11-21-2019

# Behavioral Analyses of *Zalophus californianus* and *Eumetopias jubatus* at Bonneville Dam as Tools to Understand Salmonid Take and Inform Regulation Changes

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# Behavioral analyses of *Zalophus californianus* and *Eumetopias jubatus* at Bonneville Dam as tools to understand salmonid take and inform regulation changes

By
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An undergraduate honors thesis submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in University Honors and Biology

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## Abstract

Both *Zalophus californianus* and *Eumetopias jubatus* are species known to travel upriver into the Columbia River, reaching as far as the Bonneville Lock and Dam. Bonneville Dam works with federal agencies to hatch and protect salmonids within the Columbia River. Pinnipeds at the dam have been studied since the 1980's in an effort to understand their behaviors and feeding patterns on endangered salmon species. Since 2006, the hazing of *Z. californianus* and *E. jubatus* has gone on, showing little effectiveness in lowering the sea lion's consumption rates (ranging from 0.4-5.8% annually). Behavioral analyses conducted during the spring salmon run of 2019 produced no visible sightings of salmon consumption, but showed large utilization of fire arms and boat chasing to deter sea lions from the dam area. While behavioral analysis data was limited, this data in conjunction with literature suggests that the programs run by the Oregon Department of Fish and Wildlife (ODFW) and the US Army Corps of Engineers (USACE) are unsuccessful in deterring sea lions from Bonneville Dam and should be reevaluated.


## Literature Review

Over the past 20 years, scientists and engineers at Bonneville Dam have been tracking information and providing reports on all things having to do with salmon and sea lions in the area. One of the biggest things that they have been tracking has been the numbers of sea lions in the Bonneville area. According to the 2008-2010 evaluation report from the US Army Corps of Engineers, the numbers of pinnipeds (including both sea lions and harbor seals) at the dam ranged from 31 to 166 a year from 2002-2010 (Stansell, 2010). This can be compared to the more recent report from the Army Corp, released in 2018. This 2018 study provides the data from 2002-2010, while now including data from 2011-2018, which shows numbers of sea lions fluctuating between 112-264 (Tidwell, 2019). Table 4 shows the data from both studies. This provides information that there may be more sea lions traveling to the dam, but also that these sea lions are now being monitored more. The 2018 report depicts the number of study hours associated with the sea lions and there is a sharp increase in the hours of observation in 2006-2015, before dropping back down. It's clear that these animals are being watched more at the dam, which could be part of the reason that more sea lions are being seen. This means that either, there are more sea lions at the dam, or we are just noticing them more.

Not only are the sea lion numbers being heavily monitored, but so are the fish stock numbers. Fish stocks have been monitored for decades in the hopes to understand species endangerment, the success of conservation programs, and other ecological problems that have cropped up for these species. In the USACE 2008-2010 report, yearly fish run numbers ranged from 82,006-284,733 fish from January 1$^{st}$ until May 31$^{st}$ (Stansell, 2010). According to the 2018 report, between 2011-2018 the yearly fish stock ranged from 100,887-239,326 fish (Tidwell, 2019). Table 5 shows the numbers associated with each year. Yearly rates fluctuate largely, but show an overall steady trend in numbers. Bonneville Dam even shows charts broken out by species and year to to the general public in their Bradford Island visiting center. These charts show most species, with the exception of lamprey (a non-salmonoid species), increasing in numbers since the beginning of studies in the 1940's. Figure 2 displays this chart. These data all come together to suggest an overall increase in species in recent decades, now tapering out to a steady rate.

To understand the impacts that the increased presence of sea lions has had on the fish stocks, USACE, the Oregon Department of Fish and Wildlife, and other scientists have studied sea lion predation rates at Bonneville. USACE 2008-2010 report shows an adjusted salmonid consumption rate of 2.4-4.7% of the yearly spring salmon run in 2006-2010 and expanded consumption rates of 0.4-3.4% in 2002-2005 (Stansell, 2010). These expanded rates account for missed observation time and the adjusted rates

account for catch classified as "unknown" species types. The 2018 report shows similar rate for 2011-2018, ranging from 1.4-5.8% (Tidwell, 2019). Table 5 shows the data from both of these studies. A 2019 update from USACE showed that only 6 fish catches were observed during the month of March at Bonneville Dam, with only 4 being identified as a salmonid species (Fisheries Field Unit, March 2019).

