2011 FIELD REPORT:

EVALUATION OF PINNIPED PREDATION ON ADULT SALMONIDS AND OTHER FISH IN THE BONNEVILLE DAM TAILRACE, 2011

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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 richardsi*) 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 wild spring Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*) in the tailrace of the dam. The USACE and partnering agencies have utilized 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 2011, data from 2002 to the present are also presented for comparison.

The Pinniped/Fishery Interaction Task Force, established to provide guidance to the National Oceanic and Atmospheric Administration (NOAA) for determining a course of action to reduce pinniped predation on ESA-listed salmonids at Bonneville Dam, required a check-in after three years to determine if the selected actions (particularly removal of select California sea lions) are having the desired effect. 2010 was the third year California sea lion removals had occurred, however the full impact of removals could not be fully evaluated until after results of the 2011 spring season.

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's 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 removal program of specific CSL 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. Those 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 unseen by observers, 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. Other locations were observed when time and resources allowed. Prey species were identified when possible and size (for white sturgeon) was estimated. Individual pinnipeds were identified 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 2011, regular observations began the hour of sunrise and ended the hour of sunset with one hour breaks in the morning and afternoon, and the break hour changing each day. Observations were occasionally conducted at night and were factored into the equation for determining adjusted night 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 at night. In 2011, as in 2010, the location of predation events was recorded into zones. Each tailrace was broken up into seven zones (Figure 1).

This study period was 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 a few SSL were observed catching and consuming white sturgeon in the Bonneville Dam tailrace and farther downstream between September and December in 2010. In 2011, regular observations began January 7 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 (where predation events are first observed and recorded) at Bonneville Dam, 2011.

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 night-time predation. For a variety of reasons, observers were sometimes unable to identify the fish caught during a predation event. We can make more realistic estimates of salmonid and sturgeon take beyond the total *expanded consumption estimate* by attributing "unknown" prey to specific species based on the proportion of known prey observed taken 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. We also estimated night-time consumption and added 0.9% to the daily estimates based on our night work in 2011. 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 night-time 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 video recorders equipped with either 12X or 24X optical zoom lenses, 35mm cameras, 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.

Unique individual pinnipeds identified in the field were video-taped, and/or sketched to document the characteristics that made it unique from others seen at Bonneville Dam. The sketches were made available to all observers and the individual animals were typically given temporary names in the field to aid in identification across observers. 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 2011 physical barriers (sea lion exclusion devices or SLEDs and floating orifice gate barriers or FOG's) were re-deployed to keep pinnipeds out of the fishways and the USDA (dam based) and CRITFC (boat based) continued non-lethal harassment (hazing) techniques. However, the Acoustic Deterrent Devices (ADD's) were not deployed and the states were prevented from continuing the removal program for most of the season subsequent to the 9th Circuit Court of

Appeals ruling in November 2010 to vacate the permit NOAA had granted the states of Oregon and Washington until several issues were addressed.

SLEDs and FOG's were installed at all operating main fishway entrances by the week of February 20 and SLED's were removed on July 5. Both were effective and no pinnipeds entered the fishways during the 2011 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 each year.

Boat-based hazing in 2011 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 ceased 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, and 2010.

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.

RESULTS AND DISCUSSION

PREDATION ACTIVITY

Between January 7 and May 31, 2011, observers completed over 3,315 hours of observations. During this period, observers saw pinnipeds catch and consume 4,489 fish of several species. Adult salmonids were the primary prey item, comprising 48.7% (n=2,186) of observed catches. White sturgeon and American shad (*Alosa sapidissima*) were the second and third most commonly identified prey types, comprising 30.1% (n=1,353) and 2.1% (n=93) of total observed catch respectively. Observers were unable to identify 18.6% (n=833) of the fish caught and consumed by pinnipeds during this period. This was higher than any previous year and was primarily due to Steller sea lions taking prey in the far downstream range of the viewing areas.

No CSL were observed at Bonneville Dam in the fall of 2010. However, several SSL were observed feeding on surgeon between September and December 2010. Since observations were opportunistic and intermittent, expansions were not made for these catches.

Predation on Adult Salmonids

In 2011, the expanded adult salmonid consumption estimate for the Bonneville Dam tailrace observation area was 3,557 or 1.6% of the adult salmonid run at Bonneville Dam from January 1 through May 31. Accounting for unidentified fish, the adjusted estimated consumption was 3,971 (or 1.8% 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 night-time consumption factor after hazing began (in 2006) can be seen in Appendix A. The estimated number of adult salmonids consumed increased each year since 2005 until 2011 (Figure 2), and the estimated percent of the run taken has declined each year since a high of 4.2% in 2007, reflecting an increase in the run size each year since 2007 (Figure 3). CSL were the primary predator of salmonids, accounting for 70.9% (n=1,550) of the 2,186 observed catches in 2011 (Table 2). This percentage is lower than was seen in previous years, as 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 and 16.2% (n=634) in 2010 to 29.1% (n=636) in 2011. The drop in CSL salmonid predation in 2011 relative to previous years and the continuing rise in SSL salmonid predation each year can be seen in Figure 4.

The 2011 spring Chinook salmon run was later than previous years except for 2006 and the third largest since 2002 (Figure 3). Chinook salmon were the most commonly identified prey species, comprising 91.9% (n=2,010) of observed adult salmonid catch in 2011. The expanded Chinook salmon consumption estimate for the Bonneville Dam tailrace in 2011 was 3,298 or 1.2% of the Chinook salmon run (including jacks) at Bonneville Dam 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, which extends beyond the period during which sea lions are normally present. Steelhead comprised about 8.1% (n=176) of observed adult salmonid catch during the same period in 2011. 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. 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.

Table 1. Consumption of salmonids by CSL, SSL, and harbor seals at Bonneville Dam tailrace, from surface observations conducted between 2002 and 2011. 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 %	N/A	N/A
2003	217,185	2,329	1.1 %	N/A	N/A
2004	186,804	3,533	1.9 %	N/A	N/A
2005	82,006	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	147,543	4,466	2.9 %	4,927	3.2 %
2009	186,060	4,489	2.4 %	4,960	2.7 %
2010	267,194	6,081	2.2 %	6,321	2.4 %
2011	223,380	3,557	1.6%	3,970	1.8%

Table 2. CSL and SSL predation on adult salmonids at Bonneville Dam, from January 1 through May 31, 2011. (See Table 1 for definition of expanded and adjusted estimates).

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	1,550	2,527	1.1 %	2,689	1.2 %
SSL	636	1,030	0.5 %	1,282	0.6 %

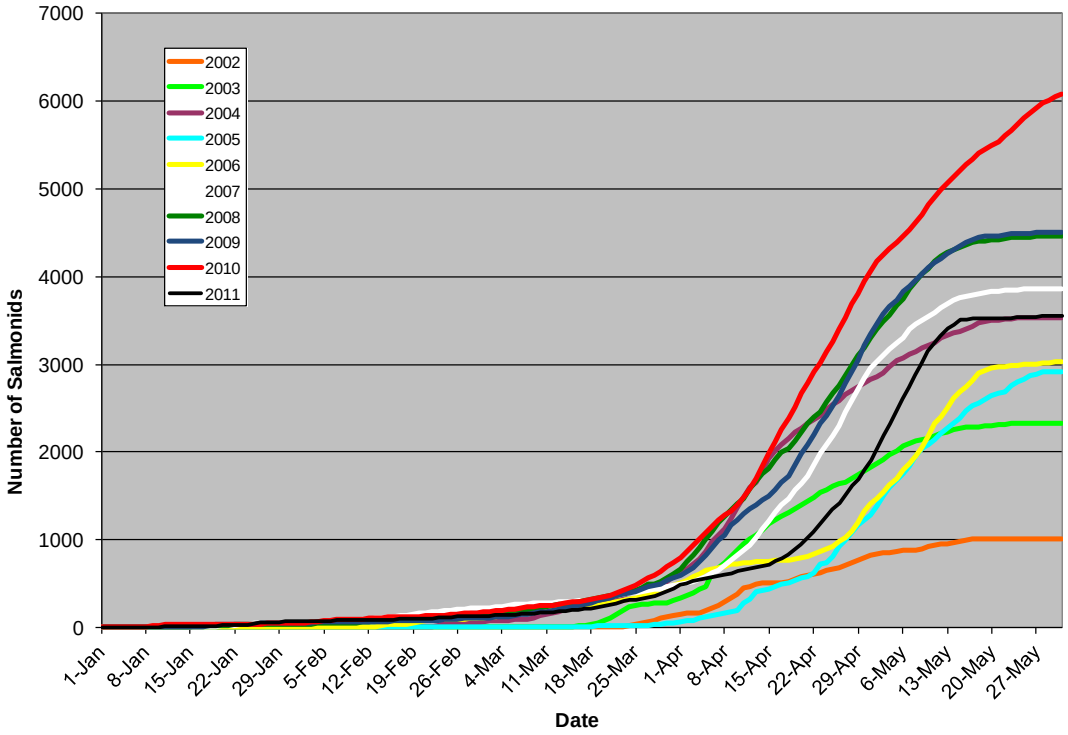

Figure 2. Cumulative salmonid catch by pinnipeds at Bonneville Dam, 2002 to 2011.

