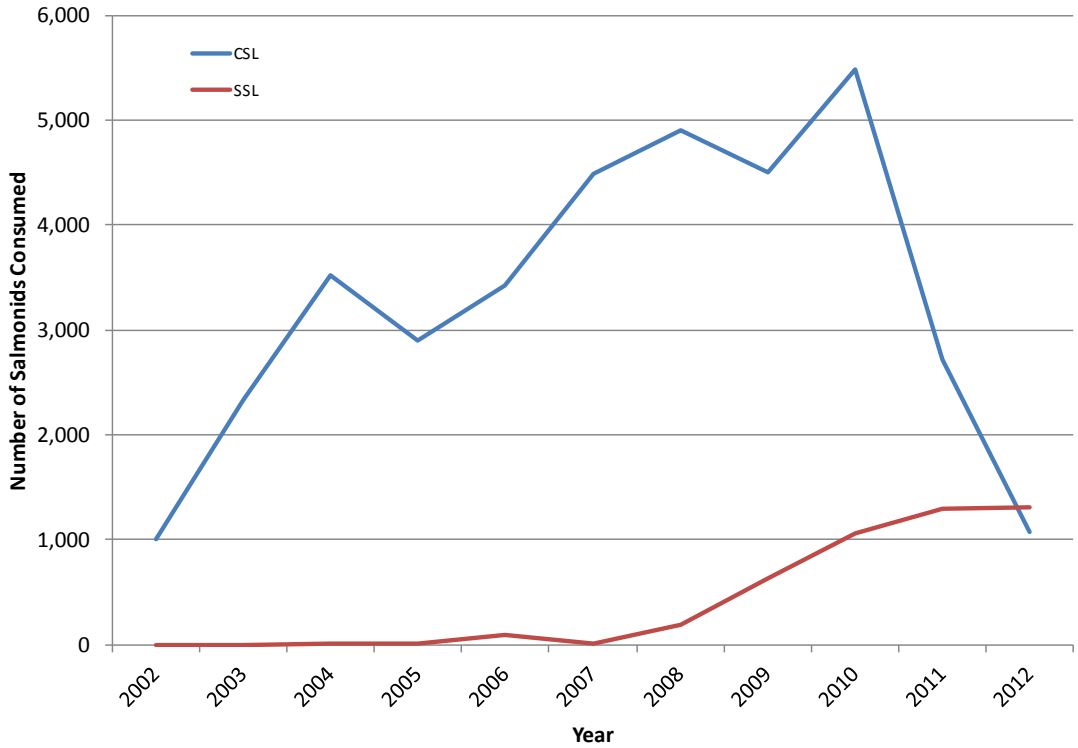

Figure 4. Salmonid consumption estimates adjusted for "unknown" and nighttime predation by CSL and SSL at Bonneville Dam, 2002-2012.

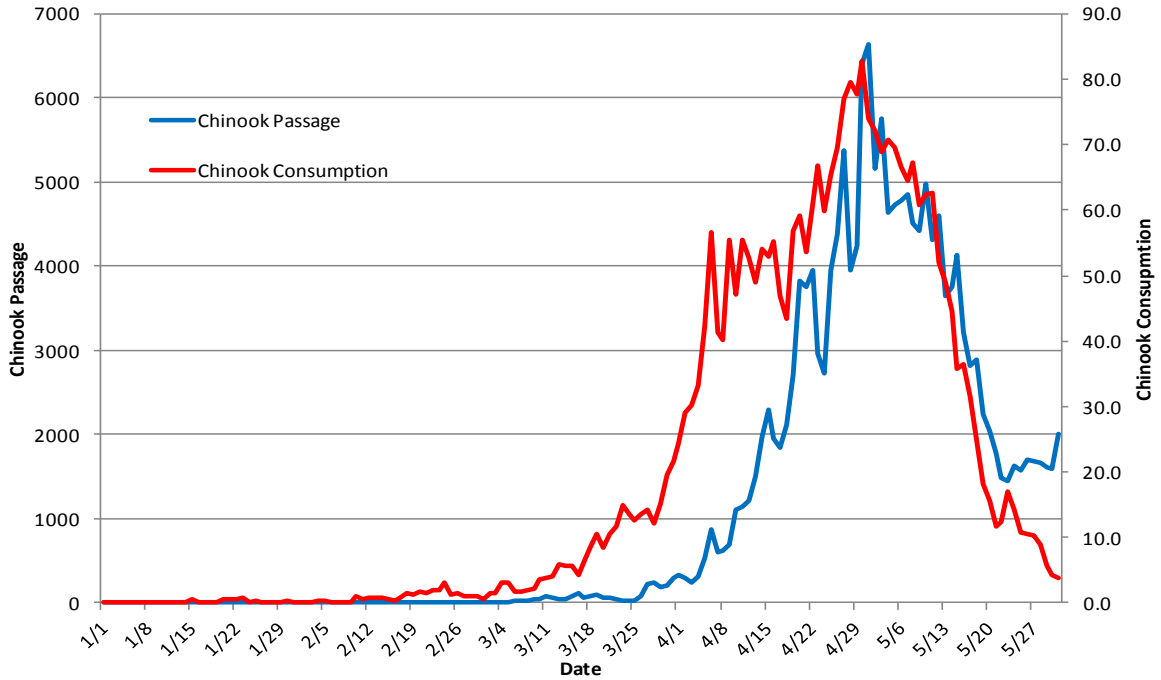

Figure 5. Mean daily Chinook consumption by CSL and mean daily Chinook passage at Bonneville Dam, 2002-2011.

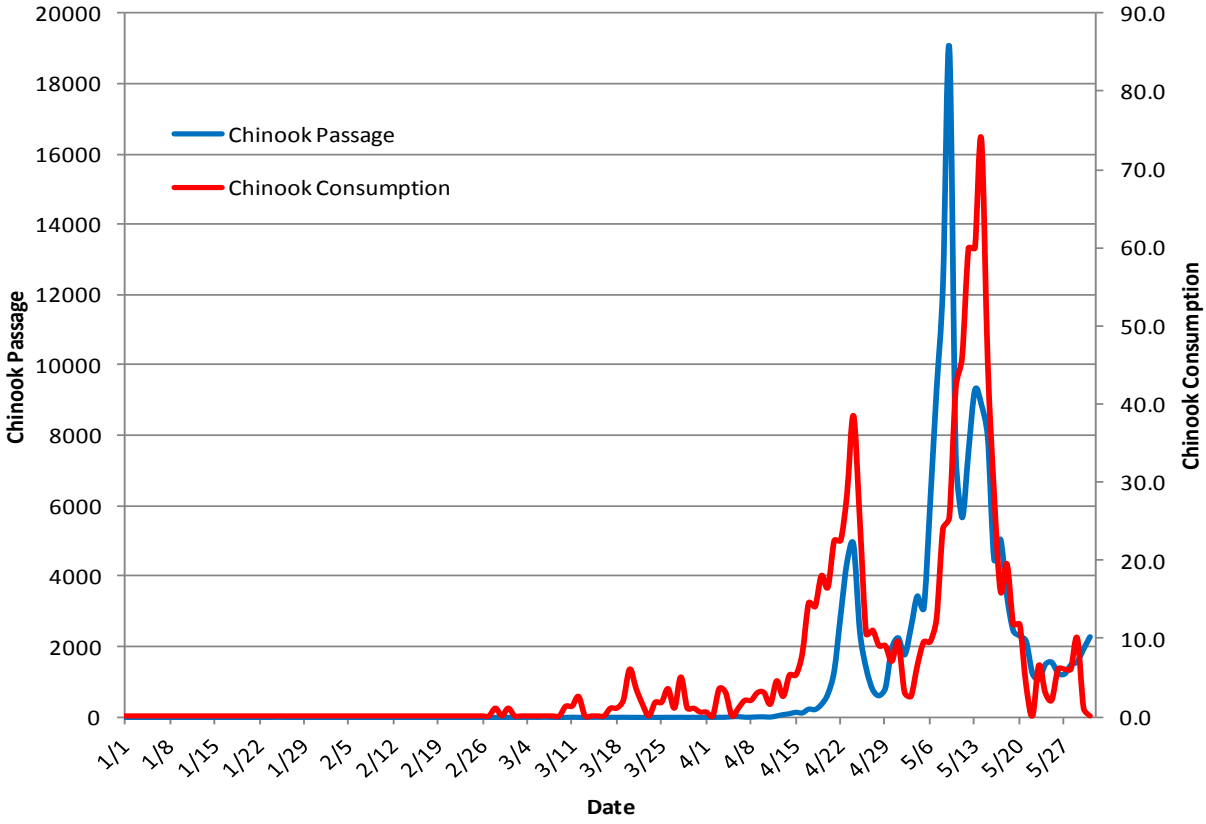

Figure 6. Mean daily Chinook consumption by CSL and mean daily Chinook passage at Bonneville Dam, 2012.

