2015 Field Report:

Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace, 2015

Fish Field Unit

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Portland District
Cascade Locks, OR 97014

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EXCECUTIVE SUMMARY

California sea lions (*Zalophus californianus*) and Steller sea lions (*Eumetopias jubatus*) swim from the Pacific Ocean, up the Columbia River to Bonneville Dam, where they feed on several stocks of Pacific salmon and steelhead (*Oncorhynchus spp.*) which are protected under Endangered Species Act. The 2015 monitoring program, executed by the U.S. Army Corps of Engineers, documented the greatest number of adult salmonids consumed and greatest abundance of sea lions since monitoring began. Non-lethal pyrotechnic deterrents were used with limited effectiveness. The state's removal program was more successful than past years, new individuals recruiting to Bonneville Dam kept sea lion abundance high.

The estimated consumption of adult salmonids by sea lions in the Bonneville Dam tailrace was 10,859 fish or 4.3% of adult salmonid passage between January 1 and May 31, 2015. California sea lions consumed 8,324 adult salmonids and Steller sea lions consumed 2,535 adult salmonids. The white sturgeon consumption estimate in 2015 was 44, the lowest recorded since 2005, the year Steller sea lions were first observed feeding on sturgeon. However Steller sea lions consumed 5.24% of the Winter Steelhead (*O. mykiss*) passing the dam between January and March.

We documented the greatest number of sea lions since the monitoring program began in 2002. The minimum annual abundance estimate was 264 sea lions in 2015, which is 59% greater than the previous high of 166 animals in 2010. There were a minimum of 195 California sea lions and 69 Steller sea lions between January 13 and May 31. The daily mean abundance of sea lions in 2015 was 37.8 (animals/day) or 2.6 times the 2002-2014 mean. The daily mean abundance of California sea lions in 2015 was 18.5 (animals/day), which is 2.3 times the 2002-2014 mean. The daily mean abundance of Steller sea lions in 2015 was 19.3 (animals/day) or 3.1 times the 2002-2014 mean.

Removal of problem sea lions continues to be the most effective means of protecting fish from their predation. While exclusion gates keep sea lions out of the fishways, other non-lethal deterrents (pyrotechnics and rubber buckshot) fired at them have only a temporary effect. For several years the Oregon Department of Fish & Wildlife and Washington Department of Fish & Wildlife have staffed a branding and removal program for problem California sea lions. In 2015 they permanently removed 32 of their authorized 92 animals near Bonneville Dam. To this point authorization has not been requested to remove Steller sea lions which are also protected by the Marine Mammal Protection Act.

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INTRODUCTION

Sea lions have been in conflict with the Columbia River salmon fishery for decades. Before passage of the Marine Mammal Protection Act in 1972, the states of Oregon and Washington paid a bounty for pinnipeds and employed full time seal hunters to clear them out of the river (Pearson and Verts 1970). California sea lions (*Zalophus californianus*) were first noted returning to the dam's tailrace during the 1980's (Stansell 2004) and one or two California sea lions (CSL) were seen consuming adult salmonids periodically from the 1980's through 2000. In 2001, up to six CSL were observed in the tailrace at one time and in 2002 at least 30 CSL were feeding in the tailrace consuming 1,000 adult salmonids (Stansell 2004). The next year showed sharp increases in the number of CSL present and predation of adult salmonids more than doubled. In addition to increasing abundance of CSL in 2003, the first Steller sea lions (*Eumetopias jubatus*) were also observed in the tailrace.

The U.S. Army Corps of Engineers' (USACE) Fish Field Unit monitors pinnipeds in the Bonneville Dam tailrace because it is an obvious source of fish loss, has the potential to cause passage delay, and is now a requirement of the Federal Columbia River Power System (FCRPS) Biological Opinion (NFMS 2000, 2008). This Biological Opinion outlines how dams must be operated to not jeopardize the continued existence of fish species listed as threatened or endangered under the Endangered Species Act.

Two Reasonable and Prudent Alternatives (RPA) actions under the predation management strategy, are specific to pinnipeds at Bonneville Dam:

RPA Action 49 - Marine Mammal Control Measures
The Corps will install and improve as needed sea lion excluder gates at all main adult fish ladder entrances at Bonneville Dam annually. In addition, the Corps will continue to support land and water based harassment efforts by NOAA Fisheries, Oregon Department of Fish &Wildlife (ODFW), Washington Department of Fish & Wildlife (WDFW), and the Tribes to keep sea lions away from the area immediately downstream of Bonneville Dam.

RPA Action 69 - Monitoring Related to Marine Mammal Predation
The Action Agencies will, Estimate overall sea lion abundance immediately below Bonneville Dam. Monitor the spatial and temporal distribution of sea lion predation attempts and estimate predation rates. Monitor the effectiveness of deterrent actions (e.g., exclusion gates, acoustics, harassment and other measures) and their timing of application on spring runs of anadromous fish passing Bonneville Dam.

The USACE pinniped monitoring program observers have been using binoculars to make surface observations from the face of the dam since 2002. The objectives of this program are to estimate seasonal presence, abundance, and number of fish consumed by pinnipeds, primarily California and Steller sea lions in the immediate tailrace of Bonneville Dam (Stansell 2004; Tackley et al., 2008; Stansell et al., 2009 to 2014). Harbor seals (*Phoca vitulina*) have rarely been observed, although their bones were found in middens in the Columbia River basin up to Celilo Falls at river mile 201, now inundated by The Dalles Reservoir (Lyman et al. 2002).

This monitoring program is part of an ongoing effort to understand and manage pinniped predation on ESA- listed Chinook salmon (*Oncorhynchus tshawytscha*) and Steelhead (*O. mykiss*). The evolutionarily significant units (ESU) of Chinook salmon impacted by pinnipeds at Bonneville Dam from January through May are upper Columbia River spring-run (endangered), Snake River spring/summer-run (threatened), and lower Columbia River (threatened). The distinct population segments (DPS) of Steelhead that may be impacted by pinnipeds in the direct vicinity of Bonneville Dam from January through May are lower Columbia River (threatened), middle Columbia River (threatened), upper Columbia River (threatened), and Snake River basin (threatened). Due to low prey density, early migrating stocks are disproportionately impacted by pinniped predation (Keefer et al. 2012).

A number of deterrent measures have been implemented or supported by the USACE to reduce the impacts of pinnipeds on adult salmonids in the Bonneville Dam tailrace. Due to CSL entering and consuming salmonids within the fishways, the USACE installed physical barriers (i.e. sea lion exclusion gates) in 2006 at all adult fish ladder entrances and smaller versions covering the floating orifices of PH2. The sea lion excluder gates are built with spacing that allows adult salmonids to enter into the fishways while precluding pinnipeds. The USACE and partnering agencies have used a variety of non-lethal deterrents since 2006 in an attempt to drive pinnipeds from the tailrace with emphasis directed toward clearing the areas around fishways entrances of pinnipeds to allow for better salmonid passage.

In 2006, the states of Oregon, Washington, and Idaho (the States) submitted requests to the National Oceanic and Atmospheric Administration (NOAA) for authorization under Section 120 of the Marine Mammal Protection Act (MMPA) to lethally remove CSL at Bonneville Dam that were having significant negative impact on the recovery of ESA listed Chinook salmon and Steelhead. Authorization was granted in 2008 (U.S. Office of the Federal Register 2008), trapping and permanent removal of CSL began shortly after but implementation has been sporadic due to litigation. To date, 102 CSL have been removed under this authorization.

This report is an annual summary of monitoring and deterrence efforts implemented by, or coordinated with, the USACE and ODFW, WDFW, Columbia River Inter-Tribal Fish Commission (CRITFC), NOAA, and the U.S. Department of Agriculture (USDA).

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 consumed.

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

Study Area

Bonneville Lock and Dam is located 146 river miles from the mouth of the Columbia River. The dam spans the Columbia River between the states of Oregon and Washington and is composed of three main concrete structures separated by islands. Surface observations were taken at each of the three tailrace sub-areas downstream of powerhouse one (PH1), powerhouse two (PH2), and the spillway (SPW; Figure 1). Pinniped observations were also conducted at Tower Island, a landmass that separates PH1 tailrace from the downstream approach to the old navigation lock. It is regularly used as a haulout for pinnipeds at Bonneville Dam. The states anchor four floating sea lion traps in the vicinity of Tower Island during the months that CSL are present.

Surface Observations

Surface observations were conducted five days per week, during all daylight hours, from 11 January to 31 May 2015. Observers used binoculars (8x42 or 10x50) to monitor pinniped abundance, identify fish catches, and identify individual CSL and SSL based on human-applied brands and/or natural markings when possible. To cover all daylight-hours observers worked in two shifts. The morning observation shift started at the hour of sunrise with three observers, each one assigned to a tailrace sub-area. The afternoon shift, also with three observers, started during midday and ended at the hour of sunset. Observers were randomly assigned one hour breaks toward the middle of their shifts (lunch). In order to minimize unobserved hours, an additional observer was used to cover observations during break periods when possible. Observers cycled through the three tailrace sub-areas each week, but typically only observed at one tailrace sub-area for an entire observation shift. Observers rotated between the morning and afternoon shifts on a weekly basis.

A minimum of one observer was posted at a tailrace sub-area for each hour observed. When additional observers were available, a second observer was added to a tailrace sub-area to aid the primary observer. During predation events, observers recorded the location and fish species being consumed. When observers were unable to determine the species of fish being consumed, it was recorded as an unidentified catch.

Surface observations are a useful tool for assessing pinniped predation (Roffe and Mate 1984) as CSL come to the surface to thrash large prey, such as Chinook salmon, into pieces small enough to swallow. However, in recent years, SSL (larger than CSL) have been observed with Steelhead and Chinook jacks already partially swallowed when they arrive at the water’s surface. This ability to swallow adult salmonids whole suggests that SSL may be able to consume them entirely underwater. *All adult salmonid consumption estimates outlined in this report should be considered minimum estimates*.