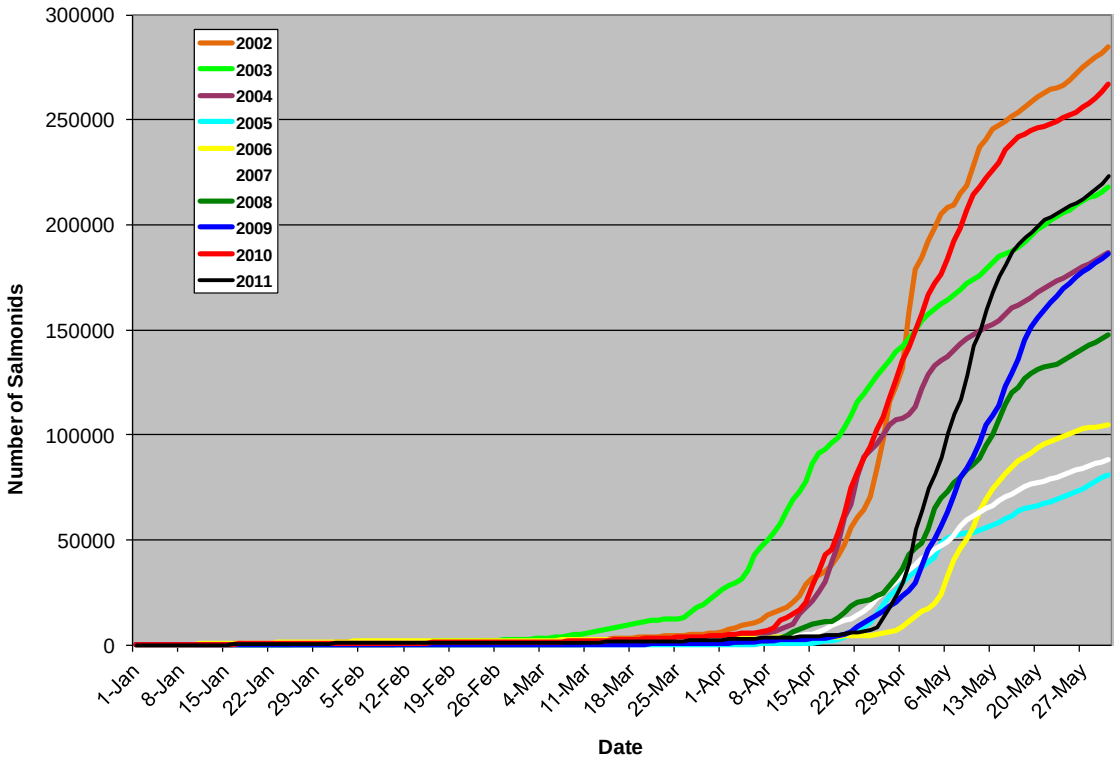

Figure 3. Cumulative daily counts of adult (including jacks) Chinook salmon and steelhead passing Bonneville Dam, 2002 to 2011.

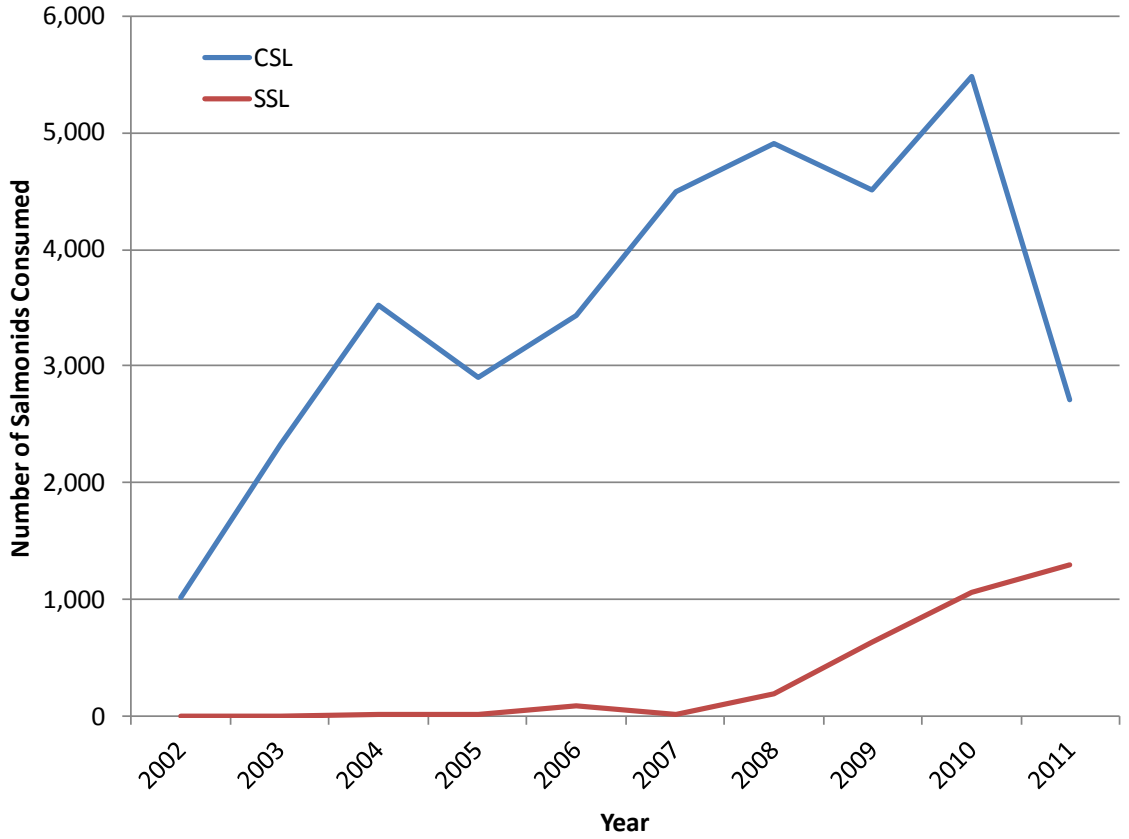

Figure 4. Adjusted (to include unknown and night-time predation) salmonid consumption estimates for CSL and SSL at Bonneville Dam, 2002-2011.

Table 3. Consumption of spring Chinook salmon by pinnipeds at Bonneville Dam between 2002 and 2011.

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%

* 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 2011, the expanded white sturgeon consumption estimate for our study area was 2,178, 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 3,003. White sturgeon were the most commonly observed prey for SSL. White sturgeon made 99.8% (n=1,350) of the 1,353 observed sturgeon catches in 2011. SSL were known to be catching and consuming sturgeon in the vicinity of Bonneville Dam as early as October 2010, so observed and expanded catches represent minimum catch and do not include the predation outside the normal observation period. CSL took less sturgeon this year (3 observed) than the last three years (6, 37 and 9). This could be due to the removal of the larger CSL in the last few years. These larger individuals would also tend to return early in the year, and so may have had more of an opportunity and desire to eat sturgeon until the salmon run showed up. Predation on sturgeon dropped off dramatically after the last week of March when spring Chinook salmon began to show up and became the preferred prey of both SSL and CSL by mid-April (Figure 5).

Table 4. Consumption of white sturgeon by pinnipeds at Bonneville Dam from 1 January through 31 May, 2005 to 2011.

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

When possible, observers estimated the total lengths of sturgeon caught by pinnipeds in one foot increments. The estimated total lengths of sturgeon caught between 2006 and 2011 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 6).