Table 3. Consumption of spring Chinook salmon by pinnipeds at Bonneville Dam between 2002 and 2012.

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 %
2010	293,662	5,757	2.0 %
2011	272,469	3,298	1.2%
2012	196,667	1,750	0.9%

* 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.

Steelhead comprised 17.1% (n=210) of observed adult salmonid catch in 2012. 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. During the last few years, SSL were often observed swallowing steelhead whole, suggesting that they could consume steelhead and Chinook salmon jacks entirely below the surface. All consumption estimates provided are minimum estimates, but it should be noted that SSL predation may be underestimated more than CSL predation by the current surface observation methods.

The estimates of salmonid predation during the fall of 2011 by SSL was 415 salmonids (528 adjusted estimate). Broken out by species, the adjusted estimates are 317 fall Chinook, 187 steelhead, 20 coho, and 4 chum. This is about 0.6% of the salmonids passing Bonneville during the same time period.

Predation on White Sturgeon

In 2012, the expanded white sturgeon consumption estimate for our study area was 2,227, continuing the upward trend of 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 2,498. White sturgeon were the most commonly observed prey for SSL. SSL made 100% of the observed sturgeon catches in 2012. Predation on sturgeon dropped off dramatically after the first week of April when spring Chinook salmon began to show up and became the preferred prey of both SSL and CSL by mid-April (Figure 7).

Table 4. Consumption of white sturgeon by pinnipeds at Bonneville Dam from 1 January through 31 May, 2005 to 2012.

Year	Total Hours Observed	Observed Sturgeon Catch	Expanded Sturgeon Consumption estimate	Adjusted Sturgeon Consumption estimate
2005	1,108	1	N/A	N/A
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
2010	3,609	1,100	1,879	2,172
2011	3,315	1,353	2,178	3,003
2012	3,404	1,342	2,227	2,498

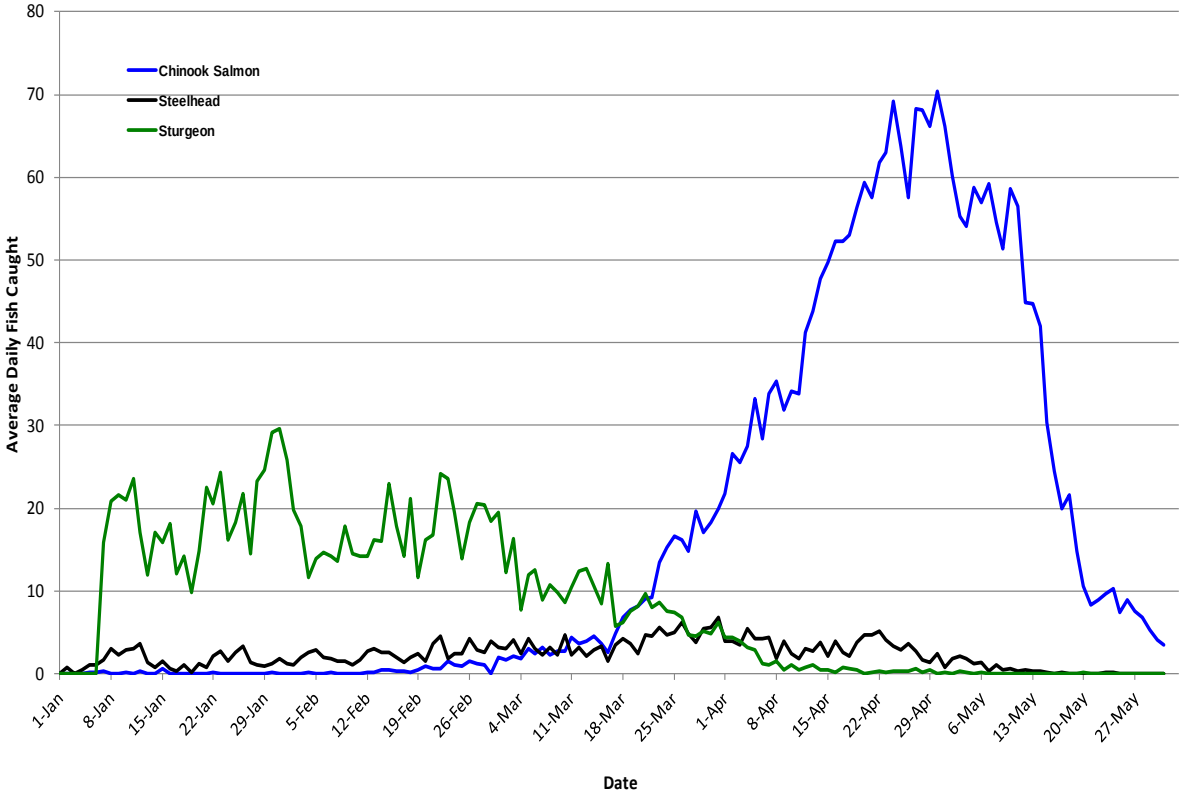

Figure 7. Daily average estimated Chinook salmon, steelhead, and white sturgeon consumption by both SSL and CSL at Bonneville Dam from January 1 through May 31, 2006 to 2012.

SSL were observed consuming an estimated 627 sturgeon in the Bonneville Dam tailrace between October 1 and December 31, 2011. Adjusting for unidentified prey, the estimated total additional sturgeon consumed in the fall/winter was 828. More sturgeon predation occurs well below the Bonneville Dam tailrace area, but no systematical observation program has been conducted.

When possible, observers estimated the lengths of sturgeon caught by pinnipeds in one foot increments. The estimated lengths of sturgeon caught between 2006 and 2012 ranged from less than 2 ft (0.6 m) to over 7 ft (2.7 m), but 82.2% of sturgeon lengths (n=4,074) were 4 ft (1.2 m) or shorter (Figure 8).

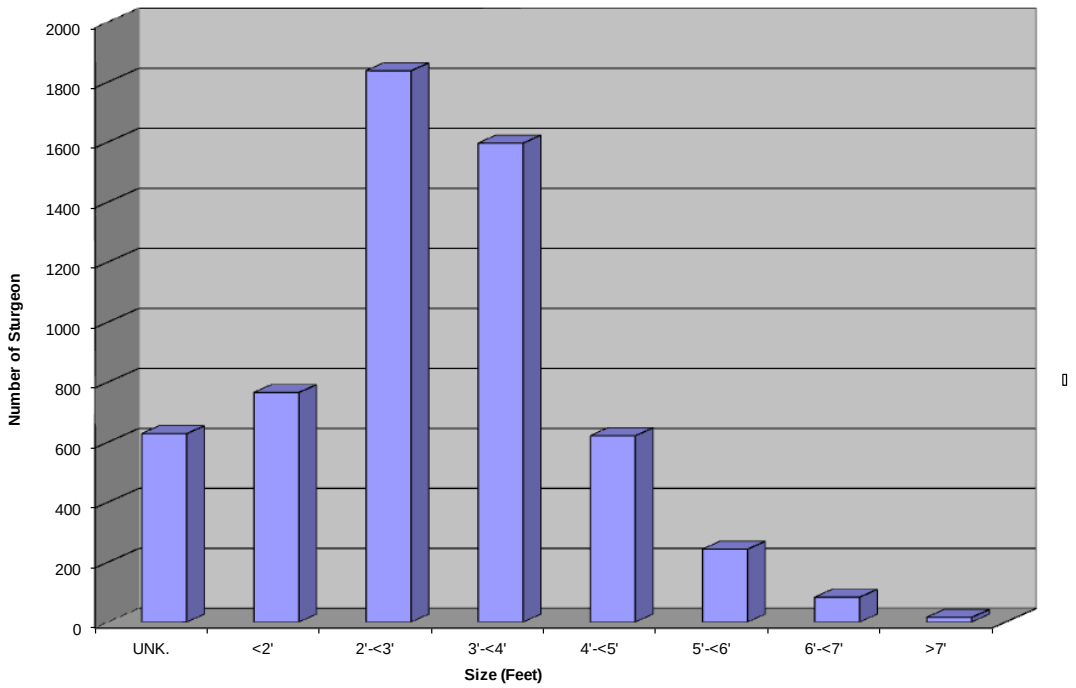

Figure 8. Estimated lengths of white sturgeon consumed by SSL and CSL at Bonneville Dam, from January 1 through May 31, 2006 to 2012.