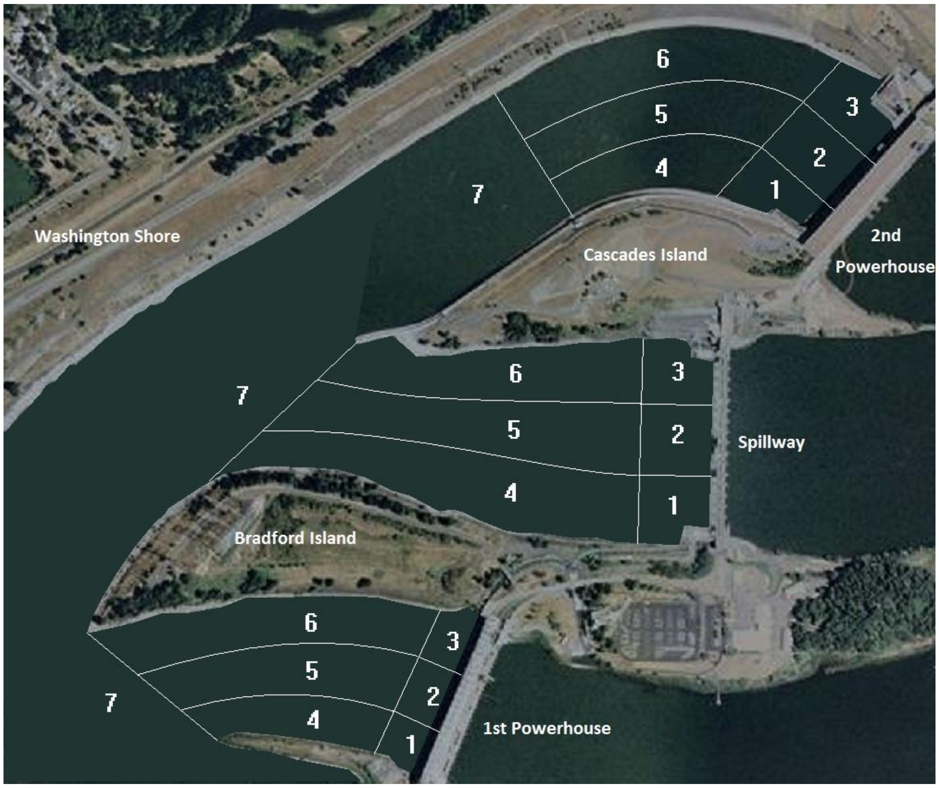

Figure 1. Bonneville Dam study area with each of the three tailrace sub-areas separated into zones for assigning the location of predation events.

Estimation of Fish Consumption

Methods to account for the number of salmonids and other fish eaten by sea lions during the life of this monitoring program have been consistent, but there have been some refinements to improve them. Primarily the initial Consumption Estimate evolved to the latter Adjusted Consumption Estimate to integrate unknown predation events. The Adjusted Consumption Estimate is our best estimate and we believe is the truest reflection of what we observe in the field. For continuity's sake, we report both here.

Consumption Estimates

To account for hours or days when observers were not present, or twilight hours when they could not see, raw surface observation data was corrected to provide the consumption estimate. Surface observations data was used to estimate pinniped consumption of fish in these categories: Chinook salmon, Steelhead, Pacific Lamprey (*Entosphenus tridentatus*), White Sturgeon (*Acipenser transmontanus*), and unidentified fish typically too far away for an observer to identify. Unidentified fish are accounted for using the *adjusted consumption estimate* (see below).

Daily estimates of the numbers of fish consumed (also termed "catch") were made by combining the observed catch at each of the three tailrace sub-areas. Linear interpolation was used to estimate consumption for daylight hours not observed (lunches, any time observer not present).

Nighttime observations were made in some years, however, predation events were determined to be very infrequent and the outcomes difficult to evaluate due to poor visibility so the 2015 estimate was not adjusted for nocturnal predation (see Nocturnal Predation).

It was common for pinnipeds to be hunting close to the dam when observers arrived for the morning and when they departed at night although difficult to see. To account for this crepuscular feeding, one half of the number of observed catches for the first and last hour of observations for each day were added. For example, if two Chinook salmon were consumed during the first hour of observations, then the morning crepuscular hour would be assigned one Chinook salmon consumed. If there were no catches made in the first and last hours of observation, then there would be no catches assigned to the crepuscular hours. Crepuscular feeding was also observed and accounted for in previous years (Tackley et al. 2008 and Stansell et al. 2009, 2011).

For days without observations (e.g., weekends, holidays), fish consumption was estimated using the mean of the daily consumption estimate the day before and the day after the unobserved period. For example, the estimated number of fish consumed on a Friday and the following Monday were averaged to fill in the data gaps for the unobserved weekend days of Saturday and Sunday. Once all of the observed, interpolated, and expanded data were calculated for each tailrace sub-area for all days within the study period, and then these data were summed to calculate the overall *Consumption Estimate* for each pinniped species and prey category for the entire study period.

We also report the percentage of the adult salmon passing Bonneville Dam that were consumed by pinnipeds. To make this estimate the salmonid consumption estimate (above) was divided by the total adult salmonid passage count (daytime counts, all adult salmonids including jacks) from January 1 through May 31 plus the salmonid consumption estimate then multiplied by 100. Salmon counts were taken from the USACE adult fish count website (http://www.nwp.usace.army.mil/Missions/Environment/Fish/Counts.aspx).

Adjusted Consumption Estimates

Unidentified catches can account for as much as 10% of all catches. The *adjusted consumption estimate* assigns unidentified catches proportional to the identified fish catches each day. For example, if there were ten unidentified fish catches in one day, and of those, six were captured by CSL and four were captured by SSL then they would be divided based on the identified fish catches that were recorded for each pinniped species for that day. For instance, if CSL were documented taking a total of 20 identified fish catches for that day and 10 were Steelhead and 10 were Chinook salmon, then the four unidentified fish catches would be proportionally partitioned and two would be assigned to Steelhead and two would be assigned to Chinook salmon. Once the unidentified fish catches are partitioned, then the *adjusted consumption estimate* can be calculated in the same manner as the *consumption estimate* from the previous section.

Once unidentified fish catches are assigned to a prey species groups for each day, then all days are added together for the adjusted season total. The adjusted season total is then added to the *expanded consumption estimate* to calculate the *adjusted consumption estimate*.

Fall Observations

Pinniped abundance estimates were also made outside the usual season, during the fall as time allowed. In recent years it has been noted that pinnipeds (mainly SSL) are arriving at Bonneville Dam tailrace as early as August (Ida Royer, pers comm.). To address data needs, USACE began monitoring the number of pinnipeds present from August through December in 2011. Abundance estimates from August through December are focused at four locations in the Bonneville Dam tailrace. The four locations are PH1, PH2, SPW and the Tower Island haul out site. Predation data were collected from 2011 to 2013 (Stansell et al. 2014).

Daily Pinniped Abundance Estimation

Point counts of pinnipeds were conducted to determine the minimum number of CSL and SSL present each observation day. A point count was taken at each tailrace sub-area at the end of all observation hours. Point counts were also periodically conducted at Tower Island to coincide with the point counts at the tailrace sub-areas. Point counts from the four areas were compiled to calculate a total point count for the Bonneville Dam tailrace. The highest hourly point counts for each pinniped species were combined to calculate the daily pinniped abundance estimate for the Bonneville Dam tailrace for each observation day.

At times, compilation of all individually identified CSL and/or SSL throughout an observation day would yield a count greater than the number of pinnipeds derived from point counts. In these cases, the count of individual CSL and/or SSL was used in lieu of the point count for that day.

Annual Pinniped Abundance Estimation

Identification of individual CSL and SSL was used to determine the minimum number of individual pinnipeds present. We used photography, videography, field sketches and observer notes to identify individual CSL and SSL and to confirm the identities of individual pinnipeds. Individual pinnipeds were identified by noting a combination of physical characteristics such as human-applied brands, scars, color patterns, body size, maturity, and also behaviors. A catalog of photos and sketches of all individual pinnipeds is maintained and updated annually.

Management Activities

To protect endangered salmon non-lethal means are used to chase sea lions from the tailrace area and when that fails the states of Oregon and Washington staff a removal program. Sea lion deterrents used at Bonneville Dam include included cracker shells and rubber buckshot fired from 12 gauge shotguns from the top of the dam, boat chasing using above-water pyrotechnics (cracker shells), and underwater percussive devices known as seal bombs.

Boat-based hazing was conducted by CRITFC and included boat chasing, above-water pyrotechnics (cracker shells), and underwater percussive devices known as seal bombs. The CRITFC hazing boat mainly operated in the Bonneville Dam tailrace boat restricted zone. For fish passage and safety hazing with percussive devices are not allowed within 100 feet of dam structures or within 165 feet of fishway entrances. In order to minimize the impact to fish, the use of seal bombs was prohibited within 330 feet of fishways, collection channels, or fish outfalls for the PH2 corner collector and smolt monitoring facility. The use of seal bombs in 2015 ceased completely in the tailrace on April 10 after adult salmonid passage exceeded 1,000 fish per day at Bonneville Dam. More detailed information on boat-based hazing activities are described by Wright et al., 2007 and Brown et al., 2008 and 2014.

When sea lions began entering fishway (fish ladders) at Bonneville Dam specially designed gates were installed to exclude them. Sea lion exclusion gates are installed annually at all eight main fishway entrances of Bonneville Dam. They are essentially huge grates with rounded edges creating opening 15.38” wide. They allow migrating fish to enter the fishway but exclude pinnipeds. In addition to the eight sea lion exclusion gates, there are smaller sea lion exclusion gates installed on the sixteen floating orifice gates (FOG) of PH2. The FOG at PH2 provides additional fishway entry points for migrating adult salmonids, but are sized to preclude pinniped entry.