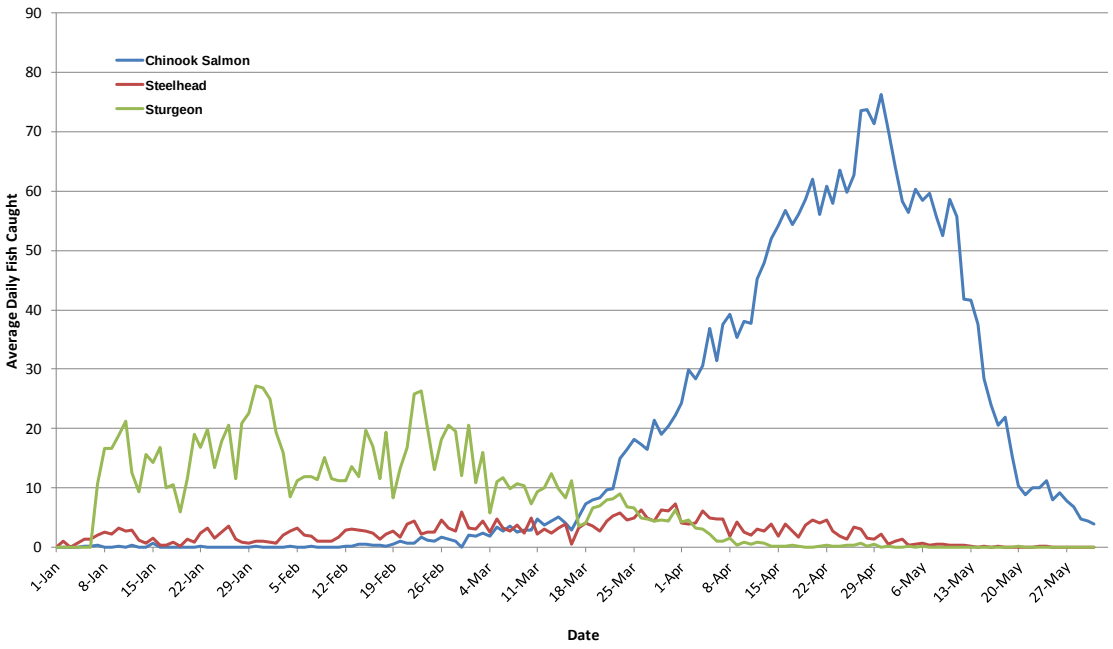

Figure 5. Daily average estimated Chinook salmon, steelhead, and white sturgeon caught by both SSL and CSL at Bonneville Dam from January 1 through May 31, 2006 to 2011.

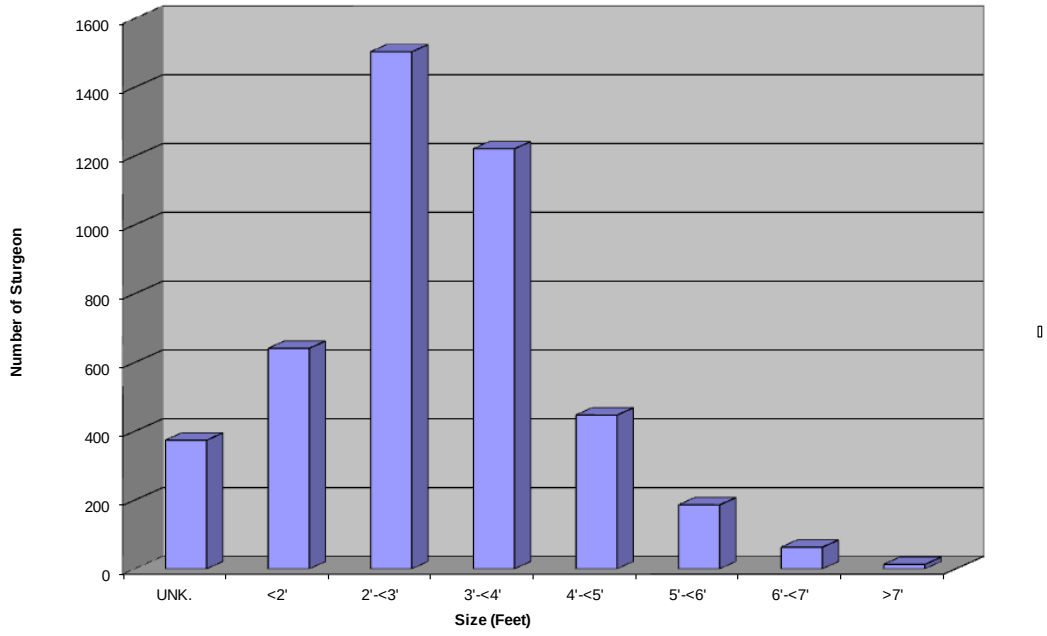

Figure 6. Estimated total lengths of white sturgeon consumed by SSL and CSL at Bonneville Dam, from January 1 through May 31, 2006 to 2011.

Predation on Pacific Lamprey

In 2011, the expanded Pacific lamprey consumption estimate was 33, fewer than any previous year (Table 5). CSL made 14 of the 16 observed lamprey catches in the Bonneville Dam observation area. Lamprey catch also comprised the lowest proportion of total observed catch (0.4%) since 2002. 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 likely underestimate should be equal among years, so the drop in lamprey predation observed is more likely a factor of lower numbers of lamprey available to be preyed upon, which is supported by the overall drop in lamprey passage numbers at Bonneville Dam (Figure 7). The lamprey passage season is mid-May through October.

Table 5. Consumption of Pacific lamprey by pinnipeds at Bonneville Dam from January 1 through May 31, 2002 to 2011.

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%

Location of Predation Events

There appeared to be a preference in predation locations between CSL and SSL. Salmonid take by CSL seem to be primarily near the dam at PH1, more evenly distributed at PH2 and farther downstream at the spillway than we saw in 2010 (Appendix Figure B-1). SSL predation on Chinook salmon occurs more mid-tailrace at PH2 and the spillway, but this year was more evenly distributed at PH1 (Appendix Figure B-2). SSL predation on sturgeon was again, primarily far downstream in zone 7, but more predation was seen near the dams this year compared to previous years (Appendix Figure B-3). This preponderance of downstream sturgeon predation indicates we are likely underestimating sturgeon take, as many of those activities 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 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, this is simply the location 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.

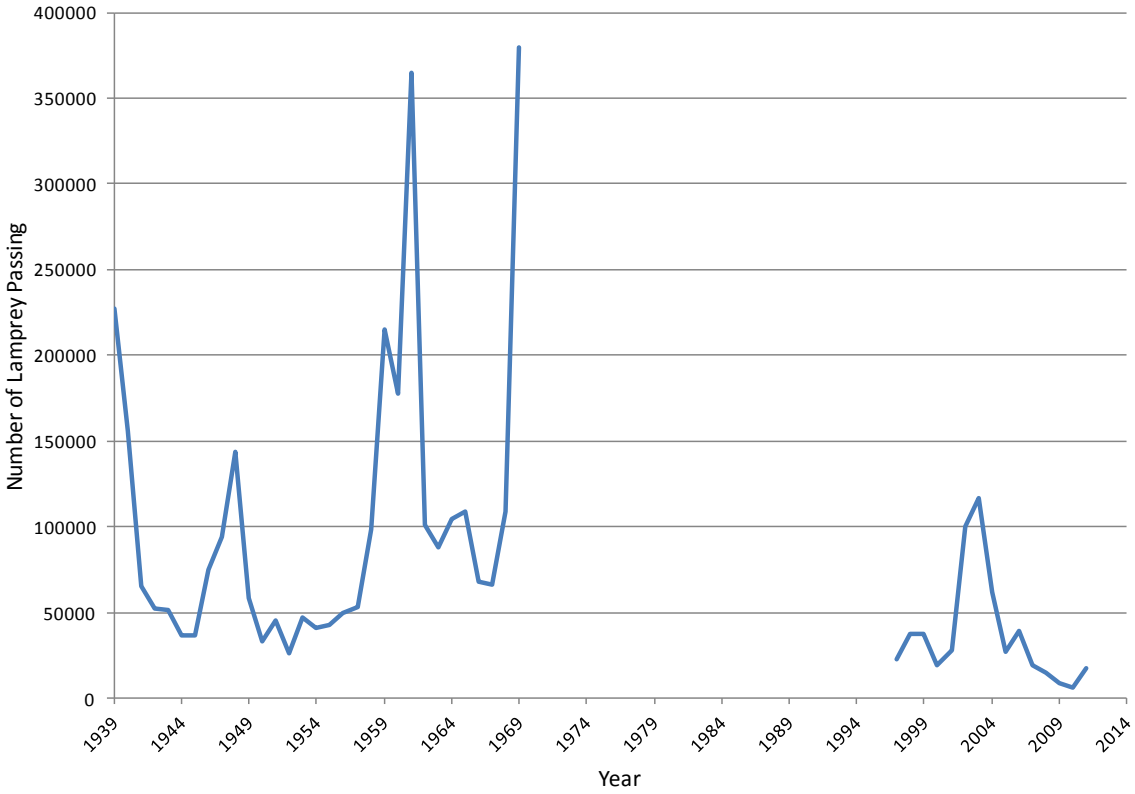

Figure 7. Lamprey passage estimates at Bonneville Dam since 1939 to 2011. Lamprey were not counted at Bonneville Dam from 1970 to 1996.