Predation on Pacific Lamprey

In 2012, the expanded Pacific lamprey consumption estimate was 79, one of the lowest estimates of the previous 10 years of observation (Table 5). CSL made 34 of the 40 observed lamprey catches in the Bonneville Dam observation area. Lamprey catch proportion of total observed catch was 1.4%, continuing the trend of low lamprey predation compared to 2003-2006. Due to the small body size and presumed vulnerability of lamprey to predation, our surface observation approach may significantly underestimate actual predation on lamprey. However, this underestimate should be similar among years, so the drop in lamprey predation observed is more likely a factor of lower numbers of lamprey available for predation, which is supported by the overall drop in lamprey passage numbers at Bonneville Dam (Figure 9). The lamprey passage season is mid-May through October.

Location of Predation Events

Chinook consumed by zones for CSL and SSL was similar in 2012 across the tailrace, with most consumed occurring near the dam at PH1 (Appendix Figures B-1 and B-2). Although there were some changes in proportions of catch between years for the zones, none was very dramatic or meaningful. SSL predation on sturgeon was again, primarily in zone 7, but there was a rather large increase in the amount of predation occurring in zone 3 of PH1, near the north fishway entrances (Appendix Figure B-3). This preponderance of downstream sturgeon predation indicates we are likely underestimating sturgeon consumed, as many of these events are occurring at the extreme edge of our viewing area. For example, smaller sturgeon consumed in zone 7 of PH2 could likely be consumed unseen (typically sturgeon less than 4 feet were

Table 5. Consumption of Pacific lamprey by pinnipeds at Bonneville Dam from January 1 through May 31, 2002 to 2012.

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%
2010	3,609	39	77	0.7%
2011	3,115	16	33	0.4%
2012	3,404	40	79	1.4%

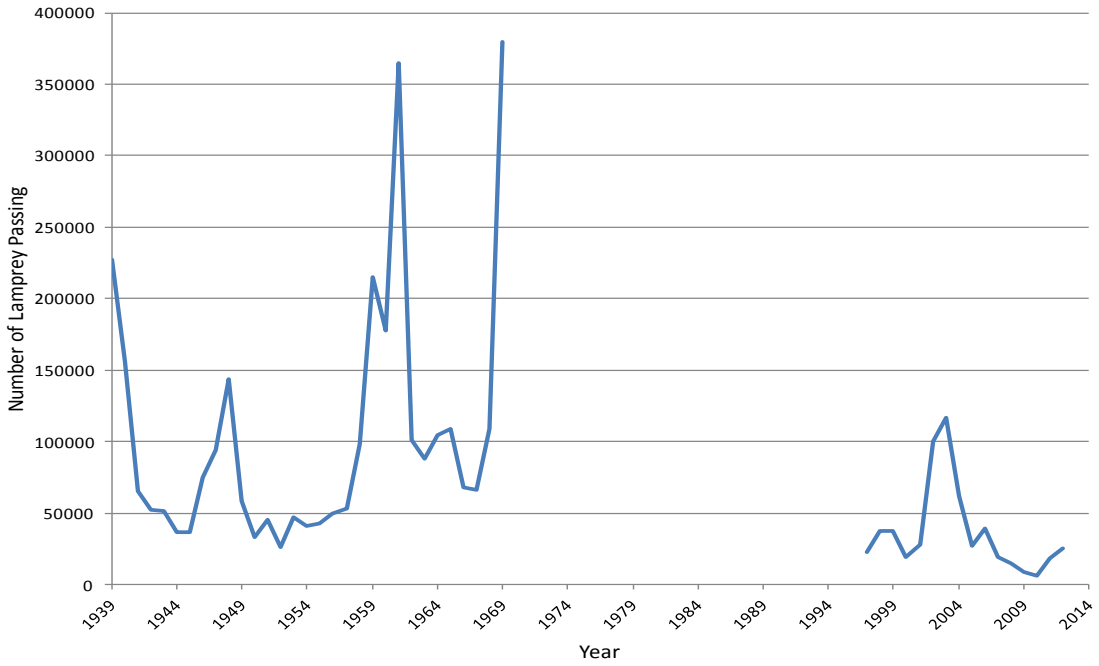

Figure 9. Lamprey day time passage estimates at Bonneville Dam from 1939 to 2012. Lamprey were not counted at Bonneville Dam from 1970 to 1996.

completely consumed in 1-5 minutes), whereas larger sturgeon can be seen being consumed as the SSL drift downstream into zone 7 of the spillway tailrace. We have noted larger sturgeon being fed upon by multiple individuals for as long as an hour or more. As always, the recorded zone is the location where the predator is first seen with the fish, and it is entirely possible the fish was caught farther upstream and dragged downstream underwater into other zones before being seen.

Predation on salmonids primarily occurred in the PH2 tailrace before 2006 but has alternately predominated between PH1 and PH2 since 2006, possibly due to hazing activities, powerhouse flow, or access to haul out and rafting locations (Table 6). It is not due to salmonid passage changing between powerhouses, as PH2 has consistently passed more fish (59-77%) each year. Sturgeon were primarily observed being consumed at the spillway from 2006-2008; however, more have been seen consumed at PH2 since then.

Table 6. Percentage of salmonids and sturgeon predation for each tailrace location.

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
					Salmon						
PH2	55.0	57.4	55.0	43.4	34.7	26.4	37.7	32.4	47.8	24.1	26.9
PH1	30.5	34.9	39.2	32.6	56.7	40.6	34.9	51.6	26.3	55.2	62.3
Spillway	14.5	7.7	5.8	24.1	8.6	33.0	27.4	16.0	25.9	20.7	10.9
					Sturgeon						
PH2	0.0	0.0	0.0	0.0	14.4	29.7	33.5	44.8	56.1	39.0	45.6
PH1	0.0	0.0	0.0	100.0	7.2	5.3	2.8	20.3	13.1	26.5	13.8
Spillway	0.0	0.0	0.0	0.0	78.4	65.0	63.7	34.9	30.8	34.5	40.6

Night Observations

Thirty-one hours of nighttime observations were made on six nights in 2012. We only observed two salmonids being consumed during the early morning crepuscular hour, and the crepuscular hours are accounted for already by our day time expansion equations. Although data for previous years (Stansell, et al., 2009) suggested an additional 3.5% of predation events could occur after dark, we found nighttime predation accounted for only an additional 0.9% in 2011 (Stansell, et al., 2011), and this is the factor we used for 2012 as it was more realistic than the 0.0% we saw in 2012 with our small sample size. Actual predation at night could have been more, but we did not see any evidence of this with our night-vision binoculars. Predation estimates for salmonids adjusted to include nighttime predation estimates are given in Appendix C.

Additional Observations

We made occasional observations outside the standard tailrace viewing area, but much fewer than in previous years. Only two hours were observed at the mouth of Tanner Creek below Bonneville Dam where pinnipeds were often seen hunting. During those hours, CSL were observed to consume one Chinook and one lamprey.

On April 15, 2011 CSL (designated CSL B325) was documented to have passed through the navigation lock upstream into the forebay. He has been identified numerous times at The Dalles Dam and on a private dock at The Dalles marina and is still upstream of Bonneville Dam as of this report (about 1 ½ years). This year, after several reports of multiple sea lions being observed in the Bonneville pool, the states took a boat into the forebay of Bonneville Dam on May 15 and they were able to document the CSLs C014, U95, and a small unbranded CSL (not B325). Several sightings of C014 and U95 have been made either at The Dalles Dam or in the Bonneville forebay all summer, and it is likely that both these CSL (and possibly others) are also still upstream of Bonneville Dam as of this report.

PINNIPED ABUNDANCE, RESIDENCE TIMES, AND RECURRENCE

The estimated number of individual pinnipeds observed at Bonneville Dam in 2012 was 112, lower than the last two years but the fourth highest since observations began in 2002 (Table 7). SSL numbers dropped a bit in 2012 to 73 individuals. The maximum of 33 SSL observed on one day in 2012 was similar to last year, but not as high as the 53 SSL seen in 2010. CSL numbers dropped again in 2012 to 39 (excluding one upstream of Bonneville since April 2011) after jumping up to 89 in 2010 and then dropped to 54 in 2011. The maximum number of CSL seen on any one day was only 14 this year. No harbor seals were observed this year at Bonneville (although two were seen in December). As in previous years, hazing activity typically resulted in changes in behavior (more time below the water surface, less time with backs and unique markings exposed, etc. which made identification of individuals challenging. These abundance figures should be considered minimum estimates.

Table 7. Minimum estimated number of individual pinnipeds observed at Bonneville Dam from 2002 to 2012.