Personnel from ODFW and WDFW operated four floating sea lion traps (Brown et al., 2008) in the Bonneville Dam tailrace during May. The sea lion traps were used to capture CSL for branding, outfitting with transmitters, and permanent removal of individual CSL that qualified under Section 120 of the Marine Mammal Protection Act. Steller sea lions were also captured in the floating sea lion traps, but were released back into the tailrace without further handling.

RESULTS

Predation

Between January 13 and May 31, 2015, several observers completed 2,995 hours of daytime observations covering 58% of daylight hours. They recorded pinnipeds feeding on 5,890 Chinook salmon, 121 Steelhead, 108 Pacific lamprey (*Entosphenus tridentatus*), and 24 White Sturgeon (*Acipenser transmontanus*) (raw counts, underwater predation not included). If the species of salmnoid could not be determined it was recorded as unidentified (n = 523).

Predation on Adult Salmonids
In 2015, we documented the highest predation of adult salmonid by pinnipeds in the Bonneville Dam tailrace since monitoring began, 77% by CSL and 23% by SSL. The initial consumption estimate for adult salmonids in the Bonneville Dam tailrace was 9,981 fish. When accounting for Pacific salmon not identified to the species level, the adjusted consumption estimate for adult salmonids was 10,859 or 4.3% of the run (Table 1).Second only to 2007 when pinnipeds consumed 4.7% of the adult salmonid run, note salmonid passage was only 88,474 in 2007.

Table 1. Consumption of adult salmonids by all pinnipeds combined, Bonneville Dam tailrace. Salmonid passage includes all adult salmonids (including jacks) that passed Bonneville Dam from January 1 through May 31.

Year	Bonneville Dam salmonid passage	Expanded salmonid consumption estimate		Adjusted salmonid consumption estimate	
		Estimated consumption	Percentage of run consumed	Estimated consumption	Percentage of run consumed
2002	284,732	1,010	0.4%	1,010	0.4%
2003	217,934	2,329	1.1%	2,329	1.1%
2004	186,771	3,533	1.9%	3,533	1.9%
2005	81,252	2,920	3.5%	2,920	3.5%
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	2.6%
2010	267,167	6,081	2.2%	6,321	2.3%
2011	223,380	3,557	1.6%	3,971	1.8%
2012	171,665	2,107	1.2%	2,360	1.4%
2013	120,619	2,714	2.2%	2,928	2.4%
2014	219,929	4,314	1.9%	4,704	2.1%
2015	239,326	9,981	4.0%	10,859	4.3%

Table 2. California sea lion (CSL) and Steller sea lion (SSL) predation on adult salmonids at Bonneville Dam, from January 1 through May 31, 2015

Predator	Observed Salmonid Catch	Expanded Salmonid Consumption Estimate		Adjusted Salmonid Consumption Estimate	
		Estimated consumption	Percentage of run consumed	Estimated consumption	Percentage of run consumed
CSL	4,713	7,779	3.1%	8,324	3.3%
SSL	1,298	2,202	0.9%	2,535	1.0%

California sea lions consumed an estimated 8,324 adult salmonids in 2015 (Figure 2). This is the highest level of predation ever recorded for CSL at Bonneville Dam, surpassing the previous high of 6,321 in 2010. Steller sea lions consumed an estimated 2,535 adult salmonids in 2015. This continues the trend of increasing Steller sea lion predation since 2004, when SSL were first arrived (Figure 2).

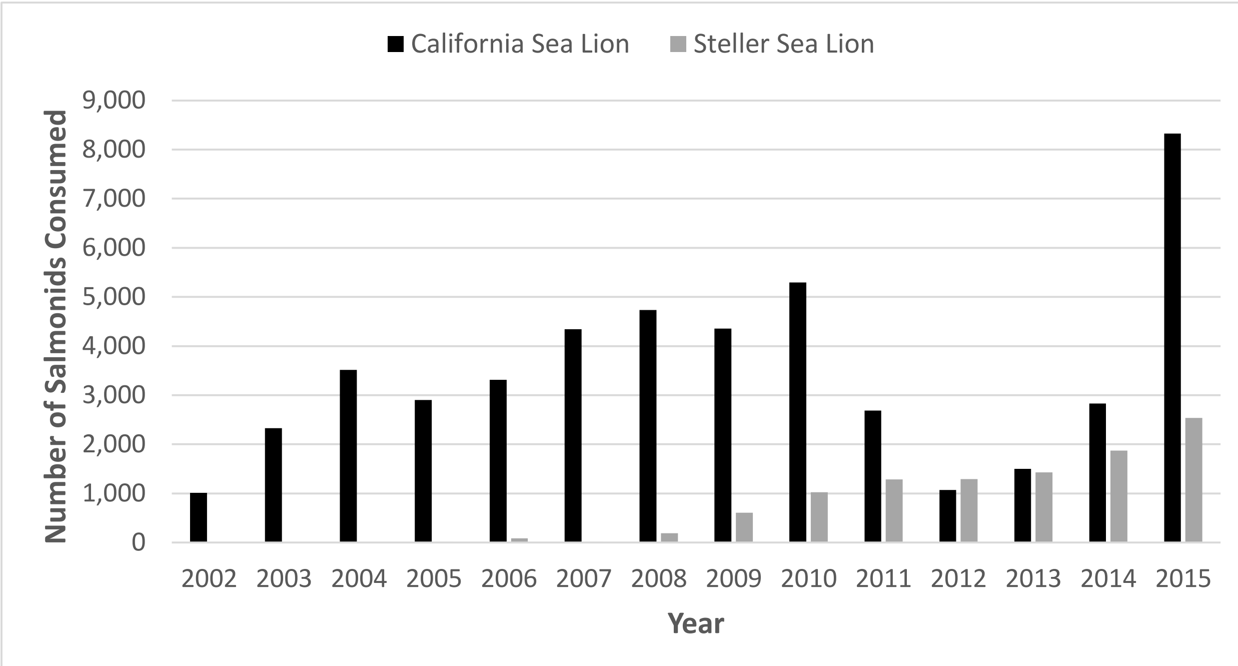

Figure 2. Adjusted salmonid consumption estimates by California and Steller sea lions at Bonneville Dam. Expanded for unobserved hours, days, and adjusted for unidentified fish.

Predation on Chinook salmon

The Chinook salmon consumption estimate for the Bonneville Dam tailrace in 2015 was 9,780 or 3.3% of the Chinook salmon run (283,696 adults and jacks) from January 1 through June 15 (Table 3). The adjusted Chinook salmon consumption estimate for the Bonneville Dam tailrace in 2015 was 10,622 or 3.6% of the Chinook salmon run from January 1 through June 15.

Table 3. Consumption of spring Chinook salmon by pinnipeds at Bonneville Dam tailrace between 2002 and 2015.

Year	Chinook salmon passage (Jan. 1 – June 15)	Expanded Chinook consumption estimate	Percent of Chinook run consumed (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%
2013	155,729	2,525	1.6%
2014	257,354	4,209	1.6%
2015	283,696	9,780	3.3%

* 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. After April 25, we used observed catch distribution to divide unidentified salmonid consumption.

† In 2005, regular observations started on March 18.

Predation on Winter Steelhead

For the purpose of this report Winter Steelhead are defined as Steelhead passing between 16 November and 31 March (USACE 2015 Fish Passage Plan from table BON-4). The adjusted Winter Steelhead consumption estimate for the Bonneville Dam tailrace was 162 fish or 5.24% of the Steelhead passing during our observations from January 13 through March 31, 2015 (2,931 fish). Steller sea lions are present at Bonneville Dam, in low numbers, as early as August then depart in May so they have the greatest overlap with the winter run. Since our observations do not begin until January, predation that happens before January is not captured here (see Figure 9 for Steller sea lion abundance).

Predation on White Sturgeon

In 2015, the adjusted White Sturgeon consumption estimate for Bonneville Dam tailrace was 44. They were primarily consumed by SSL (22 of the 24 observed catches). This estimate is the lowest since 2005, when SSL were first observed to consume sturgeon in our study area. It peaked in 2011 when SSL consumed 3,003 (Table 4) and has declined each year to the point where it is now rare to see.

When possible, observers estimated the lengths of sturgeon captured by pinnipeds in one foot increments. The estimated lengths of sturgeon caught between 2006 and 2015 ranged from less than 2 ft (0.6 m) to over 7 ft (2.7 m), but 80.3% of sturgeon lengths (4,442) were 4 ft (1.2 m) or shorter.

Table 4. Consumption of White Sturgeon by pinnipeds at Bonneville Dam tailrace from January 1 through May 31, 2005 to 2015.

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
2013	3,247	314	552	635
2014	2,947	79	127	147
2015	2,995	24	39	44

Predation on Pacific Lamprey

In 2015, the expanded Pacific Lamprey consumption estimate was 196 (Table 5). The CSL made 95 of the 108 observed lamprey catches in the Bonneville Dam tailrace. The lamprey proportion of total observed catch was 1.6%. Due to the small body size and presumed vulnerability to predation, our surface observation methods may significantly underestimate actual predation on lamprey – they could be consumed underwater. However, this underestimate should be similar among years.

Table 5. Consumption of Pacific Lamprey by Pinnipeds at Bonneville Dam from January 1 through May 31, 2002 to 2015.

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%
2013	3,247	38	66	1.7%
2014	2,947	41	85	1.5%
2015	2,995	108	196	1.6%

Spatial Distribution of Predation Events

In 2015, there were a total of 6,011 observed predation events on adult salmonids on the Bonneville Dam tailrace with subtle difference in the spatial distribution by species (Figure 3 and Figure 4).