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; more have been seen taken at PH2 the past three years.

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

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

Night Observations

Twenty eight hours of night time observations were made on three nights in 2011. Although data for previous years (Stansell, et al., 2009) suggested an additional 3.5% of predation events could occur after dark during the season, we found predation accounted for only an additional 0.9% in 2011. This could be the result of slightly less boat and dam based hazing effort the last few years. Predation estimates for salmonids adjusted to include night-time predation estimates can be seen in Appendix A.

Additional Observations

Observations outside the standard tailrace viewing area were occasionally made. Over 14 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 take 14 Chinook, one lamprey, and one unknown fish, and SSL took 3 Chinook. Occasional observations were also made in June, where one CSL was observed on both June 6 and June 16.

On April 15, CSL (designated B325) was documented to have passed through the navigation lock upstream and was in the forebay. On April 23, it was confirmed that a second CSL (designated B358) was also up in the forebay. The states put one trap upstream of the dam and on May 20 caught B358, branded him C018, and released him below the dam. B325 has eluded capture and remains upstream at the time of this report, being seen as far upstream as The Dalles marina on a private dock and several locations in between.

PINNIPED ABUNDANCE, RESIDENCE TIMES, AND RECURRENCE

The estimated number of individual pinnipeds observed at Bonneville Dam in 2011 was 144, lower than last year but the second highest since observations began in 2002 (Table 7). SSL numbers continued to rise in 2011 to 89 individuals. The 32 SSL observed on one day in 2011 was not as high as the 53 SSL seen last year. CSL numbers dropped in 2011 to 54 after jumping up to 89 in 2010. Over the past two years, unusually large numbers of CSL have moved north of California after the summer breeding season. In 2009 this was likely the result of a significant warm water event related to El Nino that caused many CSL to move northward in search of cooler waters and abundant prey. In 2009 and 2010, increasing numbers of young, sub-adult sea lions have been observed at many locations in Oregon and Washington (Robin Brown, ODFW, Steve Jeffries, WDFW, pers. comm.). The increase in CSL at Bonneville Dam in 2010, many of which were not seen at the dam before, could be the result of this large group of young males exploring new areas, such as the Columbia River, to prey on fish. Many of these animals had not been seen at the dam before. 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) that made identification of individuals challenging. These abundance figures should be considered minimum estimates.

Daily pinniped abundance peaked in April 2011 (Figure 8), primarily due to SSL numbers. The highest number of pinnipeds counted on any one day in 2011 was 48 (April 26), which was lower than 2010 and comparable to 2009 in which we saw the first reduction in peak numbers

since we began monitoring (Figure 9). Mean daily number of pinnipeds present was 17.5 in 2011, the lowest since 2007 (Figure 9). The CSL component (5.5 per day) shows far fewer animals present daily on average than we have seen since 2002 and the maximum seen on any one day (25) has been virtually the same the last three years and fewer than any other year since 2002 (Figure 10). However, SSL were present in similar numbers (12.0 per day) in 2010 and 2011, both of which are higher than previous years (Figure 11).

Table 7. Minimum estimated total number of individual pinnipeds observed at Bonneville Dam from 2002 to 2011.

	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

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

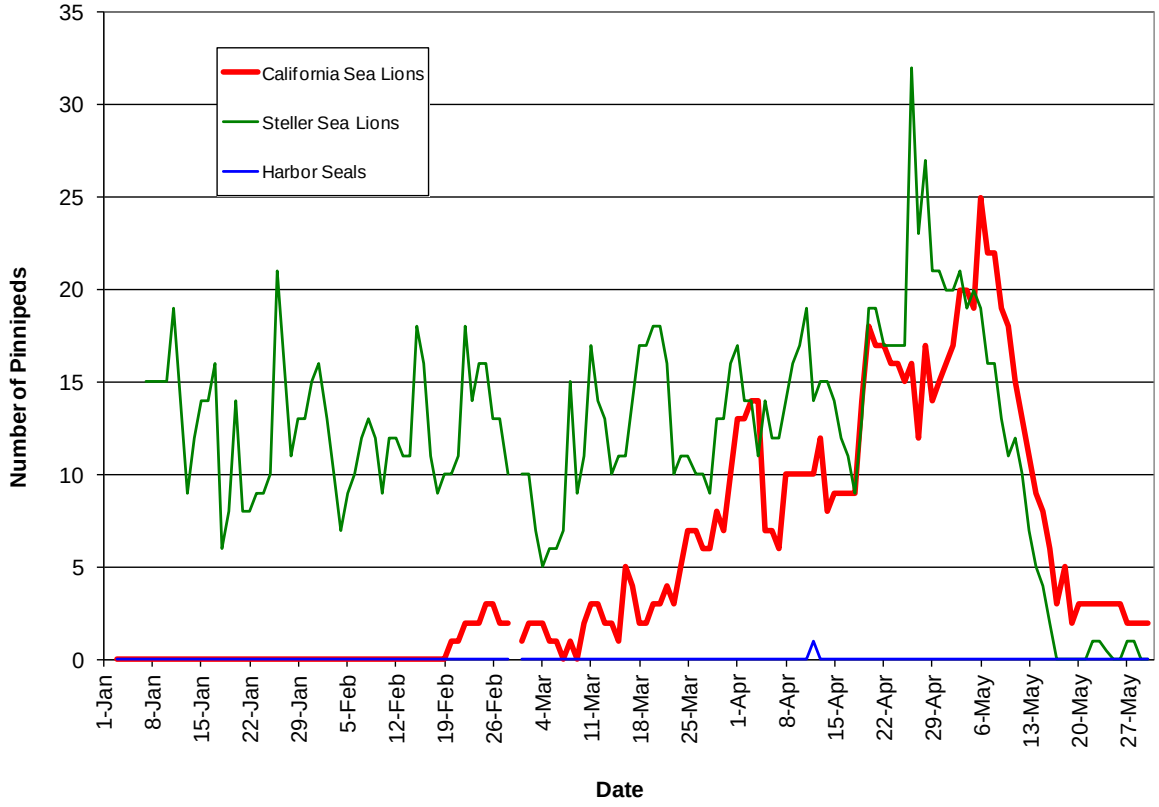

Figure 8. Daily abundance estimates for CSL, SSL, and harbor seals at Bonneville Dam from January 1 through May 31, 2011.