	CSL	SSL	Harbor seals	Total pinnipeds
2002	30	0	1	31
2003	104	3	2	109
2004	99	3	2	104
2005*	81	4	1	86
2006	72	11	3	86
2007	71	9	2	82
2008	82	39	2	123
2009	54	26	2	82
2010	89	75	2	166
2011	54	89	1	144
2012	39	73	0	112

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

Daily pinniped abundance peaked in late April 2012 (Figure 10), primarily due to SSL numbers. The highest number of pinnipeds counted on any one day in 2012 was 42 (April 25), which was slightly lower than 2011 and much lower than 2010 (Figure 11). Mean daily number of pinnipeds present was 15.5 in 2012, the lowest since 2007 (Figure 11). The CSL component (3.2 per day) shows far fewer animals present daily on average than we have seen since 2002 and the maximum seen on any one day (14) was also the lowest since 2002 (Figure 12). However, SSL were present in similar numbers this year (12.4 per day) as in 2010 and 2011, both of which are higher than previous years (Figure 12).

The most number of days an individual CSL was observed at Bonneville Dam was 27 days in 2012, the lowest since 2003 (Figure 13). The first CSL was observed on January 9 in 2012. This was by the same individual that was also the first to arrive in 2011 (February 21) and has been seen the longest (since 2008) of all identified CSL for 2012. Most of the individuals returning multiple years have been removed over the previous four years, and this may account for the trend of most individuals now arriving later in the season and spending less time at Bonneville Dam.

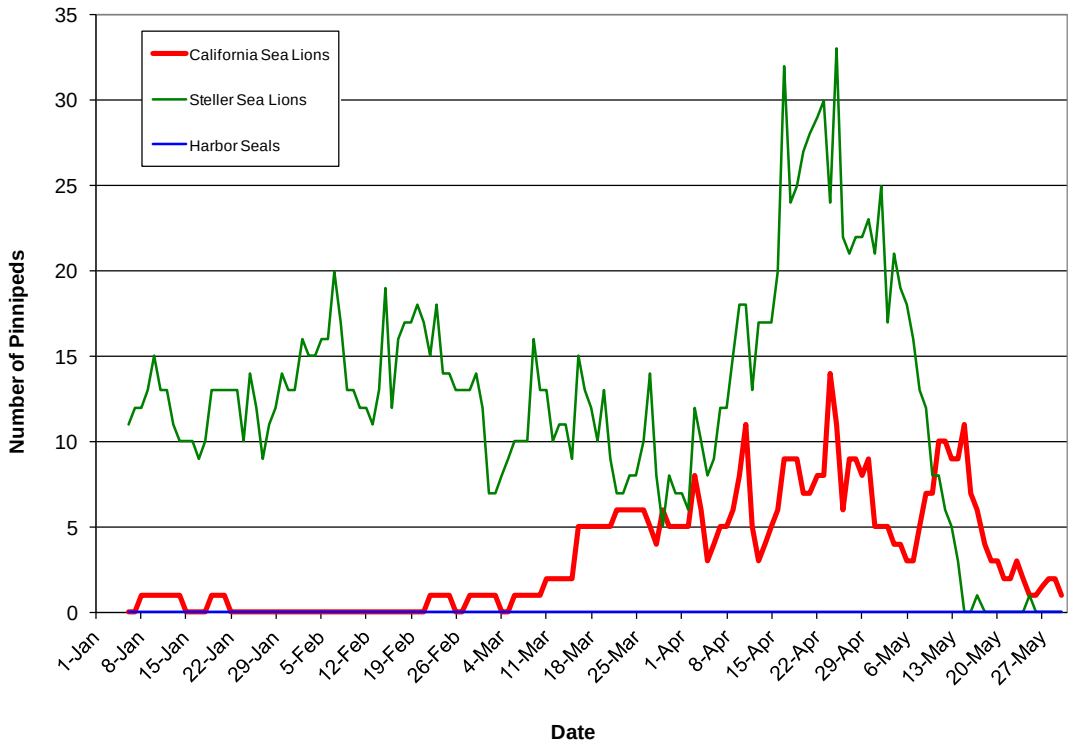

Figure 10. Daily abundance estimates for CSL, SSL, and harbor seals at Bonneville Dam from January 1 through May 31, 2012.

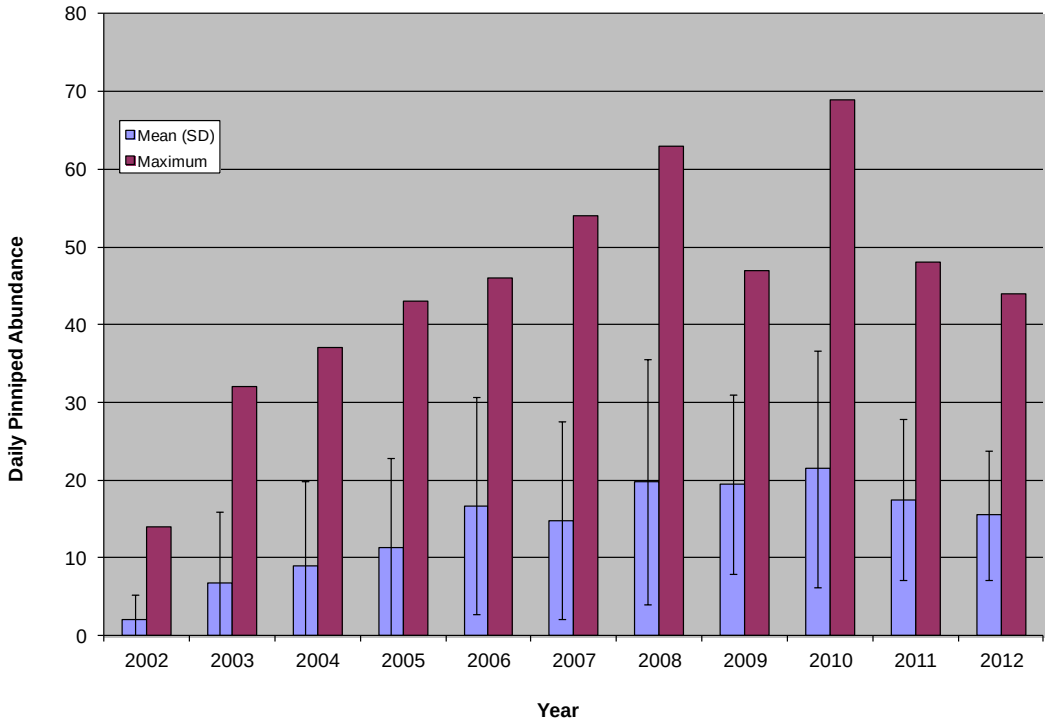

Figure 11. Mean, standard deviation, and maximum daily estimated number of pinnipeds present at Bonneville Dam between January 1 and May 31, 2002 to 2012.

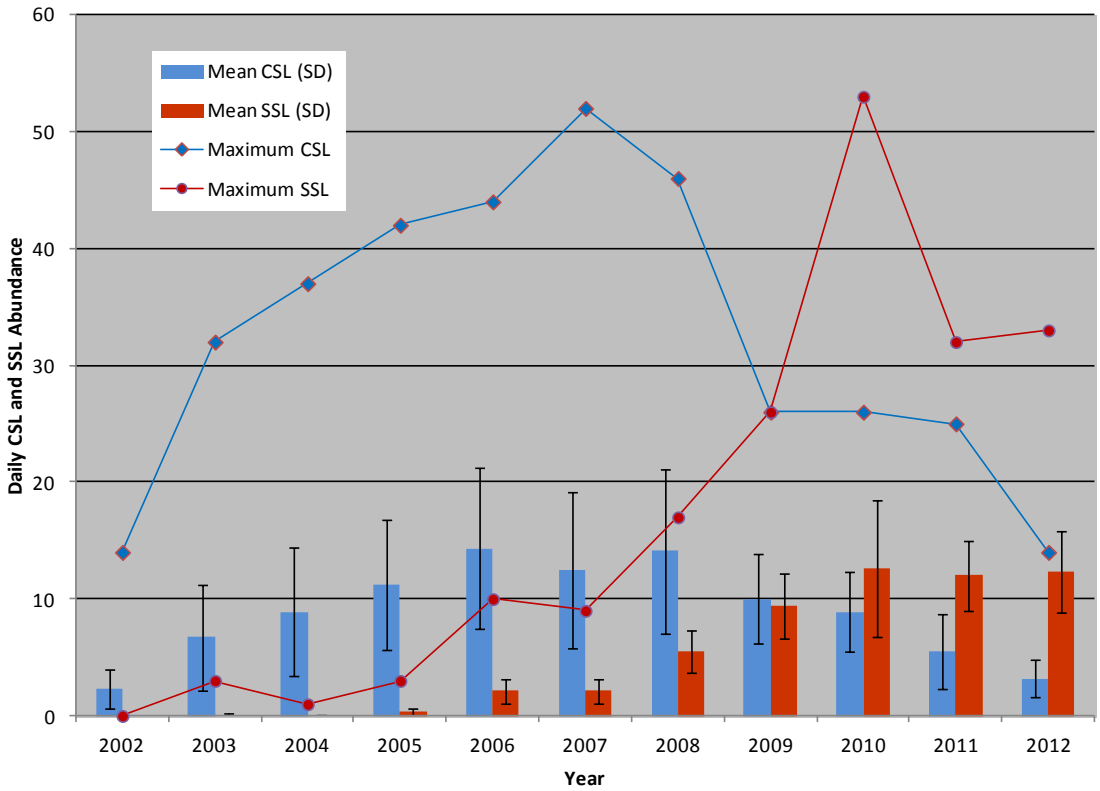

Figure 12. Mean, standard deviation, and maximum daily estimated number of CSL and SSL present at Bonneville Dam between January 1 and May 31, 2002 to 2012.