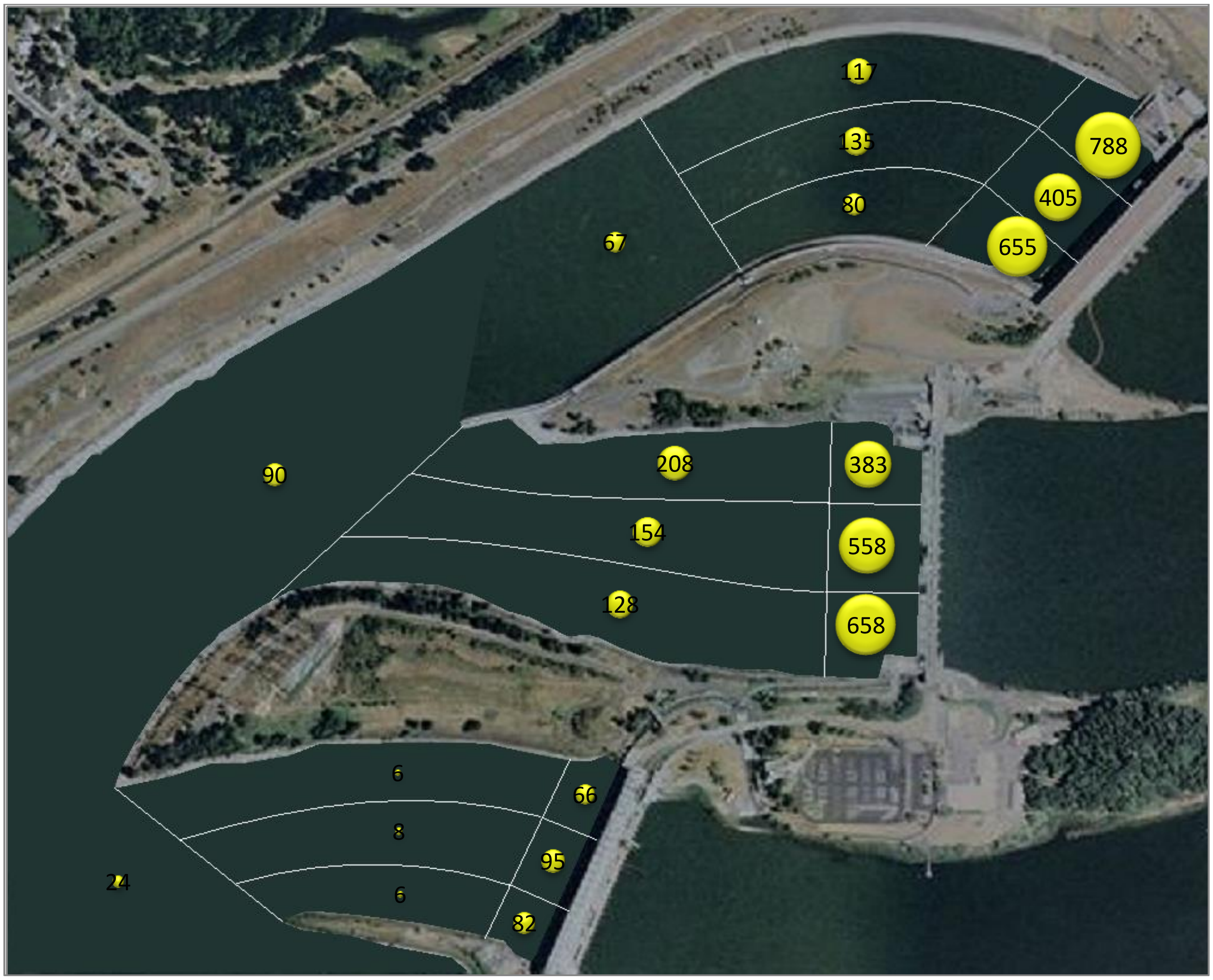

Figure 3. Spatial distribution of observed salmonid predation by California sea lions in 2015.

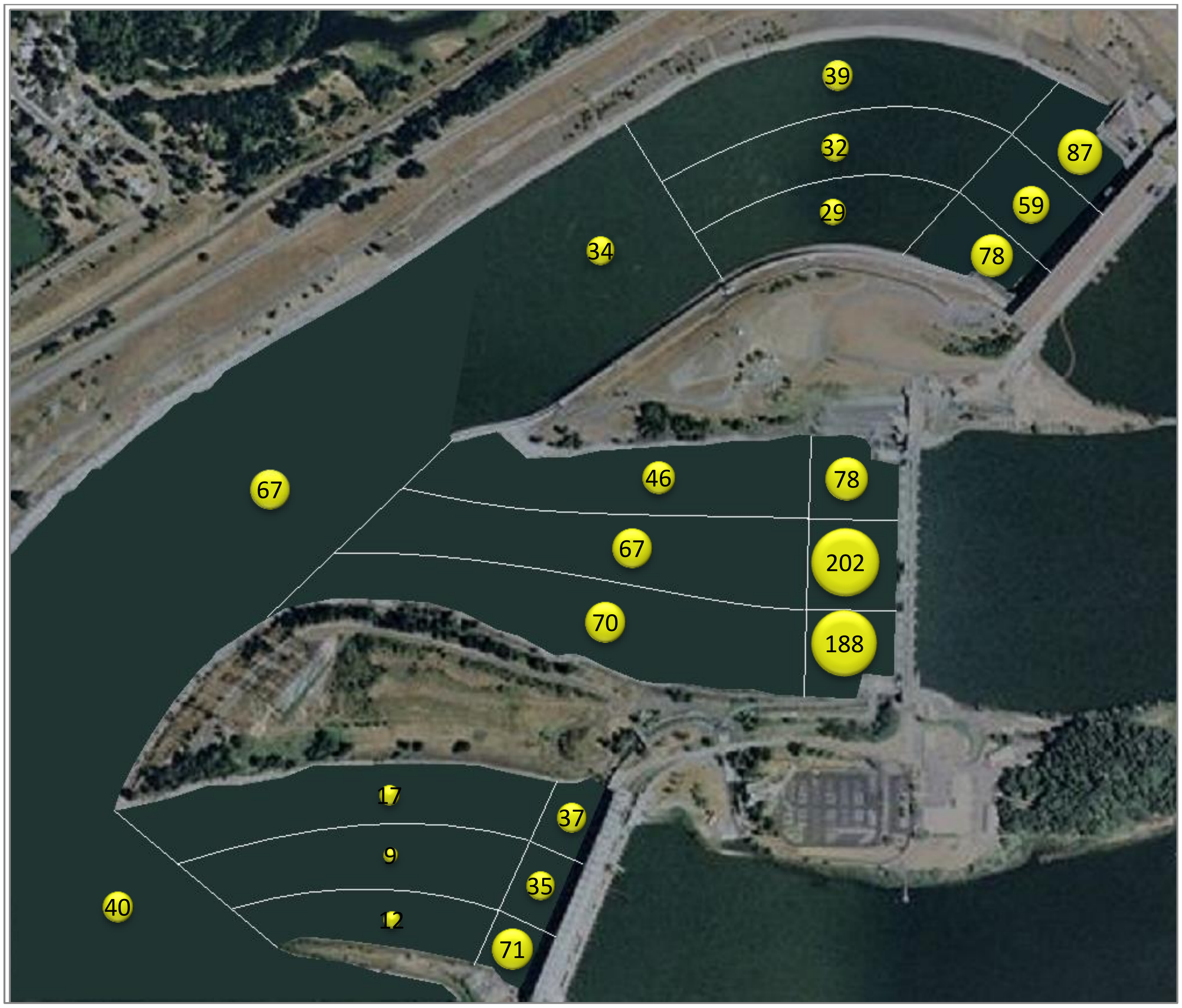

Figure 4. Spatial distribution of observed salmonid predation by Steller sea lions in 2015.

Combined, the spatial distribution of salmonid predation events was 8.5% (508) at PH1, 43.4% (2,606) at PH2, and 48.2% (2897) at SPW. This is a departure from recent years when salmonid predation was more evenly distributed among the tailraces (
Figure 5) and is likely due to the turbine units at PH1 sitting idle from April 10 to May 31 and thus there was less flow to attract salmon and there predators into the PH1 tailrace.

From April 10 to May 31, 87.8% of all observed salmonid catches for the entire study period occurred. During this same time period we observed 272 hours at PH1 and recorded 134 salmonid catches. This is a mean of 0.5 catches per hour of observation. In contrast, PH2 had 2,301 salmonid catches (mean 5.3 per hour) in 433 hours of observation and SPW had 2,840 salmonid catches (mean 6.4 per hour) in 446 hours of observation. This contrast was also observed with the number of pinnipeds that were actively hunting at the end point of each observation hour. From April 10 to May 31, PH1 had a mean of 2.3 pinnipeds engaged in hunting at the end of observed hours, while PH2 had 10.7 and SPW had a mean of 14.4.

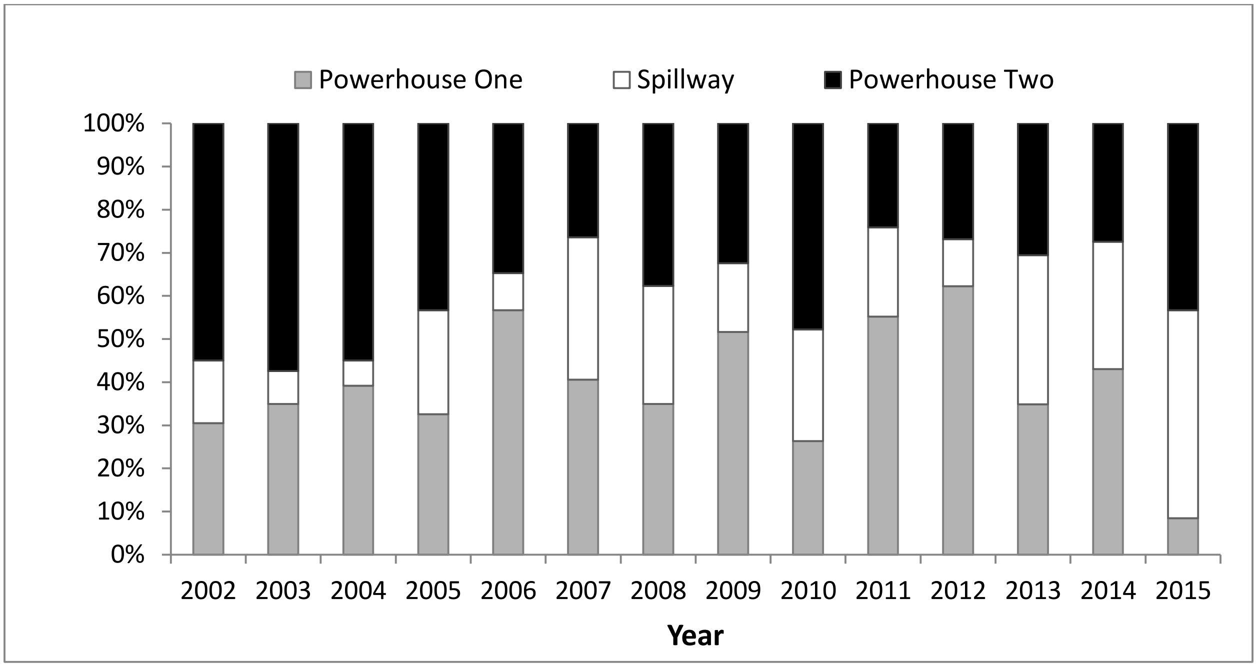

Figure 5. Proportional consumption of salmonids by location and year.