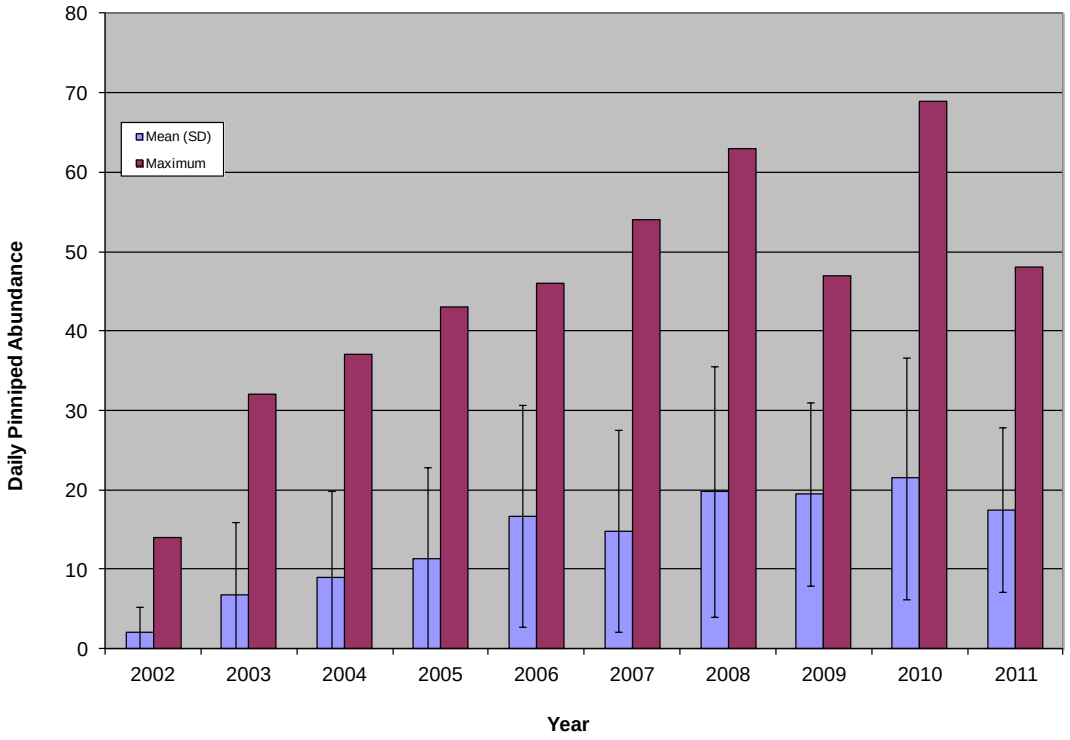

Figure 9. Mean, standard deviation, and maximum daily estimated number of pinnipeds present at Bonneville Dam between January 1 and May 31, 2002 to 2011.

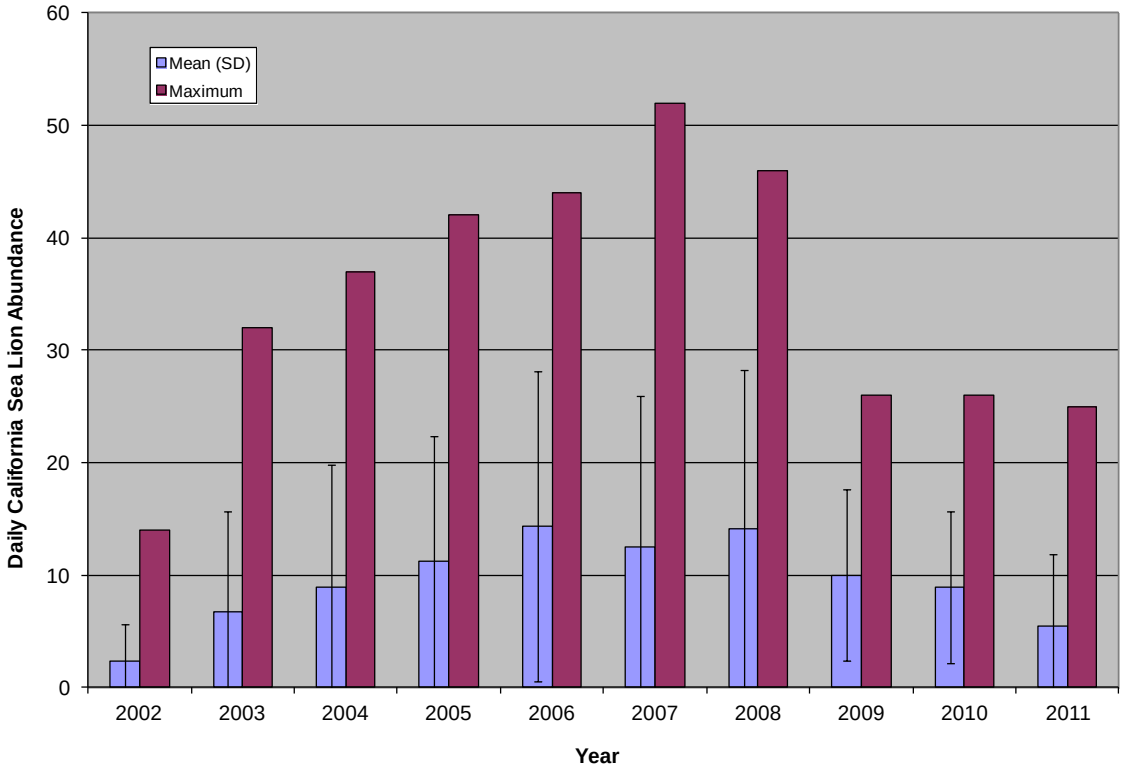

Figure10. Mean, standard deviation, and maximum daily estimated number of CSL present at Bonneville Dam between January 1 and May 31, 2002 to 2011.

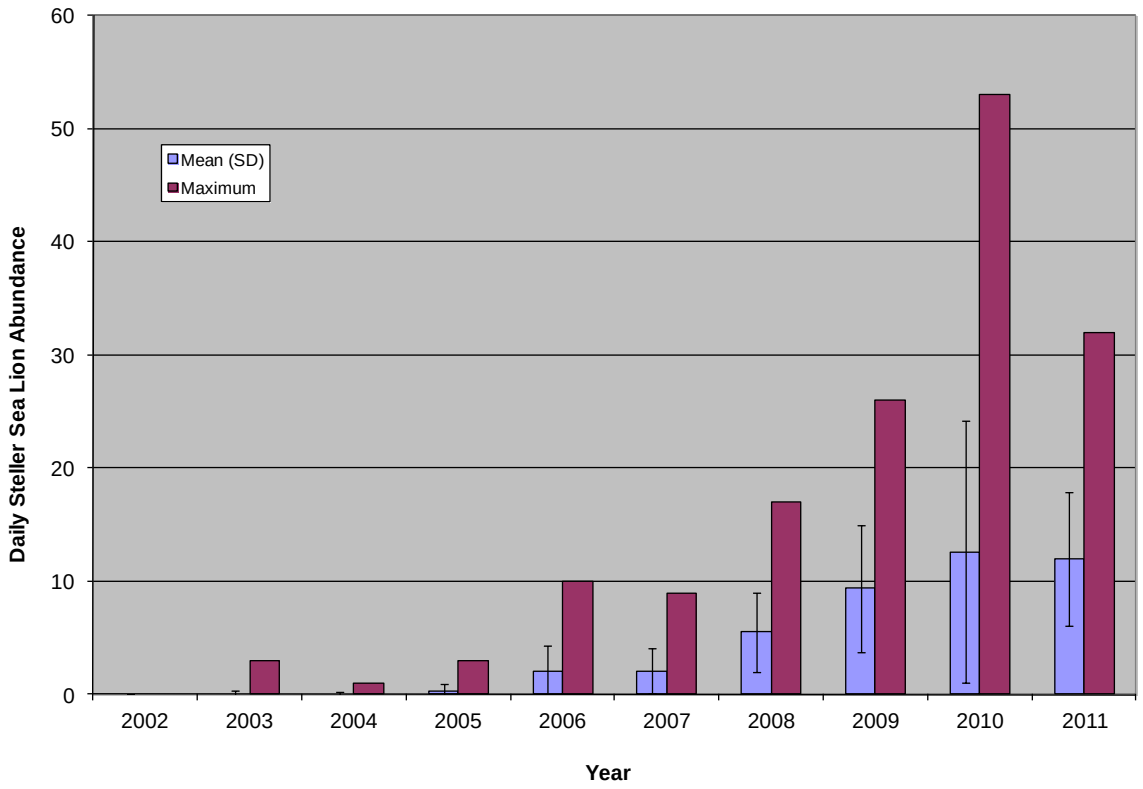

Figure 11. Mean, standard deviation, and maximum daily estimated number of SSL present at Bonneville Dam between January 1 and May 31, 2002 to 2011.

The most number of days an individual CSL was observed at Bonneville Dam was 31 days in 2011, the lowest since 2004 (Figure 12). The first CSL was observed on February 21 in 2011, later than any year since 2004. Many of the individuals returning multiple years have been removed over the previous three years, and this may account for the trend of individuals now arriving later in the season and spending less time at Bonneville Dam.

CSL not previously identified continue to show up each year. Of the 48 highly identifiable animals observed in 2011, 17 (35.4%) were new additions to that category (including 6 branded and 7 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% and 64.6% for 2003 through 2011, respectively. The phenomenon seen in 2010, where more new individuals were identified than returning individuals (explained in the first paragraph of this section) was likely a one-time event. We have observed over 150 individual CSL that have returned for one or more years to Bonneville Dam (Table 8).