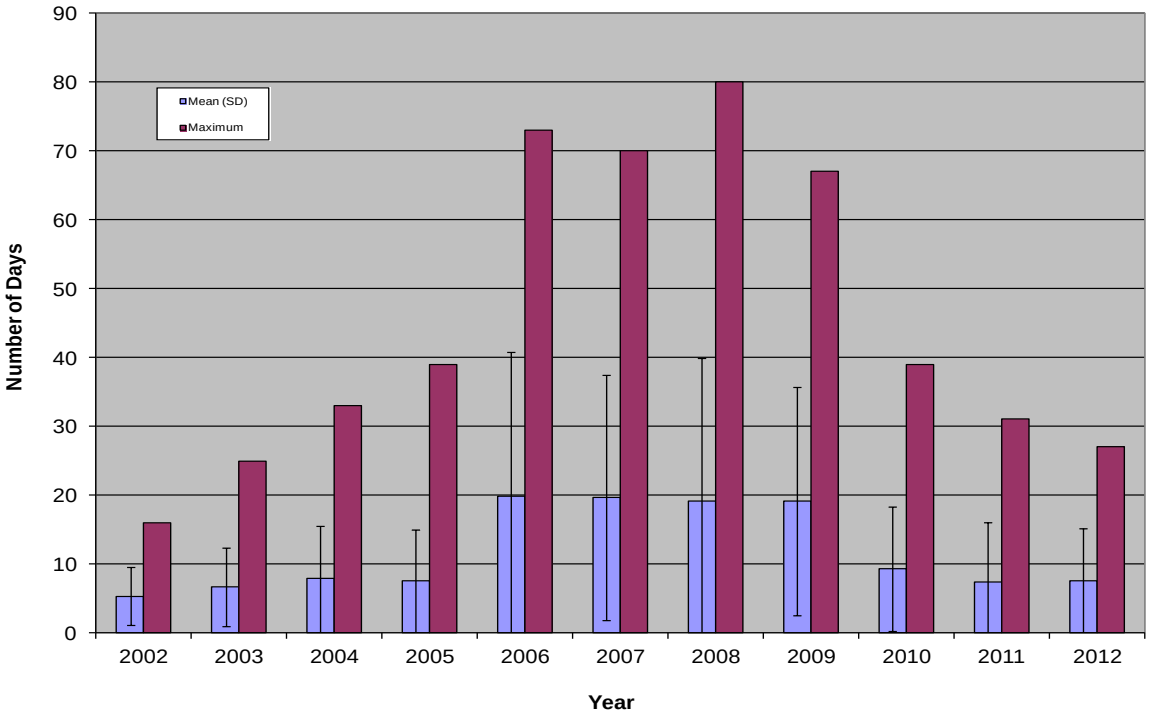

Figure 13. Mean, standard deviation,and maximum number of days individually identified CSL were observed at Bonneville Dam between January 1 and May 31, 2002 to 2012.

CSL not previously identified continue to show up each year. Of the 35 highly identifiable animals observed in 2012, 14 (35.9%) were new additions to that category (including 4 branded and 3 more given brands while at Bonneville). The percentage of CSL returning each year was at least 19.2%, 51.2%, 77.1%, 62.3%, 65.6%, 66.2%, 69.8%, 34.6%, 64.6%, and 64.1% for 2003 through 2012, respectively. The phenomenon seen in 2010, where more new individuals were identified than returning individuals (discussed in Stansell et al., 2011) was likely a one-time event. We have observed over 160 individual CSL that have returned for one or more years to Bonneville Dam (Table 8).

Table 8. Number of years that individually identified CSL and SSL were present at Bonneville Dam between 2002 and 2012 and the number that have been removed. Individuals present for less than one year (<1) were new animals identified in 2012.

Number of years present	All identified CSL	All identified SSL	Listed for Removal CSL	Removed/Known Dead CSL
8	6	0	6	4
7	4	1	4	2
6	1	1	1	0
5	19	6	18	7
4	26	6	22	6
3	40	14	23	14
2	64	34	36	14
1	278	120	21	7
<1	22	45	3	1

DETERRENTS AND MANAGEMENT ACTIVITIES

Physical Barriers

In 2012, SLEDs/FOGs were installed at the main fishway entrance of Cascades Island and PH2 on December 9, 2011, B-branch entrance on February 16, 2012, and PH1 entrances on February 22, 2012. 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 2012 despite significant predation activity near dam structures and high tailwater levels that over-topped the SLEDs and FOGs. SLEDs were removed from PH1 and B-branch entrances on June 28, 2012 and PH2 and Cascades Island on July 16, 2012.

As in the previous two years, no pinnipeds hauled out on the PH2 tailrace concrete apron along Cascades Island in 2012 (barring a few single short-term events), preferring instead to rest in pods near the shoreline or near the traps. Concrete blocks set on the concrete apron impeded haul out in this area and encouraged haul out on the traps.

Non-Lethal Harassment

No acoustic deterrent devices were deployed in 2012, as they have proved ineffective during testing from 2006 to 2010 under the conditions prevailing near the fishway entrances.

Boat crews from CRITFC hazed up to five days a week most weeks between March 1 and the mid-May, and their results will be presented in a separate report. USDA agents hazed from the dam on 92 days between March 1 and May 31. Table 9 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). In addition, boats were present for research or other work in the tailrace an additional 31.7 hours (primarily in the spillway) and although not actively hazing, their presence may have had an effect on pinnipeds as they have come to associate the noise of boats with hazing. Bird hazing (25.6 hours) may also have had some impact on pinnipeds.

Table 9. Total hours of hazing activity in the Bonneville Dam tailrace observation area in 2012. Data excludes weekends when observers were not present.

	Number of Times Hazers were Present at Least Once in an Hour		Total Time (Hours) Hazers were Present	
	Boat hazing	*Dam hazing*	*Boat hazing*	*Dam hazing*
Location				
Powerhouse 1	107	263	22.9	81.5
Powerhouse 2	46	193	13.9	46.2
Spillway	60	305	1.7	10.8
Total	*213*	*761*	*38.4*	*138.5*

As in past 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. Overall, actual active hazing was less than previous years.

Trapping and Removal

In 2012, personnel from ODFW and WDFW operated four traps in the Bonneville Dam tailrace area, as they have for the past several years. These traps were used to capture sea lions for branding, for application of acoustic and GPS transmitters, and for permanent removal of specific CSL from the population. Additional trapping occurs at Astoria, primarily for branding purposes. Twelve CSL that were on the list for removal were captured at Bonneville in 2012 plus one additional CSL in Astoria later in the year. Other captured CSL and SSL that were not already branded were given brands, and some were given an acoustic and/or GPS transmitter, and released at Bonneville. Successful trapping events are summarized in Appendix C.

In 2012, a total of 17 different CSL were captured at Bonneville. Of those, six were given brands, one an acoustic transmitter, one a GPS transmitter, one was relocated to Shedd Aquarium (C011), and 11 were euthanized (C01, C015, C016, C779, C019, C961, C04, C05, C013, U61 and U159). One additional CSL (C021) was trapped in Astoria and euthanized. Acoustic and GPS tracking data will be presented by ODFW, WDFW and CRITFC in a separate report (Brown et al., 2012, in prep.).

In addition, 20 SSL were trapped in 2012, 19 were branded (O18-O36), and one was already branded but given an acoustic transmitter. Of the remainder, eight were given acoustic

transmitters and seven GPS transmitters. Most were observed multiple days at Bonneville after release but a few were never seen at Bonneville again including one tracked to Dall Island, Alaska and another to Sitkain, Alaska (Wright, ODFW, personal communication).