In 2015, pinniped predation on salmonids – in the observed areas – was concentrated in close proximity to the dam and its fishway entrances in both forebay and tailrace areas. In these areas, individual brands are readily observed. Looking at predation across all three observation areas, 75.3% of all salmonid predation events took place in zones 1-3; while zones 4-6 had 19.4% and zone 7 had 5.4% (zones are depicted in Figure 1). Per protocol, the recorded zone of predation is the location where the pinniped is first observed with a fish. It is plausible that a fish was caught in one zone and dragged to a different zone before being noticed by an observer. This dragging of fish catches has become common as pinnipeds are often observed making catches in zones 1-3, but then dragging the fish downriver into zones from 4-7 to consume them.

Temporal Distribution of Predation Events

Steelhead were observed being consumed throughout the entire study period in 2015. Steller sea lions primarily consumed Steelhead during January and February prior to the arrival of spring Chinook salmon. We estimate that 68% of the Steelhead predation by pinnipeds took place from January through March. The first observed Chinook salmon catch was on March 2 by a SSL. Steller sea lions primarily consumed Chinook salmon during March, April and May. Their predation on adult salmonids peaked on April 27.

In 2015, California sea lions were rarely observed in the Bonneville Dam tailrace prior to March. Throughout most of March, CSL that arrived in the tailrace did not stay for long periods, usually only a few hours. In late March, CSL began to stay in the tailrace for longer periods and their predation on salmonids increased. California sea lions primarily consumed Chinook salmon during April and May. Their predation on adult salmonids peaked on April 29. We estimate that 96% of the Chinook salmon predation by pinnipeds took place during April and May.

Predation on White Sturgeon and Pacific Lamprey by pinnipeds was rare in 2015. White sturgeon predation events were observed periodically from January through April, but none were observed after April 15. The first Pacific Lamprey predation event of the 2015 field season occurred on March 30. Lamprey were consumed by pinnipeds periodically through April, but the majority (83%) were consumed in May.

Nocturnal Predation

Stansell et al. (2009, 2011) suggested that nocturnal predation by pinnipeds at Bonneville Dam tailrace accounted for an additional 3.5% in 2009 and 0.9% in 2011. The dam is away from major cities and situated between mountains so gets minimal ambient light. Nighttime observers depend on the lights of the dam so can best see the area right next to the dam, about the area of the first zones. Nighttime observations were not conducted in 2015, due to their difficulty and the potential for additional uncertainty, no adjustment made for nocturnal predation in this report. See appendix A for predation estimates that include a nighttime component.

Pinniped Abundance, Residence Times, and Recurrence

Annual Pinniped Abundance

The estimated number of individual pinnipeds observed at Bonneville Dam in 2015 was 264. This is the highest number of individual pinnipeds observed in one year since observations began in 2002 (Table 6). It should be noted that the annual pinniped abundance numbers are based on tallying pinnipeds that are identifiable based on human-applied brands and/or unique natural markings. Pinnipeds that lack brands or unique natural markings are not tallied as part of the annual pinniped abundance estimate.

We documented a minimum of 195 individual CSL at Bonneville Dam tailrace in 2015 (Table 6). This is the greatest number of individual CSL documented in one year since observations began in 2002. We also documented 55 individual SSL at Bonneville Dam tailrace in 2015. Of the individual SSL tallied, 65% were animals that had been documented at Bonneville in previous years. The majority (71%) of the individual SSL documented in 2015 were unbranded. Of the 16 branded SSL observed, 94% were repeat animals. There were no harbor seals spotted in 2015.

Branding of pinnipeds allows for their unique identification. The majority (97%) of the 195 CSL that were documented as individuals in 2015 were branded. Branding effort by ODFW and WDFW resulted in 131 CSL being branded at Bonneville in 2015, the most in any year. Two of the 131 newly branded CSL were identified as individuals that had been at Bonneville the previous year. Of the 189 branded CSL documented in 2015, 29 were repeat animals and 160 were animals that were either branded at Bonneville in 2015 or that were branded elsewhere, most commonly by ODFW at the East Mooring Basin in Astoria, OR.

Hazing activities typically resulted in changes in pinniped behavior (e.g., 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 6. Minimum estimated number of individual pinnipeds observed at Bonneville Dam tailrace from January 1 to May 31, 2002 to 2015.

	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
2013	56	80	0	136
2014	71	65	1	137
2015	195	69†	0	264

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

† In 2015, the minimum estimated number of Steller sea lions was 55. This number was less than the maximum number of Steller sea lions observed on one day, so the maximum number observed on one day was used as the minimum estimated number.

Pinniped Abundance

Steller sea lions were present in the Bonneville dam tailrace the entire study period, climbing in March, peaking in late April before dropping again. California sea lion abundance had a brief peak in March, slowly climbed to a maximum in mid-May, then quickly declined to zero by the end of May (Figure 6). It should be noted that ad-hock counts of sea lions were taken in the fall (August – December) and only SSL were found. Those results are reported separately in (Figure 9).

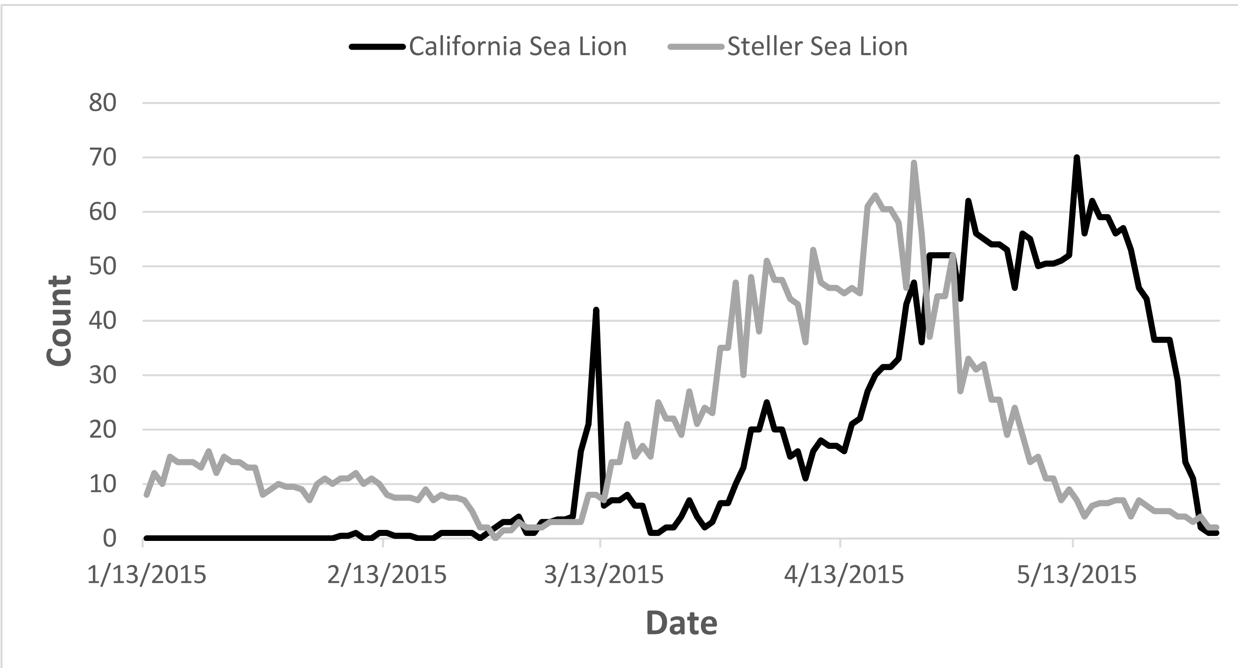

Figure 6. Daily abundance of California sea lions and Steller sea lions at Bonneville Dam.

After leveling off the last few years, pinniped abundance nearly doubled in 2015. The mean daily number of pinnipeds present in 2015 was 37.8 or 2.6 times the 2002-2014 mean of 14.4 pinnipeds per day (Figure 7). The maximum number of pinnipeds present on one day was 116 on April 22 setting a new record for Bonneville Dam. The former single day record was 71 pinnipeds set in 2010 which was surpassed on 15 separate days in 2015.