The Marine Mammal Protection Act (MMPA) is the biggest factor that determines what states can and cannot do to marine mammals in terms of management. Congress passed the MMPA in 1972, an act that places protections on these species, establishes conservation programs, and explains how states can manage health and stranding events. While the main goal of the act is to protect these species, it does include the ability for states to apply for specific authority to circumvent these protections. In 1994, congress amended the MMPA to include Section 120. Section 120 provides states with the ability to apply for permits for the lethal take of pinnipeds that pose "significant negative impact on the decline or recovery of salmonoid fish stocks" ("The Marine Mammal Protection Act of 1972 as Amended"). In 2006, Oregon, Washington, and California became the second set of states to gain a permit through Section 120 with their plan to focus much of their take around the Bonneville Dam site (Cheng, 2011).

In 2005, the state of Oregon began running hazing programs in the hopes to deter sea lions and other pinnipeds from the area. Behavioral deterrents can be defined as "management techniques that use adverse stimuli to prevent animals from utilizing human resources" (Schakner, 2013). A variety of different deterrent methods are used at Bonneville Dam, including boat chasing, pyrotechnics, sea lion exclusion devices (SLEDs), acoustic devices, and visual cues (Stansell, 2010; Scordino, 2010). During a 100 day span, from February till May of 2007, boat chasers used over 14,000 cracker shells, 2,500 seal bombs, and 1,000 rubber buckshot rounds in an attempt to push sea lions out of the area (Brown, 2007). While data concerning the total costs of these programs are not accessible, the 2015-2017 legislatively adopted budget for ODFW showed projected shortfalls in the budget for pinniped and avian predation programs. ODFW requested $131,026 to be allocated to this program from their general fund, a fund which comes from Oregon State tax dollars. ("Fish Division Marine and Columbia River Fisheries Program"; "2017-2019 Legislature Approved Budget"). The 2017-2019 cost analysis for the expansion of the marine mammal program has not been released yet, providing no data on the true costs of the expansion.

While these methods are gaining increased funding and attention, the deterrents are not successful in pushing sea lions out of Bonneville Dam or in keeping them from feeding. Over time, deterrence efforts began to have smaller effects on the predation rates. *Eumetopias jubatus* were originally easier to deter, but became more conditioned and less responsive to hazing methods (Scordino, 2010). As discussed previously, yearly salmonid consumption rates have stayed steady since the beginning of observations. Robin Brown's 2007 study determined that due to the salmon predation being just as great or greater in years of hazing, that intensive hazing was unsuccessful in reducing sea lion predation at Bonneville (Brown, 2007). It's been hypothesized that sea lion predation at Bonneville Dam is a learned behavior. Many of the returning *Z. californianus* were feeding on larger proportions of salmonids compared to their newer counterparts and they "tended to be present for extended periods and probable developed selective foraging behaviors" (Keefer, 2012). Not only are these methods not working, but studies suggest that these methods may actually cause harm to the salmonid species they are aiming to protect. Kenneth Ostrand's study on white sturgeon and electrical sea lion barriers concludes that implementing these barriers would likely "alter the microhabitat use; changes in migratory, feeding, and reproductive behavior, and mortality of white sturgeon, particularly during periods of continuous operations" (Ostrand, 2009). Not only this, but there is suggestion that it would change white sturgeon seasonal and daily migrations, with site fidelity being negatively influenced by the system's operation, and that the growth and survival of non-spawning white sturgeon would be altered (Ostrand, 2009).