SSL are more difficult to identify to individual than CSL, mostly because they generally stay farther away from the dam structures than CSL and tend to be more easily moved downstream by hazing activities.

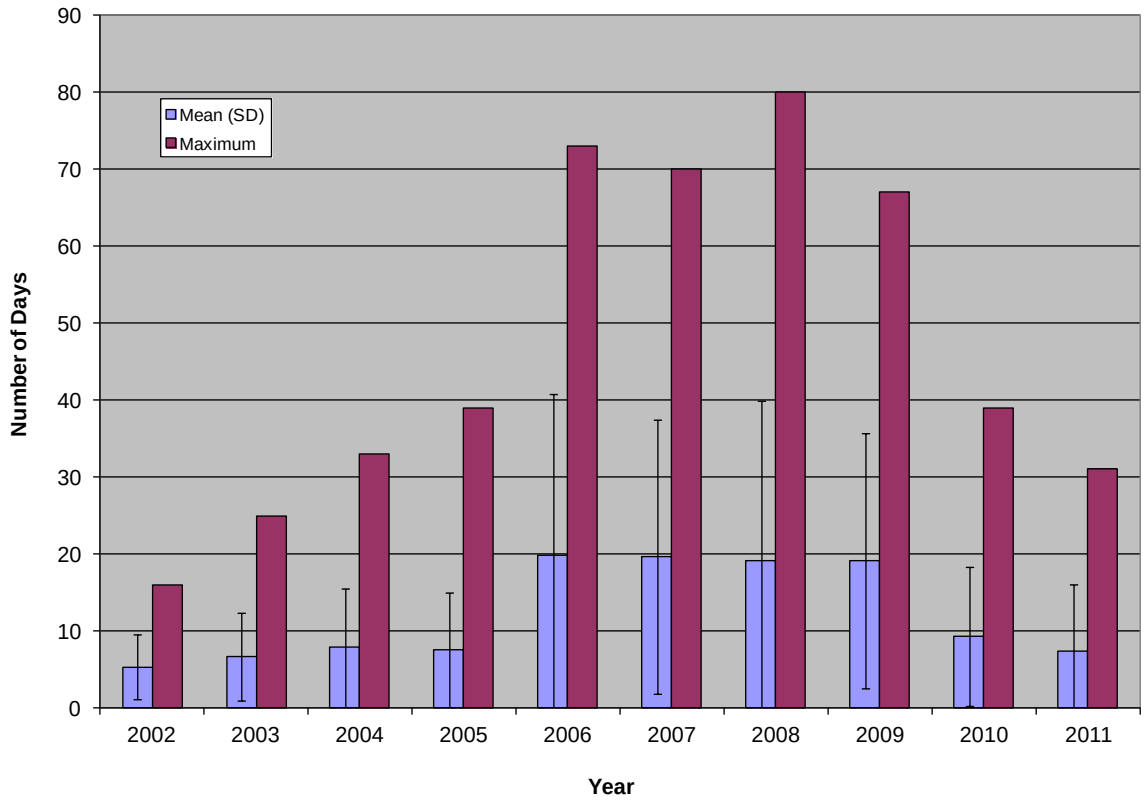

Figure 12. Mean, standard deviation,and maximum number of days individually identified CSL were observed at Bonneville Dam between January 1 and May 31, 2002 to 2011.

Table 8. Number of years that individually identified CSL were present at Bonneville Dam between 2002 and 2011 and the number that have been removed. Individuals present for less than one year (<1) were new animals identified in 2011.

Number of years present	All identified CSL	All identified SSL	Removal list CSL	Removed CSL
8	6	0	6	4
7	4	1	4	2
6	1	0	1	0
5	17	1	17	7
4	23	9	18	4
3	33	7	16	8
2	68	28	27	7
1	267	78	17	5
<1	24	58		

DETERRENTS AND MANAGEMENT ACTIVITIES

Physical Barriers

In 2011, SLEDs/FOGs were installed at the main fishway entrance of B-branch and PH1 on January 19 and at Cascades Island and PH2 during the week of February 20 (when the PH2 fishways came back in service). 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 2011 despite significant predation activity near dam structures and high tailwater levels toward the end of May that over-topped the SLEDs and FOGs. SLEDs were removed from all main entrances on July 5 and FOGs removed in August.

As in 2010, no pinnipeds hauled out on the PH2 tailrace concrete apron along Cascades Island in 2011, preferring instead to haul out on the rip-rap below the concrete or rest in pods near the shoreline, sometimes half in, half out of the water. At other times they would simply raft near the traps. Concrete blocks set on the concrete apron to impeded haul out in this area and encourage haul out on the traps. For the first few months, many pinnipeds did use the floating traps, however, these were mostly SSL which would fill up the trap and block access for most of the CSL, which defeats the purpose of trying to get more SSL to use the traps.

Non-Lethal Harassment

No acoustic deterrent devices were deployed in 2011, as they have proved ineffective during testing from 2006 to 2010 under the conditions prevailing near the fishway entrances.

CRITFC hazed from boats five days a week most weeks between February 28 and the end of May, and their results will be presented in a separate report. USDA agents hazed from the dam on 93 days between February 28 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).

Table 9. Total hours of hazing activity in the Bonneville Dam tailrace observation area in 2011. 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	177	246	31.3	106.4
Powerhouse 2	85	277	21.5	77.5
Spillway	74	238	8.7	37.4
Total	*336*	*761*	*61.5*	*221.2*

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. The high adult salmonid and sturgeon consumption estimates seen over the past several years suggest that, at best, hazing at the current level of intensity only slows the increase of predation.

Trapping and Removal

In 2011, 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 brand and apply acoustic transmitters and GPS transmitters to CSL and SSL. Captured CSL and SSL that were not already branded were given brands, and some were given an acoustic transmitter and/or GPS

transmitter, and released at Bonneville. Successful trapping events are summarized in Appendix C.

In 2011, a total of 13 different CSL were captured at Bonneville. Of those, nine were given brands and acoustic and/or GPS transmitters (C010-C018), and four which were previously branded and given acoustic/and/or GPS transmitters (C287, C930, C971, and C06). All of these CSL were released after branding or tagging. Three CSL were on the list for removal, and seven more would have qualified had the states permit not been vacated for most of the season. During a brief period of removal authority, the states did trap and remove one CSL in Astoria late May 2011, before an agreement was made to halt further removal actions in 2011 pending additional legal decisions. Acoustic and GPS tracking data will be presented by ODFW and CRITFC in a separate report (Wright et al., 2011, in prep.).

In addition, 10 SSL were trapped in 2011, branded (O009-O17), and given acoustic and/or GPS tags. Most were observed multiple days at Bonneville after release.

Impact of the Removal of Selected California Sea Lions

There is little analysis to add to what was covered in Stansell et al., 2010 other than to point out the large drop in both the CSL salmonid predation and CSL abundance for 2011 (Figures 2 and 10, Tables 10 and 11) to levels not seen since 2003. These results show the full impact of the three years of the CSL removal program conducted 2008 through 2010, as the full impact of those animals removed in 2010 could not be fully realized until the results of the 2011 season were in. It does appear 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 will make further analysis of this program more difficult. 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 2011 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.

Table 10. Consumption of adult (including jacks) salmonids by CSL and SSL at Bonneville Dam from January 1 through May 31, 2002 to 2011.

Year	California sea lions			Steller's sea lions		
	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%

Table 11. Maximum number of salmonids observed consumed by identified CSL at Bonneville Dam from January 1 through May 31, 2002 to 2011.