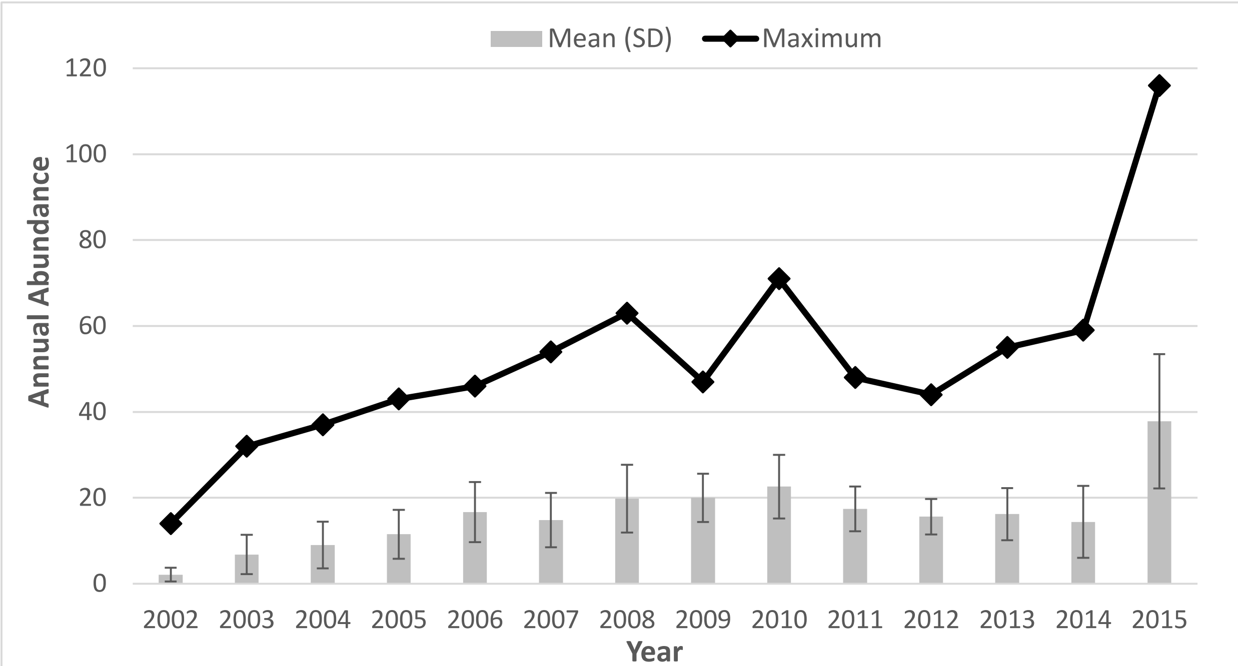

Figure 7. Mean daily and maximum abundance of California and Steller sea lions at Bonneville Dam between January and the end of May. Error bars are +/- one standard deviation.

The annual abundance of CSL present in 2015 was 18.5 per day (Figure 8). This is more than twice the 2002-2014 mean of 8.1 CSL per day. The first CSL of the 2015 field season was observed on February 9 and the maximum count of CSL seen on any one day in 2015 was 70. This is a new record for Bonneville besting the former single day record of 52 CSL set in 2007. The single day record from 2007 was surpassed on 12 separate days in 2015.

The annual abundance of SSL present in 2015 was 19.3 per day (Figure 8) more than three times the 2002-2014 mean (6.2 SSL per day). Eight SSL were present in the Bonneville Dam tailrace when observations began on January 13th, reached a maximum of 69 SSL – a new record for Bonneville Dam. The former single day record was 53 SSL set in 2010, it was surpassed on five separate days in 2015.

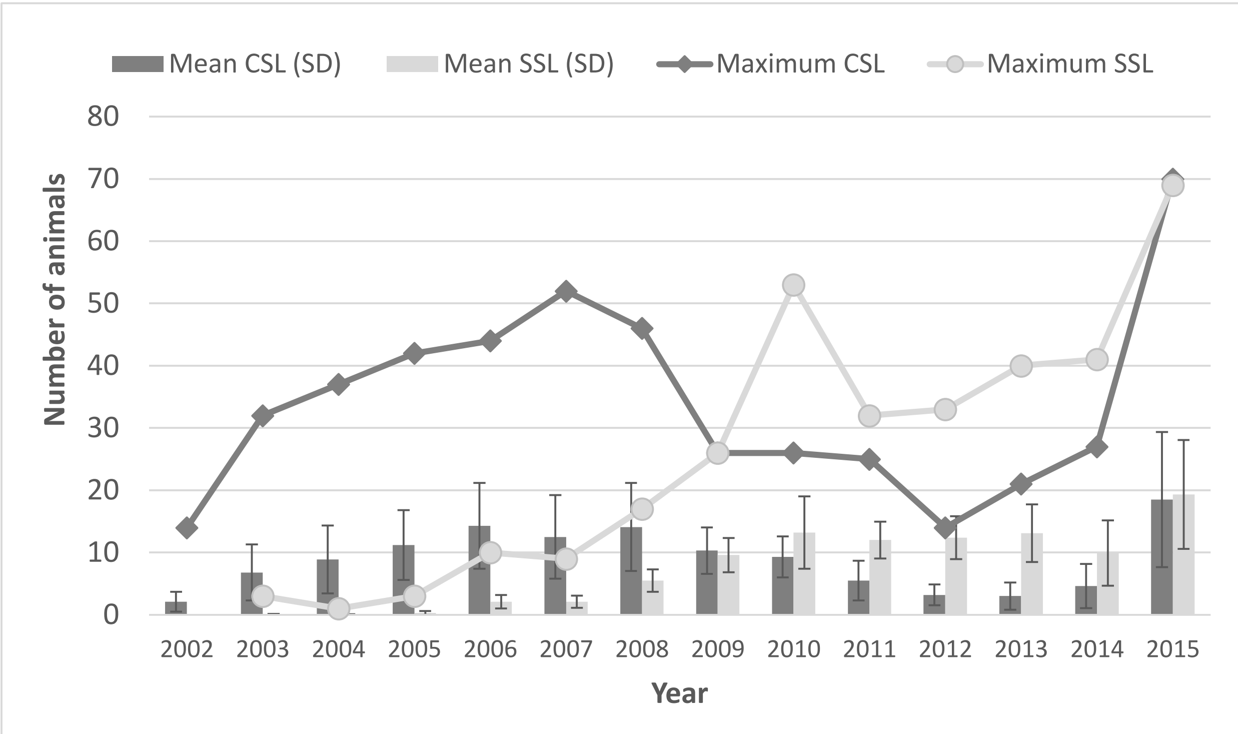

Figure 8. Abundance of California sea lions (CSL) and Steller sea lions (SSL) present at Bonneville Dam between January and then end of May, 2002 to 2015. Error bars are +/- one standard deviation.

Fall Study Period

California sea lions have been observed in the Bonneville Dam tailrace during the fall months since 2008 (Stansell et al., 2010), but less than three individual CSL were observed each year. Steller sea lions were first observed during the fall months in 2010. Unlike CSL, that would typically only be observed a few days during the fall, SSL were noted to be staying for longer periods. The USACE began an observation program for the fall study period in 2011.

The presence of SSL has increased each year from 2011 through 2015 during the fall study period (Figure 9). From a mean of 3 SSL per day in October 2011 to a mean of 22 SSL present per day in 2015. The presence of SSL usually peaks in November, drops in February, and then rebounds in March or April.

Steller sea lions now inhabit the Bonneville Dam tailrace for 10 months of the year. They are arriving during August and are present until May of the next year. Tower Island is typically used as a haul-out for SSL in the Bonneville Dam tailrace. Steller sea lions also use the floating sea lion traps for hauling out when they are anchored near Tower Island. During this time they have shifted from eating sturgeon to eating steelhead.

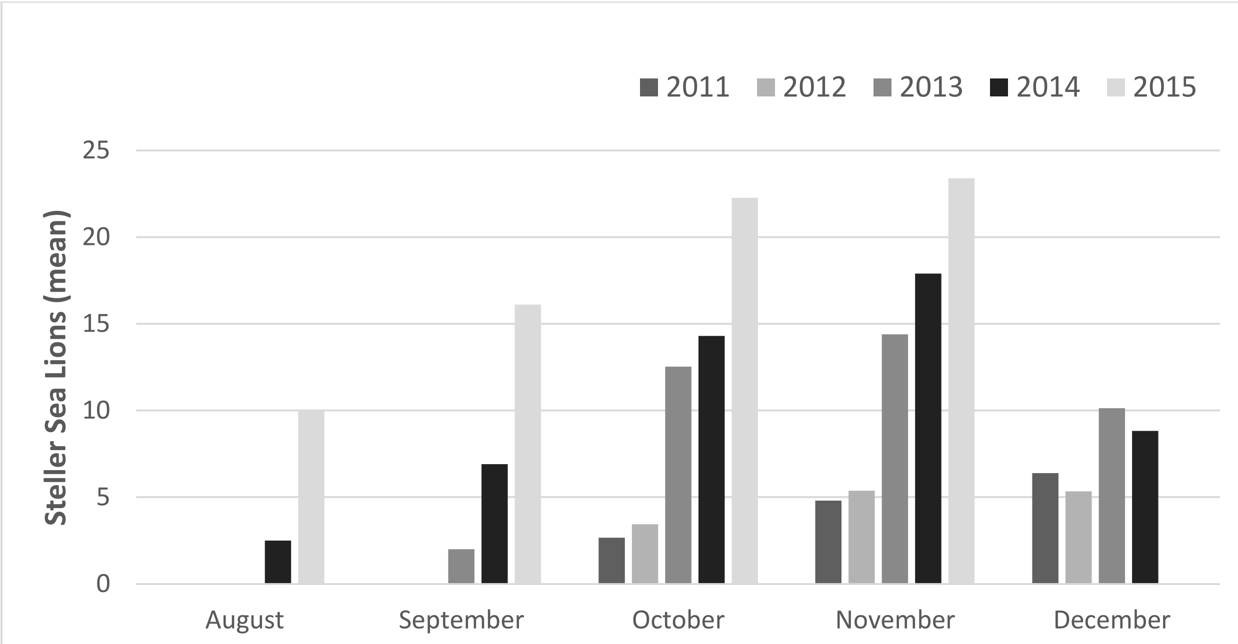

Figure 9. Monthly mean Steller sea lion abundance from August through December, 2011-2015. Data was not collected in 2011 and 2012 for August and September.