With the 2006 Section 120 permit, Oregon had the authority to begin lethal take of *Z. californianus* at Bonneville Dam. According to the June 2016 letter sent to ODFW, as well as the Washington and Idaho Departments of Fish and Wildlife, these states can continue to lethally take 1% of the potential biological removal level (PBR) annually (Stelle, 2016). This 1% PBR at the time of the letter was 9,200 sea lions which could be removed. While they can remove this many, the animal must be individually identifiable, have been observed feeding at Bonneville Dam, been at the dam for at least 5 days, and have failed to be deterred by other means (Stelle, 2016). From the beginning of these permit until May 20th 2019, 393 sea lions have been listed for removal (Thom, 2019). The National Marine Fisheries Services (NMFS) will notify Bonneville Dam when a zoo, aquarium, or other facility is willing to take these animals in. Although, if the facility fails to collect the animal within 48 hours of capture, the animal can be euthanized by the dam (Stelle, 2016). Since the start of the program, only 15 of the 393 *Z. californianus* were transferred to a facility. Of those 393, 209 were killed by injection, and the rest remain to be captured and euthanized (Thom, 2019).

The culling of *Z. californianus* was meant to act as a way to decrease predation on salmonids at the dam since hazing was not considered effective. Although, the euthanization of these sea lions is proving to be ineffective as well. Sea lions are continuing to teach each other these learned behaviors, making the removal of one have little effect on the remaining animals. Zachary Schakner discusses the social associations between California sea lions. In his article, Schakner states "It appears that with the initiation of culling in 2008, the successful repeated foragers were lethally removed. But, because the transmission process was well established, new individuals were recruited to the dam and filled the open foraging niches"( Schakner, 2017). In addition, as *Z. californianus* numbers decreased, *E. jubatus* numbers sequentially increased. Culling has also been proven to be ineffective in a variety of different habitats. In a study done in open marine areas where other marine mammals and fisheries compete, results suggested that there was actually little competition (as had been propagated by fisheries so as to justify the culling) and that even the eradication of all marine mammals in the world would not increase fishery catches, therefore large-scale culling as had been proposed was unnecessary (Morissette, 2012). In an article discussing culling of terrestrial species, multiple case studies were presented showing that culling caused increased predation by dingos, foxes, and feral cats and other negative effects in populations (Newsome, 2017).

Euthanization of sea lions at Bonneville Dam is proving to be a contentious topic for everyone involved and for the general public. In April of 2008, the Humane Society of the United States filed for an emergency injunction to halt ODFW and Washington from conducting lethal take of *Z. californianus* at Bonneville Dam (Humane Society of the US v Gutierrez, 2008). The court of appeals decided to provide a slight stay, where the dam could not euthanize any sea lions, but were allowed to capture and relocate the animals to sanctuaries and other rescue facilities. In February of 2009, the Humane Society filed for a continuance of the stay, which was ultimately denied on the grounds that they had not demonstrated the "likelihood of success on the merits"(Humane Society of the US v Gutierrez, February 2009). Their final attempt was in November of 2009, where the court decided against all of the plaintiff's arguments, allowing ODFW and the Washington State Department of Fish and Wildlife to conduct euthanization programs at Bonneville and other areas as determined in their permit (Humane Society of the US v Gutierrez, November 2009).

## Field Study

Bonneville Lock and Dam is known as a large tourist site and historic landmark along the borders of Oregon and Washington. In 1938, the U.S. Army Corps of Engineers opened the dam's first powerhouse, spillway, and the original navigation lock, making Bonneville the first federal lock and dam along the Columbia and Snake rivers ("US Army Corps of Engineers Portland District"). Since this time, a