Year	Maximum number of salmonids caught by an individual CSL	Percentage of salmonid catches attributed to individual CSLs
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%
2010	198	51.9%
2011	125	41.7%

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

Table 12. Summary of expanded estimates of clepto-parasitism events seen at Bonneville Dam , 2002 to 2011. Virtually all involve salmonids (e.g. we observed 490 Chinook, 20 steelhead, 4 sturgeon, and 16 unidentified prey stolen in 2010, the 4 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

RECOMMENDATIONS

1. In light of increasing adult salmonid and white sturgeon catch, the earlier and more protracted presence of CSL and SSL from January through May (and recent fall observations), and potential management actions by wildlife management agencies, we strongly suggest a continuation of this monitoring program at this level for three more years. 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 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. The Corps should work with ODFW and WDFW to determine if the use of barriers to prevent sea lions from hauling out near the dam is effective and beneficial to the long term goal of reducing the presence and predation of sea lions near the dam. If so, the Corps should provide funding and resources to develop permanent structures to physically deter sea lions from hauling out near the dam, particularly along the PH2 tailrace Cascades Island west end shoreline. This could serve both to increase the rate of capture on floating traps (not seen in 2010) and perhaps deter animals from residing and resting so long at Bonneville Dam each spring (seen in 2010).
6. 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).
7. ODFW/WDFW should request modifications to the qualification requirements for animals making the removal list from NOAA to allow any CSL that is present at Bonneville Dam and highly identifiable to qualify for the removal list (abolish the 5 days present and seen to take one fish criteria) to allow more animals to be listed for removal. The process or time to get animals on the list should also be reduced to allow prompt and opportunistic removals to occur when the animals are present, not weeks later.
8. Use of a critter-cam affixed to at least one 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. Hillary Thompson, Sarah Spangler, Michael Farber, Danielle Smull, Caleb Fairfax, and Lenza Paul endured the wettest weather conditions we have had yet during this program and performed admirably.

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Appendix A. Table of progressive estimates of pinniped predation on salmonids (also broken out by pinniped species) at Bonneville Dam, 2002-2011, adjusted for unidentified fish prey caught, and night-time predation.

ADJUSTED FOR DAYLIGHT HOURS AND DAYS NOT OBSERVED								
			ALL PINNIPEDS		CALIFORNIA SEA LIONS		STELLER SEA LIONS	
	TOTAL HOURS OBSERVED	TOTAL SALMONID PASSAGE	ESTIMATE SALMONID CATCH	% RUN TAKEN	ESTIMATE SALMONID CATCH	% RUN TAKEN	ESTIMATE 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	267,166	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%

ADJUSTED FOR UNIDENTIFIED FISH								
			ALL PINNIPEDS		CALIFORNIA SEA LIONS		STELLER SEA LIONS	
	TOTAL HOURS OBSERVED	TOTAL SALMONID PASSAGE	ESTIMATE SALMONID CATCH	% RUN TAKEN	ESTIMATE SALMONID CATCH	% RUN TAKEN	ESTIMATE 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	267,166	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%

ADJUSTED FOR NIGHT HOURS NOT OBSERVED (AN ADDITIONAL 3.5% ADDED 2006-2010, 0.9% 2011)								
			ALL PINNIPEDS		CALIFORNIA SEA LIONS		STELLER SEA LIONS	
	TOTAL HOURS OBSERVED	TOTAL SALMONID PASSAGE	ESTIMATE SALMONID CATCH	% RUN TAKEN	ESTIMATE SALMONID CATCH	% RUN TAKEN	ESTIMATE 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	267,166	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%

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

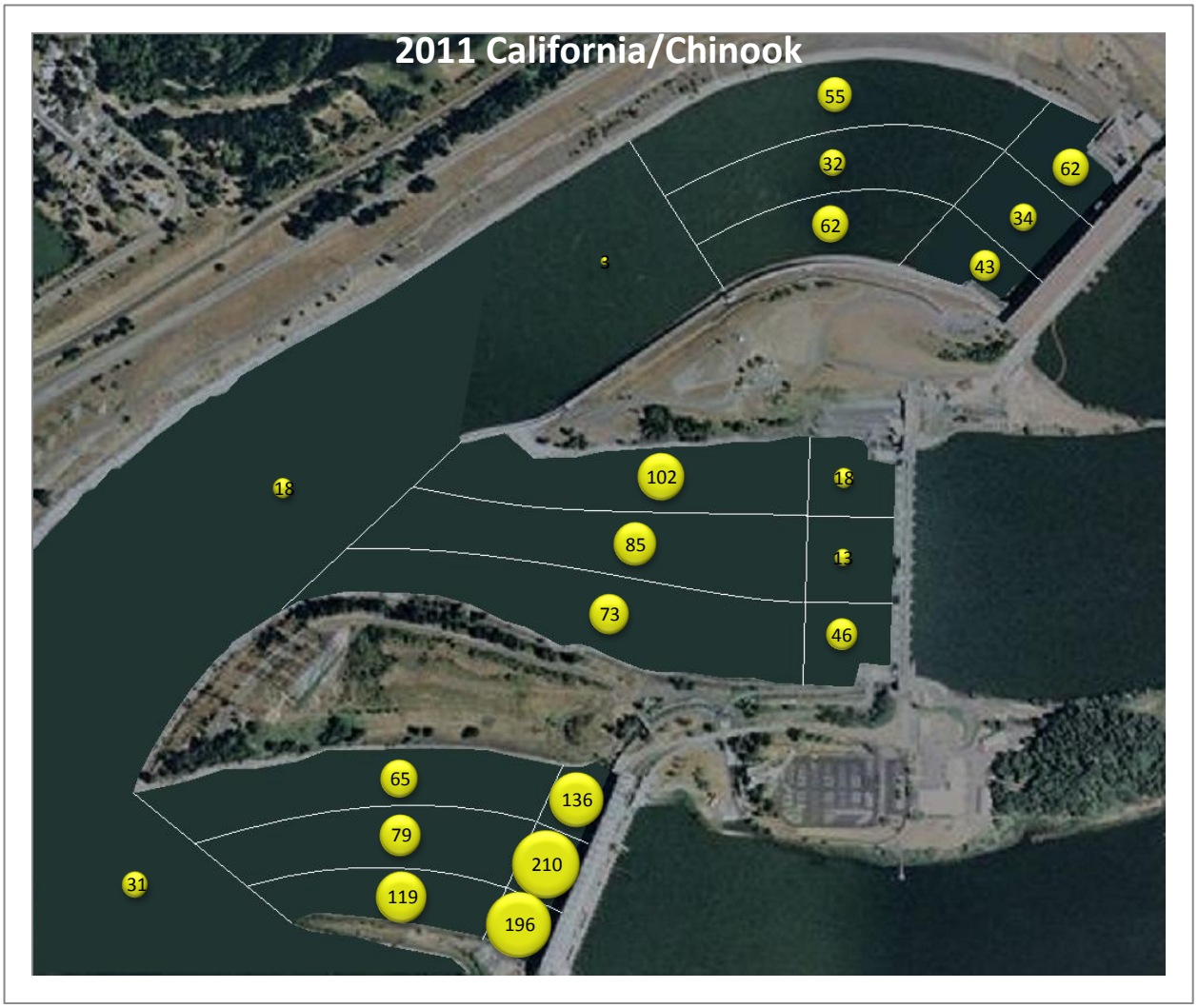

Figure B1. Frequency distribution by location of Chinook salmon caught by CSL at Bonneville Dam, 2011.