Impact of the Removal of Selected California Sea Lions

There continued to be a large drop in both the CSL salmonid predation and CSL abundance in 2012 that began in 2011 (Figures 2 and 10, Tables 10 and 11) to levels not seen since 2003. These results show the impact of the three years of the CSL removal program conducted 2008 through 2010. It appears to indicate that the removal program was gradually reducing the abundance and predation on salmonids caused by CSL. However, the unusual event of the influx of large numbers of new CSL males showing up at Bonneville Dam tailrace in 2010, coupled with the virtual halting of removal actions in 2011, have and make further analysis of this program more difficult. It is also likely the reduction in predation on the early Chinook salmon runs is due to the removal of many of the returning CSL that tended to arrive earlier each year waiting for the arrival of Chinook salmon. The increasing presence and salmon predation by SSL at Bonneville Dam could also continue to complicate the issue if current trends persist. There was less clepto-parasitism observed in 2012 than last year, particularly by SSL on CSL, but it is unclear why this occurred (Table 12). Perhaps it was because there were fewer opportunities for that behavior as there were fewer CSL present and less CSL predation overall. And lastly, the removal of 12 CSL at Bonneville in 2012 obviously impacted the daily CSL abundance which was lower for this year.

Table 10. Consumption of adult (including jacks) salmonids by CSL and SSL at Bonneville Dam from January 1 through May 31, 2002 to 2012.

	California sea lions			Steller's sea lions		
Year	Expanded salmonid consumption	Salmonid consumption per capita	% of run (Jan 1 – May 31)	Estimated salmonid consumption	Salmonid consumption per capita	% of run (Jan 1 – May 31)
2002	1,010	33.7	0.4%	0	0.0	0.0 %
2003	2,329	22.4	1.1%	0	0.0	0.0 %
2004	3,516	35.1	1.9%	13	4.3	0.0 %
2005	2,904	35.9	3.4%	16	4.0	0.0 %
2006	2,944	40.9	2.7%	76	6.9	0.1 %
2007	3,846	54.2	4.2%	13	1.4	0.0 %
2008	4,294	52.4	2.8%	176	4.5	0.1 %
2009	4,014	74.3	2.1%	475	18.3	0.3 %
2010	5,095	57.2	1.9%	986	13.1	0.4 %
2011	2,527	46.8	1.1%	1,030	11.6	0.5%
2012	998	25.6	0.6%	1,109	15.2	0.6%

It is possible that the increasing presence of SSL, high flows (and correspondingly higher turbidity and lower temperatures), and late spring Chinook runs of the last two years have also been contributing factors to the decline of CSL abundance and predation. However, it should be pointed out that there have been even later runs of spring Chinook in the past 11 years (2006 and 2009). Also, CSL and SSL have co-mingled since 2006, and it is unclear whether SSL numbers are increasing due to the decline of CSL numbers, or of the increase in SSL numbers are

responsible for "driving out" some of the CSL. One would think higher flows, turbidity, and lower temperatures should have affected SSL the same as CSL, yet SSL abundance and predation were highest during the past two years.

Table 11. Maximum number of salmonids observed consumed by identified CSL at Bonneville Dam from January 1 through May 31, 2002 to 2012.

Year	Maximum number of salmonids caught by an individual CSL	Percentage of salmonid catches attributed to individual CSLs
2002	51	85.6%
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%
2010	198	51.9%
2011	125	41.7%
2012	41	53.0%

* Began observation season late, didn't have opportunity to train observers on individual CSL identification.

Table 12. Summary of expanded estimates of cleptoparasitism events observed at Bonneville Dam , 2002 to 2012. Most involve salmonids (e.g. we observed 490 Chinook, 20 steelhead, 4 sturgeon, and 16 unidentified prey stolen in 2010, all sturgeon being SSL from SSL events).

Year	CSL from CSL	CSL from SSL	SSL from SSL	SSL from CSL	Other	Total
2002	0	0	0	0	0	0
2003	14	0	0	0	0	14
2004	366	22	0	0	0	388
2005	22	0	0	22	6	50
2006	12	0	0	5	0	17
2007	33	0	0	4	0	37
2008	161	0	4	135	5	305
2009	152	4	7	324	6	492
2010	58	2	37	801	0	898
2011	2	0	12	279	0	293
2012	2	0	55	35	0	92

RECOMMENDATIONS

1. In light of increasing SSL presence and white sturgeon and salmonid consumption, the earlier and more protracted presence of SSL from October through May, and concurrent decrease in CSL presence and predation, we strongly suggest a continuation of this monitoring program at this level for four more years. The states again have received a permit to remove specific CSL from the Bonneville population. The full impact of removal of specific individual CSL cannot be fully measured until the subsequent years' monitoring is completed. However, long term monitoring efforts need to be discussed among the action agencies to determine the usefulness, resolution, and costs of the information obtained.
2. The Corps should continue to coordinate with agency partners performing observations in the area downstream of our study area, such as ODFW, Portland State University 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 and regional fish passage agencies should consider installing these barriers in the fall, or leaving them in place for the entire fish passage season.
4. 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.
5. ODFW/WDFW should strongly consider adding additional traps and/or additional methods for removal of more individuals each season (e.g. 30, not 10-15).
6. Use of an optical camera (e.g.critter-cam©) affixed to multi-year CSL early in the season would allow biologists to get a better understanding of how and where the sea lions are taking prey, and possibly if there is significant underwater consumption going on unobserved by surface observations.

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 Columbia River Inter-Tribal Fish Commission conducted the vast majority of the boat-based hazing program, while the USDA Wildlife Services continued 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. Bernard Klatte, and Sean Tackley (USACE) helped with study objectives, funding, and program support. The Bonneville Lock and Dam rigging crew should be commended for successfully deploying and removing SLEDs.

A very big thank you goes to all the observers who collected valuable data for us this year. Interns from the Student Conservation Association (SCA) did a great job with observations and assisting with data management. Kathryn Powers, Olivia Brown, Justine Hergert, Jaclyn Schultz, Brittany Balbag, and Mark Betzhold endured the extreme cold, snow, and rainy weather conditions this past winter and spring and performed admirably. Mike Jonas and Patricia Madson of the Fisheries Field Unit helped with observations in the fall of 2011 in addition to their other duties and their efforts helped increase the sample size for our fall work.

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Appendix A. Table of progressive estimates of pinniped predation on salmonids (also broken out by pinniped species) at Bonneville Dam, 2002-2012, adjusted for unidentified fish prey caught, and nighttime predation.

ADJUSTED FOR DAYLIGHT HOURS AND DAYS NOT OBSERVED									
			ALL PINNIPEDS		CALIFORNIA SEA LIONS		STELLER SEA LIONS		
	TOTAL HOURS OBSERVED	TOTAL SALMONID PASSAGE	ESTIMATED SALMONID CATCH	% RUN TAKEN	ESTIMATED SALMONID CATCH	% RUN TAKEN	ESTIMATED SALMONID CATCH	% RUN TAKEN	
2002	662	284,732	1,010	0.35%	1,010	0.35%	0	0.00%	
2003	1,356	217,934	2,329	1.06%	2,329	1.06%	0	0.00%	
2004	516	186,771	3,533	1.86%	3,522	1.85%	7	0.00%	
2005	1,109	81,252	2,920	3.47%	2,904	3.45%	16	0.02%	
2006	3,650	105,063	3,023	2.80%	2,944	2.73%	76	0.07%	
2007	4,433	88,474	3,859	4.18%	3,846	4.17%	13	0.01%	
2008	5,131	147,558	4,466	2.94%	4,294	2.83%	172	0.12%	
2009	3,455	186,056	4,489	2.36%	4,037	2.12%	452	0.24%	
2010	3,609	267,167	6,081	2.23%	5,095	1.87%	986	0.37%	
2011	3,315	223,380	3,557	1.57%	2,527	1.12%	1,030	0.46%	
2012	3,404	165,681	2,107	1.26%	998	0.60%	1,109	0.66%	

ADJUSTED FOR UNIDENTIFIED FISH									
			ALL PINNIPEDS		CALIFORNIA SEA LIONS		STELLER SEA LIONS		
	TOTAL HOURS OBSERVED	TOTAL SALMONID PASSAGE	ESTIMATED SALMONID CATCH	% RUN TAKEN	ESTIMATED SALMONID CATCH	% RUN TAKEN	ESTIMATED SALMONID CATCH	% RUN TAKEN	
2002	662	284,732	1,010	0.35%	1,010	0.35%	0	0.00%	
2003	1,356	217,934	2,329	1.06%	2,329	1.06%	0	0.00%	
2004	516	186,771	3,533	1.86%	3,522	1.85%	7	0.00%	
2005	1,109	81,252	2,920	3.47%	2,904	3.45%	16	0.02%	
2006	3,650	105,063	3,401	3.14%	3,312	3.06%	85	0.08%	
2007	4,433	88,474	4,355	4.69%	4,340	4.68%	15	0.02%	
2008	5,131	147,558	4,927	3.23%	4,738	3.11%	189	0.13%	
2009	3,455	186,056	4,960	2.60%	4,353	2.29%	607	0.33%	
2010	3,609	267,167	6,321	2.31%	5,296	1.94%	1,025	0.38%	
2011	3,315	223,380	3,971	1.75%	2,689	1.19%	1,282	0.57%	
2012	3,404	165,681	2,360	1.40%	1,067	0.64%	1,293	0.77%	