Residence Times

In 2015, the mean number of days that individually identified CSL were observed in the Bonneville Dam tailrace was 5.9 days (Figure 10), which is lower than the 2002-2014 mean of 10.8 days. The maximum number of days that an individual CSL was observed at Bonneville Dam tailrace in 2015 was 24 days, which is lower than the 2002-2014 mean of 41 days. Both the mean and maximum number of days that individual CSL were present showed an increase over 2013 and 2014, but are lower than 2006 through 2009, the years leading up to and immediately after ODFW and WDFW instituted a removal program for CSL at Bonneville Dam (Figure 10).

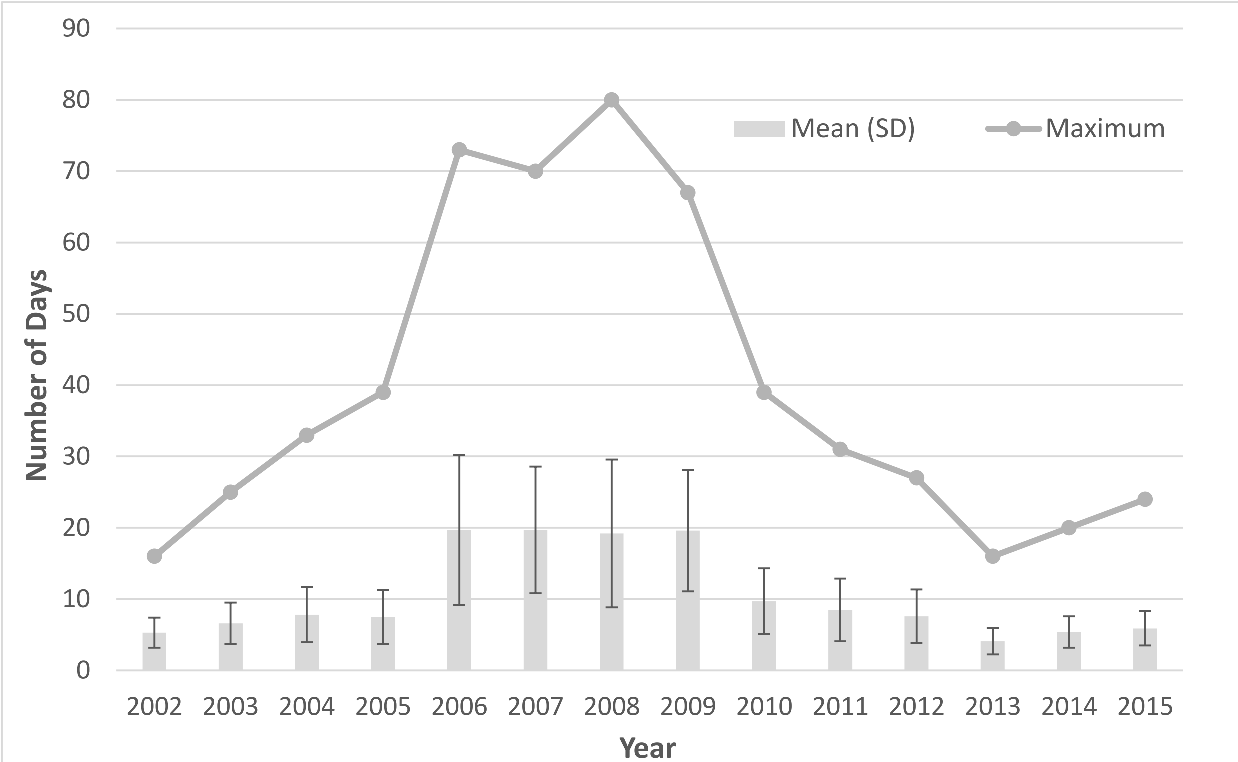

Figure 10. Residence time (days) for individually identified California sea lions observed at Bonneville Dam between January 1 and May 31, 2002 to 2015.

Recurrence

Of the individual 195 CSL tallied during 2015, 15% were animals that had been documented at Bonneville Dam in previous years (termed repeat animals) and 85% were “new” animals since they had not previously been identified since they lacked brands and/or unique natural markings. The 15% recurrence rate in 2015 represents the lowest level since observations began in 2002 and was driven down by the number of new animals. The mean recurrence rate for CSL between 2003 and 2014 was 54%.

A comparison of recurrence among CSL and SSL in 2015 is provided in Table 7. There were 29 repeat CSL during 2015. Only one of these animals has been observed at Bonneville for more than three years. Of the repeat CSL that were present during 2015, 45% were permanently removed. Of the 166 new CSL that were identified in 2015, 11% were permanently removed.

In contrast to the 15% recurrence rate of CSL during 2015, SSL had a recurrence rate of 65%. Of the 55 individual SSL present in 2015, 38% have been present for longer than three years and one individual has been observed for 9 years. Again, SSL are not targeted for removal and are returned to the water unharmed.

Table 7. Number of years that individually identified CSL and SSL returned to Bonneville Dam in 2015. Individuals present for one year were new animals identified in 2015.

Number of years observed	All identified CSL	All identified SSL	Removed CSL
9	0	1	0
8	0	4	0
7	0	3	0
6	1	2	0
5	0	5	0
4	0	6	0
3	5	5	1
2	23	10	12
1	166	19	19

Forebay Observations

Bonneville Dam has a policy to keep the downstream navigation lock gates closed at all times, except for the time that it takes for vessels to enter or exit the lock. However, in 2015 multiple CSL moved into Bonneville Reservoir by passing upstream through the navigation lock at Bonneville Dam. There were a minimum of six new CSL that were observed in the Bonneville Dam forebay in 2015 where they continue to feed on adult salmonids and have interfered with tribal fishing upstream.

On March 8, navigation lock operators observed two or three small CSL enter the navigation lock from the forebay side and then were locked downstream into the tailrace. The operators were unable to determine if there were two or three individual CSL due to their constant movements and the presence of floating woody debris in the navigation lock. The operators took cell phone pictures of these animals and we were able to determine that they were small and not likely to be one of the CSL that have been documented in the Bonneville Pool during past years.

On April 8, a small unbranded CSL was observed in the forebay. On May 18, a branded CSL (U625) was observed in the forebay. The CSL (U625) is still residing in the forebay as of this report.

In light of multiple CSL being present in the forebay, ODFW placed a floating sea lion trap in the forebay at the end of May. Shortly after placement, a CSL was observed to be hauling out on the trap regularly. On June 3, ODFW and WDFW captured a branded CSL (U322) on the forebay trap. The CSL (U322) was released on the Oregon coast on June 4.

A branded CSL (C049) was observed using the forebay trap regularly from July through September. On October 20, ODFW and WDFW captured the CSL (C049) on the forebay trap. The CSL (C049) was released on the Oregon coast on October 22.

In addition to the CSL that moved into the forebay in 2015, there are two CSL that have been residing in Bonneville Pool for multiple years. An unbranded CSL (B325) was first observed in the forebay in April 2011. In May 2012, a branded CSL (C014) was observed in the forebay. Since 2012, both B325 and C014 have regularly been observed at The Dalles Dam tailrace and The Dalles Marina including multiple sightings in 2015.

Deterrents and Management Activities

Physical Barriers

Sea lion exclusion gates were installed at all fishway entrances by March 4. Specifically, the exclusion gates at PH2 were installed on February 24, Cascades Island entrance (north side of the SPW) on March 1, B-branch entrance (south side of the SPW) on March 4, and PH1 on March 4. All SLEDs were removed for the season between July 8 and July 20.

The sea lion exclusion gates on the FOG of PH2 now remain installed year round. The sea lion exclusion gates were effective in 2015. There were no pinnipeds observed inside the fishways, nor did any observers note pinnipeds attempting to get through the exclusion gates despite considerable predation activity near the fishway entrances.

Non-Lethal Harassment

Dam-based hazing in 2015 began on March 18 and continued seven days per week through May 31 for a total of 75 days. Boat-based hazing was conducted on 31 separate days between March 6 and May 14, 2015.

As in past years, hazing activity temporarily drove pinnipeds away from the direct vicinity of the dam, but the animals typically returned shortly after hazers left the area. Overall, the total number of hours that boat and dam hazers were present was similar to 2014. The amount of dam-based and boat-based hazing that was recorded by USACE during pinniped observations is below (Table 8). Data excludes weekends and boat hazing downstream of the BRZ as our observers were not present to record this information.

The 2015 hazing season was typical in that the SPW received less hazing activity than the other tailraces due to its large size and the spilling water that starts each year on April 10 and continues the rest of the pinniped observation season. Dam-based hazing is less effective in the SPW because of the limited distance that cracker shells can be propelled by shotgun. Even if a pinniped is within range of cracker shells, the sound produced by the spilling water greatly muffles the noise produced by the cracker shell making them ineffective. Once spilling starts, boat-based hazing cannot be performed in the SPW since taking a boat into the rough conditions created by spill make it unsafe to operate there and so is not permitted by BRZ entry rules.

The 2015 hazing season was atypical in that little hazing occurred at PH1. Due to low river flows turbine units at PH1 were idle from April 10, when mandatory spill for juveniles began, until the end of the study period. This caused the majority of the pinnipeds to concentrate their hunting at SPW and PH2. Since there were few pinnipeds to haze at PH1, and it is generally ineffective to haze at SPW once spill begins, both dam-based and boat-based hazers focused their efforts at PH2.

No acoustic deterrent devices were deployed in 2015 as they have proved ineffective during testing from 2006 to 2010 under the environmental conditions that are present near dam structures and fishway entrances.

Table 8. Total hours of hazing activity in the Bonneville Dam tailrace in 2015. Data excludes weekends (hazers present) and specific hours when observers were not present.