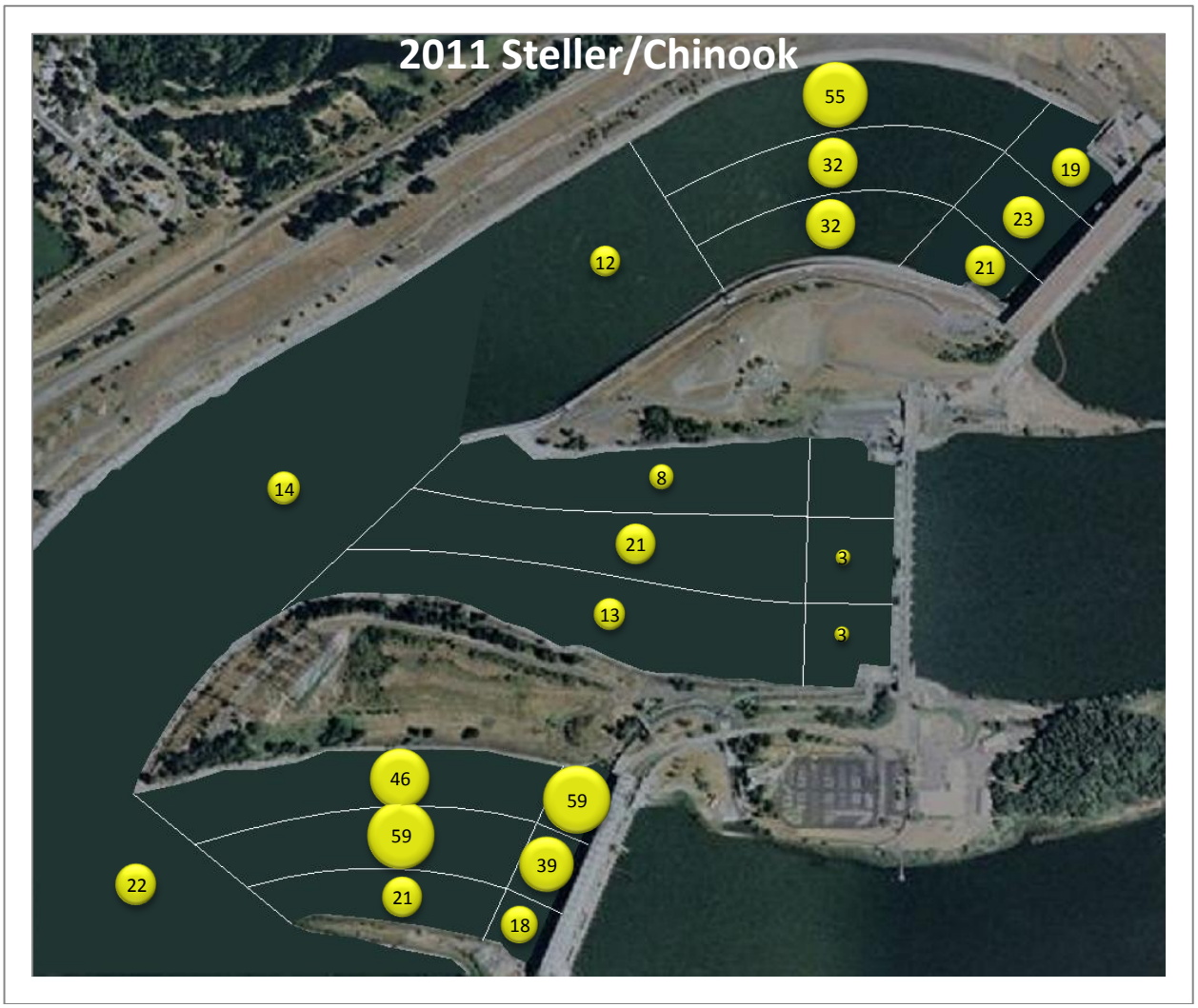

Figure B2. Frequency distribution by location of Chinook salmon caught by SSL at Bonneville Dam, 2011.

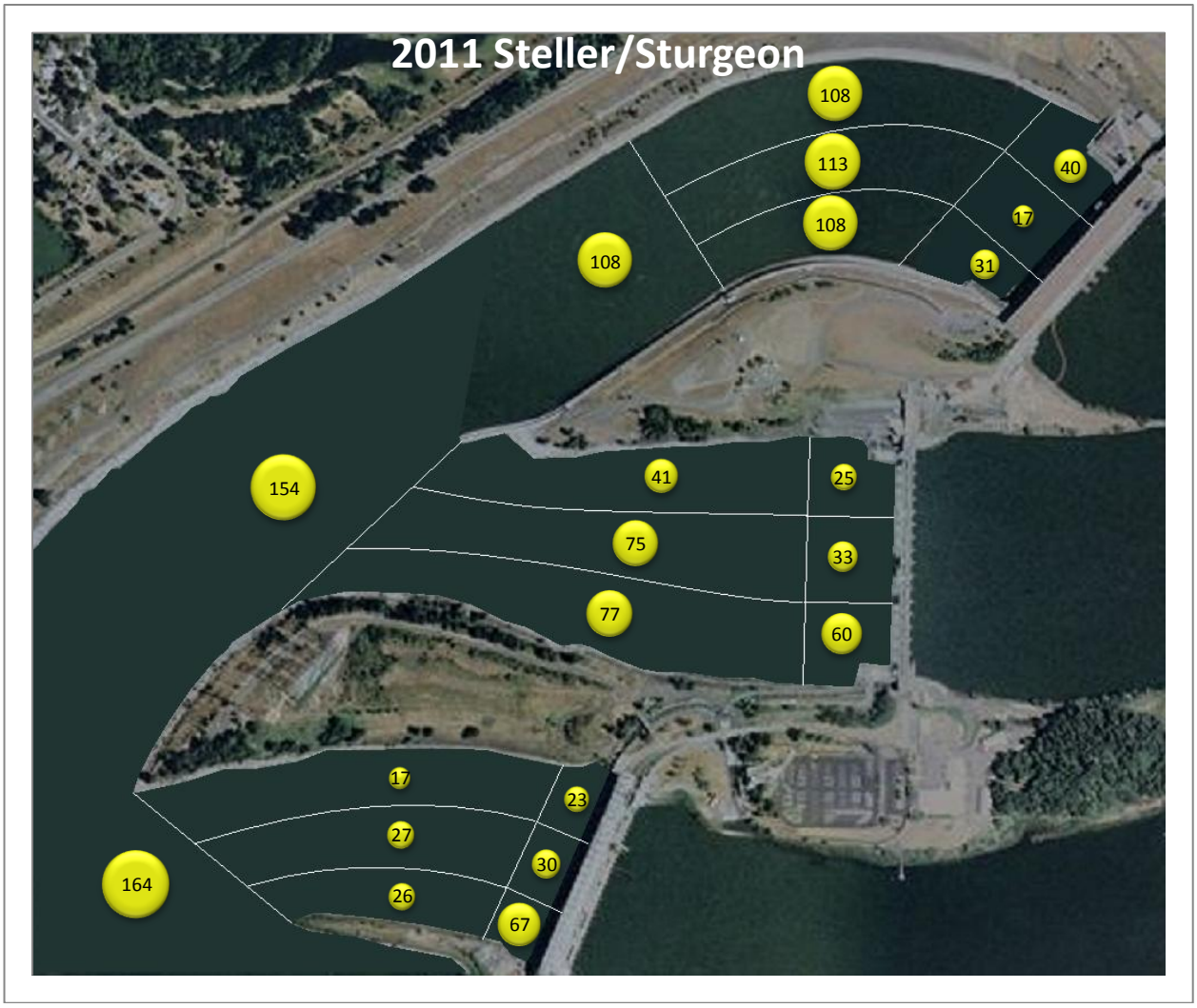

Figure B3. Frequency distribution by location of white sturgeon caught by SSL at Bonneville Dam, 2011.

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

Species	*Sea lion ID*	*Capture date*	*On removal list?*	*Action*	*Additional information*
CSL	C287	3/30/11	Yes	Released	Given acoustic and GPS tag and released
CSL	C930	3/30/11	Yes	Released	Given acoustic and GPS tag and released
SSL	O009/S84	3/30/11		Released	Branded given acoustic and GPS tag and released
SSL	O10/S155	3/30/11		Released	Branded given acoustic and GPS tag and released
SSL	O11/S156	3/30/11		Released	Branded given acoustic and GPS tag and released
SSL	O12	3/31/11		Released	Branded given acoustic and GPS tag and released
SSL	O13/S157	3/31/11		Released	Branded given acoustic and GPS tag and released
CSL	C010/B355	3/31/11	No	Released	Branded and released
SSL	S127	4/6/11		Released	Given acoustic tag, not branded, and released
SSL	O14	4/7/11		Released	Branded given acoustic tag and released
SSL	O15	4/7/11		Released	Branded given acoustic tag and released
SSL	O16/S73	4/7/11		Released	Branded given acoustic tag and released
SSL	O17/S95	4/7/11		Released	Branded given acoustic tag and released
CSL	C011/B357	4/14/11	No	Released	Branded given acoustic tag and released
CSL	C012/B330	4/19/11	No	Released	Branded given acoustic tag and released
CSL	C013/B356	4/19/11	No	Released	Branded given acoustic tag and released
CSL	C06	4/19/11	No	Released	Given acoustic tag and released
CSL	C971	4/20/11	Yes	Released	Given acoustic tag and released
CSL	C014	4/20/11	No	Released	Branded and released
CSL	C015/B303	4/21/11	No	Released	Branded and released
CSL	C016	4/21/11	No	Released	Branded and released
CSL	C017	5/16/11	No	Released	Branded and released
CSL	B22/B205	5/17/11	Yes	Euthanized	Astoria
CSL	C018/B358	5/20/11	No	Released	Branded and released

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.