ADJUSTED FOR NIGHT HOURS NOT OBSERVED (AN ADDITIONAL 3.5% ADDED 2006-2010, 0.9% 2011-2112)									
			ALL PINNIPEDS		CALIFORNIA SEA LIONS		STELLER SEA LIONS		
	TOTAL HOURS OBSERVED	TOTAL SALMONID PASSAGE	ESTIMATED SALMONID CATCH	% RUN TAKEN	ESTIMATED SALMONID CATCH	% RUN TAKEN	ESTIMATED SALMONID CATCH	% RUN TAKEN	
2002	662	284,732	1,010	0.35%	1,010	0.35%	0	0.00%	
2003	1,356	217,934	2,329	1.06%	2,329	1.06%	0	0.00%	
2004	516	186,771	3,533	1.86%	3,522	1.85%	7	0.00%	
2005	1,109	81,252	2,920	3.47%	2,904	3.45%	16	0.02%	
2006	3,650	105,063	3,520	3.24%	3,428	3.16%	88	0.08%	
2007	4,433	88,474	4,507	4.85%	4,492	4.83%	15	0.02%	
2008	5,131	147,558	5,099	3.34%	4,904	3.22%	196	0.13%	
2009	3,455	186,056	5,134	2.69%	4,505	2.36%	628	0.34%	
2010	3,609	267,167	6,542	2.39%	5,481	2.01%	1,061	0.40%	
2011	3,315	223,380	4,007	1.76%	2,713	1.20%	1,294	0.58%	
2012	3,404	165,681	2,382	1.42%	1,077	0.65%	1,305	0.78%	

Appendix B. Maps (Figures B1-B3) of Bonneville Lock and Dam and vicinity, with predations zones shown.

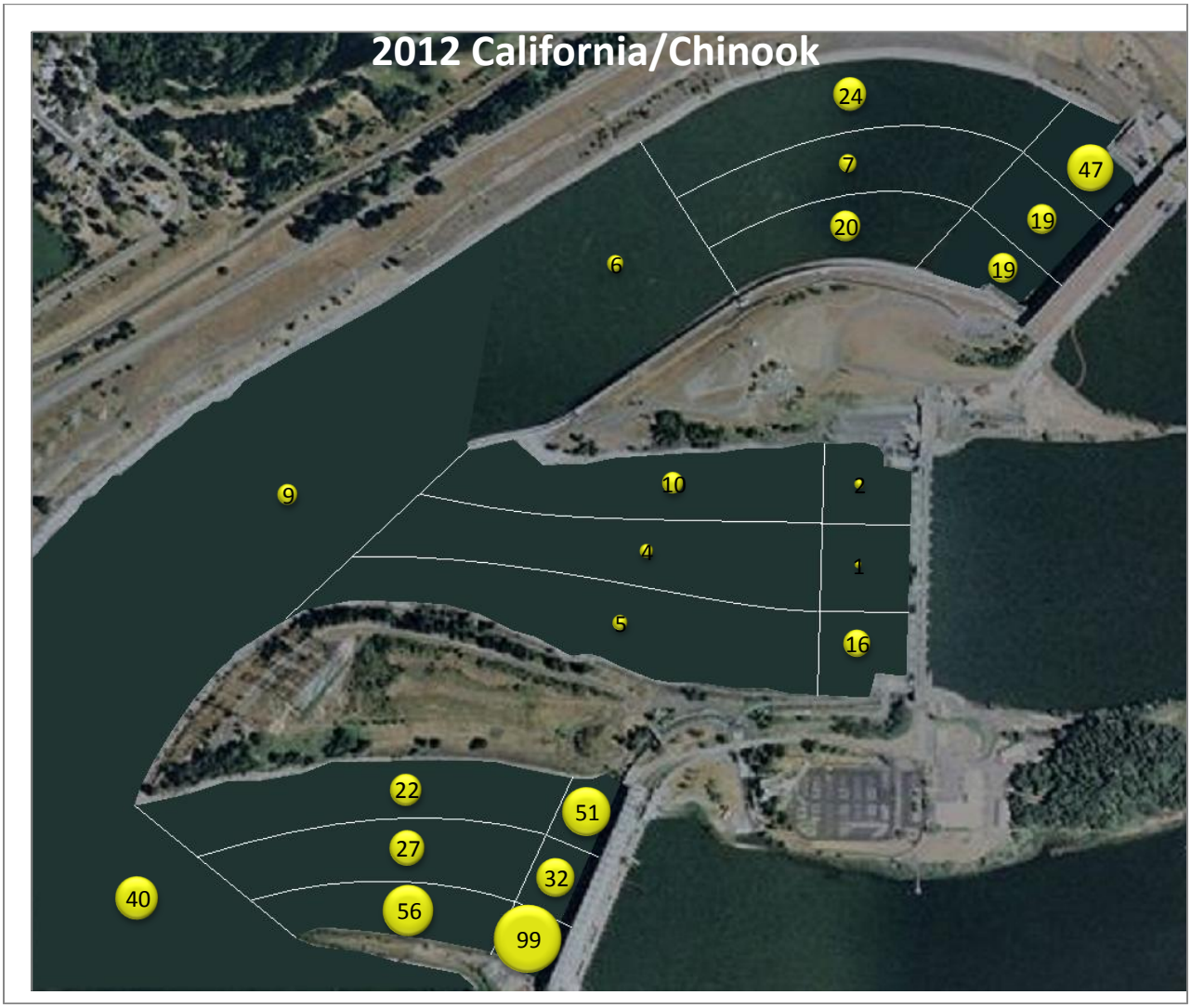

Figure B1. Frequency distribution by location of Chinook salmon caught by CSL at Bonneville Dam, 2012.