	Number of Times Hazers were Present at Least Once in an Hour		Total Time (Hours) Hazers were Present	
Location	*Boat hazing*	*Dam hazing*	*Boat hazing*	*Dam hazing*
Powerhouse 1	36	127	8.4	39.3
Powerhouse 2	56	289	21.0	114.3
Spillway	35	86	5.4	5.3
Total	*127*	*502*	*34.8*	*158.9*

Trapping and Removal

In 2015, personnel from ODFW and WDFW operated four floating sea lion traps in the Bonneville Dam tailrace as they have for the past several years. A total of 131 CSL were trapped, branded and released between April 6 and May 22 a large increase from the mean of 8.9 brandings per year the previous eight years (Table 9). The states also captured and removed 32 of the 94 CSL that were authorized for permanent removal under Section 120 of the Marine Mammal Protection Act. Of these, 30 were chemically euthanized and 2 were placed into permanent captivity at a zoo facility. In addition to the 32 CSL removed, two CSL died accidentally in one incident on a trap during the week of April 27 and one SSL died accidentally when it was caught between two traps during the week of May 4. Steller sea lions that were captured during trapping operations in 2015 were released back into the tailrace without further handling. Brown et al. (2015) provides detailed information on all pinniped management activities by ODFW, WDFW, and CRITFC at Bonneville Dam in 2015.

Impact of the Removal of Selected California Sea Lions

More CSL were removed this year than any previous year. This is a reflection of the hard work and increased efforts of the removal crew, as well as a reflection of a major increase in the number of CSL at the dam. Table 1 details the history of salmonid consumption and Figure 8 tracks the abundance of SSL. Since the removal program began in 2008 the number of SSL had been decreasing, until this year. The influx of new SSL was much larger than in 2010 or 2013. The cause of this increase has been credited in the popular media to warm water, “the blob”, and declining prey off the California coast forcing SSL to find new places to feed. Regardless of the cause, because the population of SSL at Bonneville Dam is an open one, influxes of new animals make further analysis of this program more difficult. Still Table 7 indicates that there are far fewer multi-year CSL, when compared to SSL and the residence time of CSL has decreased since the removal program began (Figure 10).

Table 9. Summary of California sea lion (CSL) branding and removals and Steller sea lion (SSL) branding at Bonneville Dam, 2007 to 2015.

Year	CSL Branded	CSL Removed	SSL Branded
2007	8	N/A	N/A
2008	4	8	N/A
2009	3	15	N/A
2010	9	14	8
2011	9	1	9
2012	6	13	19
2013	11	4	3
2014	21	15	0
2015	131	32	0
Total	202	102	39

DISCUSSION

In 2015 we recorded the greatest abundance of sea lions and highest number of salmonids eaten at Bonneville Dam since the pinniped monitoring program began in 2002. Non-lethal deterrents continued with limited effectiveness, conversely the state's removal program more successful than usual removing 32 CLS compared to a mean of 10 animals per year the seven previous years. Unfortunately, recruitment of new California sea lions kept their abundance high. Finally, the year after year increase of Steller sea lion predation and increase in residence time may indicate a need for the region to address their behavior at Bonneville Dam and elsewhere on the Columbia River.

Predators have increased, and next year prey are forecast to decrease. Pinniped abundance has increased sharply in the Columbia River estuary and adjacent coastal areas (Brown et al. 2015). This increase has coincided with the escalating salmonid predation rates we documented at Bonneville Dam and others have documented at nearby Willamette Falls (Wright et al. 2014). Not surprisingly, tandem boat surveys by the Columbia River Inter-Tribal Fish Commission have shown a sharp increase in the number of pinnipeds between Bonneville Dam and Astoria, OR downstream (Hatch et al. 2016). Spring Chinook salmon are the primary target for pinnipeds at the dam and the initial forecast for 2016 indicates a moderate-sized run of 152,000 (NOAA 2016) compared to the 283,696 that passed in 2015. If pinnipeds return to Bonneville Dam next year in similar numbers to 2015, the portion of the adult salmonid run consumed in 2016 has the potential to be the largest yet.

Increased residence time and increased salmonid consumption by Steller sea lion is concerning. Particularly, they have shifted from targeting sturgeon to Steelhead, which they can quickly swallow whole (reduced handling time). Like CSL, SSL salmon predation was at an all-time high in 2015 and it continues to increase each year (Figure 2). SSL can arrive as early as August and remain for 10 months until May of the next year - compared to CSL reside for about 3 months. The most common prey of SSL has changed from sturgeon to Winter Steelhead during January - March. In 2015 we estimated they consumed 5.24% of steelhead passing during this time. We are unable to determine what has caused the decline in sturgeon consumption by SSL. Possible causes include lower numbers of sturgeon present in the tailrace and/or a shift in prey selection toward salmonids.

Our estimate of Stellar sea lion predation could be biased low and should be considered a minimum estimate. They are much larger than California sea lions so they have the ability to swallow Steelhead whole and, therefore, may be consuming them more quickly, giving observers less time, thus less likelihood, to detect some predation events. It also means they have the potential to swallow adult salmonids while still underwater which would be undetectable using our surface observation methods. What we report here are minimum predation estimates for both sea lion species.

Non-lethal harassment has been attempted to protect fish from pinnipeds at many locations and its efficacy has been suspect (Scordino 2010). Pinnipeds at Bonneville Dam tailrace were exposed to various hazing methods in 2015 including cracker shells, rubber buckshot, seal bombs, and boat chasing. As previously documented, pinnipeds swim away from an area when hazed, returning to resume foraging after a hazing event has ended. This lack of long term effectiveness has also been observed at Ballard Locks in Washington (Scordino and Pfeifer 1993) and Willamette Falls in Oregon (Wright et al. 2015) where various hazing efforts were abandoned as ineffective. Schakner (et al. 2013) reviewed pinniped deterrent use in the Pacific Northwest and concluded that non-lethal deterrents had limited effectiveness because pinnipeds learned to either tolerate or avoid the deterrent actions. These and other researchers have found removal of sea lions an effective method for protection of salmonids (Scordino 2010; Brown et al. 2008). While costly, hazing at Bonneville Dam continues because it is one of the criteria of the removal program: The sea lion must be present under hazing conditions.

There is currently no management action to address SSL salmonid predation at Bonneville Dam. The population of SSL that visits the dam are part of the eastern distinct population segment (DPS) from breading colonies east of 144° West longitude (from Cape Suckling south to California's Channel Islands). Their numbers have recovered to the point that they were removed from the List of Endangered and Threatened Wildlife in 2013 (US Office of the Federal Register 2013) and this population continues to increase (Brown et al. 2015).

Marking more SSL would allow unique identification of individuals. Presently, the USACE Pinniped Monitoring Program is unable to identify a large number of SSL at Bonneville because they lack human-applied brands or unique natural markings. Any increase in SSL marking would allow observers to track individual predation. Since SSL have shown site fidelity to

Bonneville Dam, permanent marks, such as a brand, would be preferred to allow for their long-term monitoring.

The US Army Corps of Engineers and regional fish managers should consider installing sea lion excluder devices whenever pinnipeds are present in the Bonneville Dam tailrace or leaving them in place year-round. In the fall of 2015, USACE biologists observed SSL in the fishways of Bonneville Dam. The regionally approved Fish Passage Plan (USACE 2015) requires that sea lion excluder devices be removed during the fall passage season to ease passage for the large number of Fall Chinook. Now that SSL have learned to enter fishways, it is likely that they will continue to do so when the sea lion excluder gates are not in place.

With 2015 having the largest single year increase in salmon predation and abundance of sea lions at Bonneville Dam, there needs to be an adaptive management response. The forecast for a decrease in the Spring Chinook run means the impact of pinnipeds has the potential to be greater in 2016 than any previous year. Existing non-lethal hazing continues to be ineffective at moving feeding animals away from the Bonneville Dam tailrace. Development of new hazing techniques and, potentially, removal of problem animals may continue to be needed to minimize impacts to Endangered Species Act listed fish.

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Appendix A. Table of progressive estimates of pinniped predation on salmonids (also broken out by pinniped species) at Bonneville Dam, 2002-2015, 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%	3,516	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	2.72%	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%	4,292	2.82%	174	0.11%
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	1.86%	986	0.36%
2011	3,315	223,380	3,557	1.57%	2,527	1.11%	1,030	0.45%
2012	3,404	171,665	2,107	1.21%	998	0.57%	1,109	0.64%
2013	3,247	120,619	2,714	2.20%	1,402	1.14%	1,312	1.06%
2014	2,947	219,929	4,313	1.92%	2,615	1.17%	1,699	0.76%
2015	2,995	239,326	9,981	4.00%	7,779	3.12%	2,202	0.88%

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%	3,516	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	3.05%	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%	4,735	3.11%	192	0.13%
2009	3,455	186,056	4,960	2.60%	4,353	2.28%	607	0.32%
2010	3,609	267,167	6,321	2.31%	5,296	1.94%	1,025	0.37%
2011	3,315	223,380	3,971	1.75%	2,689	1.18%	1,282	0.56%
2012	3,404	171,665	2,360	1.36%	1,067	0.61%	1,293	0.74%
2013	3,247	120,619	2,928	2.37%	1,497	1.21%	1,431	1.16%
2014	2,947	219,929	4,704	2.09%	2,830	1.27%	1,874	0.84%
2015	2,995	239,326	10,859	4.34%	8,324	3.33%	2,535	1.01%

ADJUSTED FOR NIGHT HOURS NOT OBSERVED (AN ADDITIONAL 3.5% ADDED 2006-2010, 0.9% 2011-2014)

			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%	3,516	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%	4,901	3.21%	198	0.13%
2009	3,455	186,056	5,134	2.69%	4,505	2.36%	628	0.33%
2010	3,609	267,167	6,542	2.39%	5,481	2.00%	1,061	0.39%
2011	3,315	223,380	4,007	1.76%	2,713	1.19%	1,294	0.57%
2012	3,404	171,665	2,382	1.37%	1,077	0.62%	1,305	0.75%
2013	3,247	120,619	2,954	2.39%	1,510	1.22%	1,444	1.17%
2014	2,947	219,929	4,746	2.11%	2,855	1.28%	1,891	0.85%
2015	2,995	239,326	10,859	4.34%	8,324	3.33%	2,535	1.01%