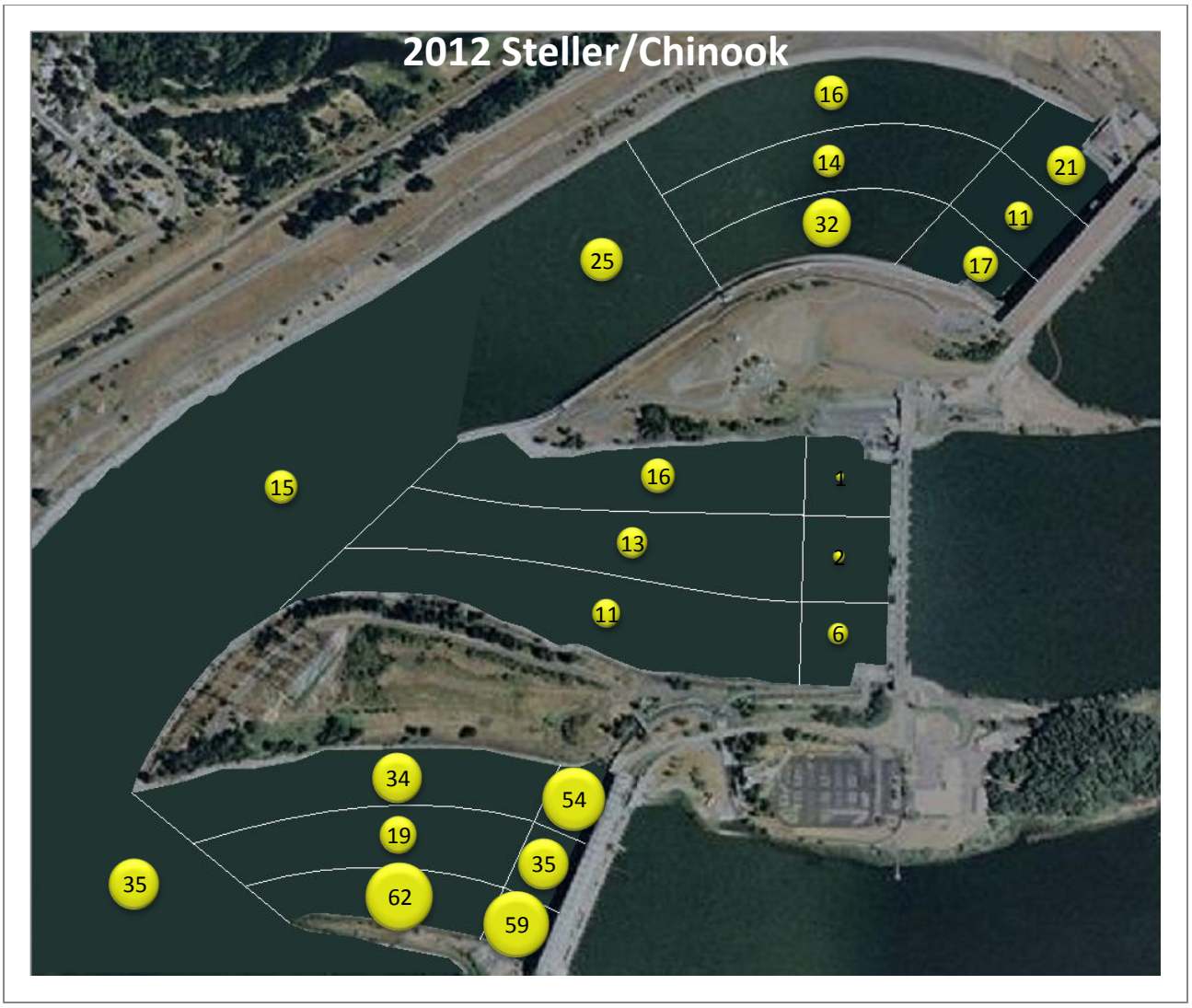

Figure B2. Frequency distribution by location of Chinook salmon caught by SSL at Bonneville Dam, 2012.

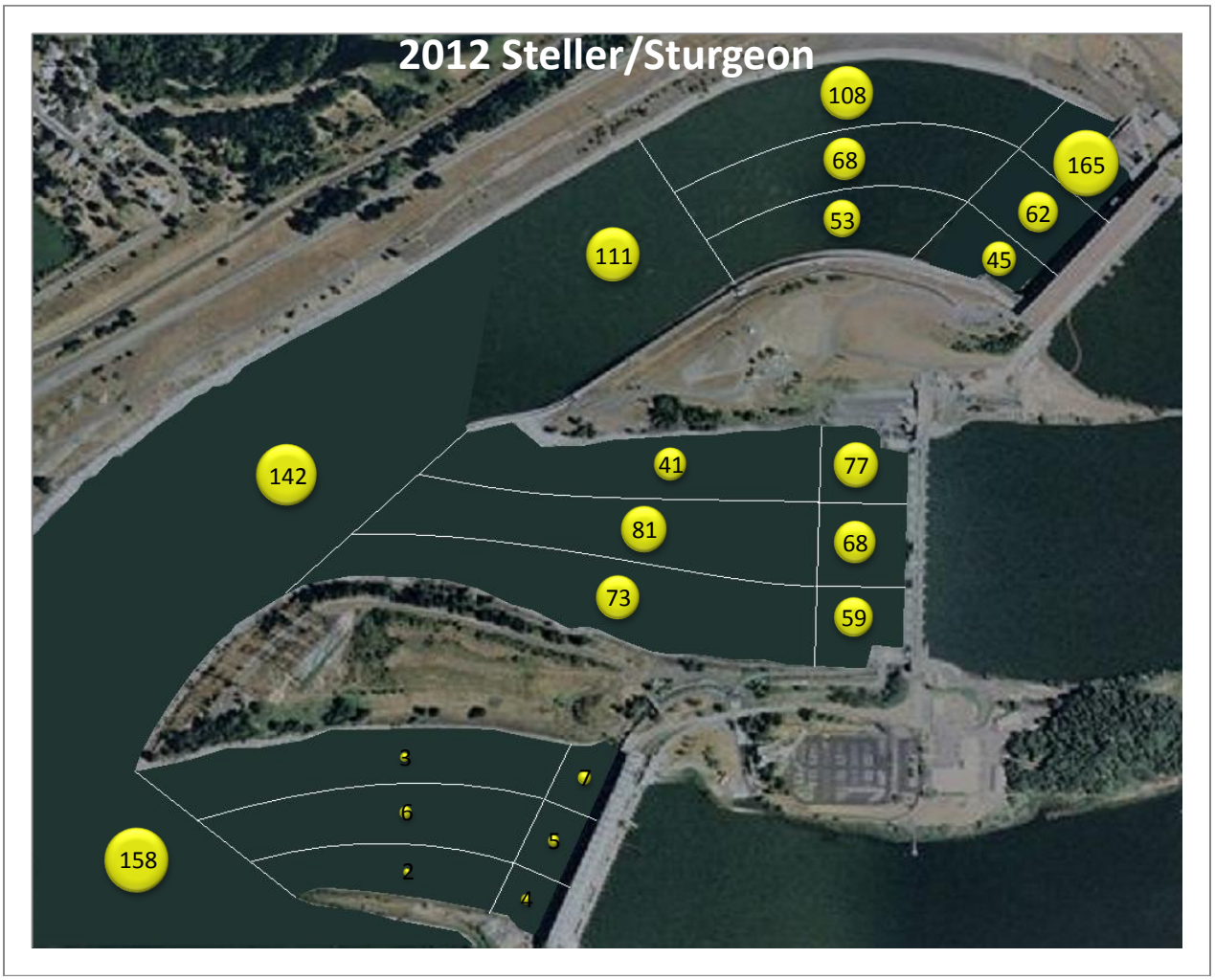

Figure B3. Frequency distribution by location of white sturgeon caught by SSL at Bonneville Dam, 2012.

Appendix C. List of CSL and SSL trapped at Bonneville Dam in 2011. (Yellow highlight denotes animal removed from population known to visit Bonneville Dam)

Species	*Sea lion ID*	*Capture date*	*On removal list?*	*Action*	*Additional information*
EJU	O18/S175	2/15/12		Released	Branded, GPS tagged and released, GPS lost by 4/10/12
EJU	O19	2/15/12		Released	Branded, GPS tagged and released
EJU	O20	2/15/12		Released	Branded, GPS tagged and released
EJU	O21	2/15/12		Released	Branded, GPS tagged and released
EJU	O22/S60	2/28/12		Released	Branded, GPS tagged and released, GPS lost by 4/11/12
EJU	O23/S179	2/28/12		Released	Branded, GPS tagged and released
EJU	O24/S29	3/20/12		Released	Branded, GPS tagged and released
EJU	O25	3/20/12		Released	Branded and released
EJU	O26	3/27/12		Released	Branded and released
ZCA	C01/B322	4/3/12	Yes	Euthanized	
ZCA	C015/B303	4/3/12	Yes	Euthanized	
EJU	O27	4/3/12		Released	Branded and released
EJU	O28	4/3/12		Released	Branded and released
EJU	O29/S7	4/3/12		Released	Branded and released
EJU	O30/S43	4/3/12		Released	Branded and released
EJU	O31/S180	4/9/12		Released	Branded and released
EJU	O32	4/9/12		Released	Branded and released
EJU	O33/S181	4/9/12		Released	Branded and released
ZCA	C016	4/9/12	Yes	Euthanized	
ZCA	C019/B367	4/9/12		Released	Branded, GPS tagged and released
ZCA	C020/B359	4/12/12		Released	Branded and released
ZCA	C779	4/12/12	Yes	Euthanized	
ZCA	C021	4/24/12		Released	Branded, acoustic pack tagged and released
ZCA	C022/B368	4/24/12		Released	Branded, acoustic pack tagged and released
ZCA	C023/B354	4/24/12		Released	Branded, acoustic pack tagged and released
EJU	O34	4/24/12		Released	Branded, acoustic pack tagged and released
EJU	O11/S156	4/24/12		Released	Acoustic pack tagged and released
ZCA	C019/B367	4/25/12	Yes	Euthanized	
ZCA	C011/B357	4/25/12	Yes	Relocated	Relocated to Shedd Aquarium, Chicago
ZCA	U65	4/25/12		Released	Acoustic pack tagged and released
ZCA	C961	4/25/12	Yes	Euthanized	
ZCA	C04/B331	4/25/12	Yes	Euthanized	
ZCA	C05/B334	4/30/12	Yes	Euthanized	
ZCA	C013/B356	4/30/12	Yes	Euthanized	
EJU	O35	5/1/12		Released	Branded, acoustic pack tagged and released
EJU	O36/S182	5/8/12		Released	Branded and released
ZCA	U61/B315	5/16/12	Yes	Euthanized	
ZCA	U159/B327	5/16/12	Yes	Euthanized	
ZCA	C024/B369	5/16/12		Released	Branded and released
ZCA	C021	8/30/12	Yes	Euthanized	Astoria

Note – Some animals have both a “C”, “U” or “O” brand and a “B” or “S” code as these individuals were originally identified through documentation of natural physical features and were subsequently branded either at Bonneville Dam or Astoria. Additional animals were trapped and released without any handling.