second powerhouse and new navigation lock have been added to the system and it today acts as a critical part of the management of the Columbia River. The site has since been deemed a national historic landmark due to it's Colonial-Revival architecture ("US Army Corps of Engineers Portland District"). Bonneville is still used as a site for collecting hydropower, navigation, and general public education. Resting on the site of Bonneville Lock and Dam is the Oregon Department of Fish & Wildlife's Bonneville Fish Hatchery. The original hatchery was built in 1909 and today acts as ODFW's largest hatchery facility with multiple species programs ("Bonneville Hatchery Visitors' Guide"). Bonneville Fish Hatchery works to raise both Chinook and Coho Salmon while also displaying and educating the public on other species, including Rainbow Trout and Sturgeon. Fish hatched at Bonneville help to supplement the natural populations of salmonid species in the Columbia River. Also on the Bonneville Lock and Dam site rests two visitors centers, one on Bradford Island called the Bradford Island Visitor's Center and one on the Washington shore called the Washington Shore Visitor Complex. The Bradford Island Visitor's Center provides the general public with information on "how nature, technology, and human's intersect" ("US Army Corps of Engineers Portland District"), while also displaying underwater views of the dam's fish ladders and educating people on the dam's migrating salmon and Pacific lamprey.

While not discussed on Bonneville's Lock and Dam webpage or in the visitors centers, Bonneville has also become home to a variety of pinniped species, most notably the California Sea Lion (*Zalophus californianus*) and the Steller Sea Lion (*Eumetopias jubatus*). *Zalophus californianus* have a range along the coast of southern California during the breeding season (with subpopulations breeding along the coast of Mexico), and males migrating in the off season up along the Oregon, Washington, and Canadian coasts (Reeves, 2002). This species of pinniped is known for it's varied diet including many types of fish, cephalopods, and more (Reeves, 2002). Males along Oregon, Washington, and northern California have been seen positioning themselves at the mouth's of streams and rivers to collect migrating species such as salmon, lamprey, and eels (Reeves, 2002). Population numbers for this species were on a decline in the 1920's to 1940's when commercial harvesting of these pinnipeds was legal, but since protection, their numbers have increased to around 175,000 in 2001 (Reeves, 2002). *Eumetopias jubatus* is a slightly larger pinniped that is known to range along the west coast of the United States, Canada, and over to Japan and the surrounding islands both during the breeding and off season (Reeves, 2002). The diet of this species tends to vary depending on seasonal availability but many sea lions in Oregon, Washington, and California have been seen moving into freshwater systems to feed on lamprey and salmonids (Reeves, 2002). There has been a population decline since the 1970's. While the cause of species decline is unknown, it is likely linked to increases in commercial fishing and changes in the marine environment. Some *E. jubatus* populations are recognized and listed under the United State's Endangered Species Act (Reeves, 2002). Both *Z. californianus* and *E. jubatus* are federally protected by the United States under the Marine Mammal Protection Act of 1972.

Since the early 1980's, ODFW and the Washington Department of Fish & Wildlife (WDFW) have been studying pinniped abundance and feeding in the Columbia River, specifically at the Bonneville Dam (Brown, 2007). Sea lions, as well as seals, have been seen to feed on salmonids migrating through the dam area, including ESA listed species. In 2005, ODFW and WDFW began hazing programs as a method of deterring sea lions feeding at the dam. In 2006, the states of Oregon, Washington, and California were given a permit to begin the lethal take of *Z. californianus* in the area. Since this time, the hazing and euthanization of sea lions around Bonneville Dam continues and now these programs have more federal funding and decreased restrictions. This field study sought to understand the behaviors of the *Z. californianus* and *E. jubatus* present at the dam, the effectiveness of the hazing and culling programs that have been introduced in the area, and in turn add to the discussion of whether the hazing and culling of California and Steller Sea Lions should continue. Specifically, this field study was designed to ask how hazing affected sea lion feeding patterns at the Bonneville Dam.

## Methods:

Behavior analyses were conducted at three sites on the Bonneville Dam grounds. Each site was chosen for it's visibility of the waterways and for having a relatively high level of sea lion activity. Site 1 ran along the Oregon side of the river near the western edge of the grounds. This site was chosen because it showed clear views of the river downstream of the dam and was the area sea lions had to swim through to access the dam. The second site, Site 2, ran along the south western side of Bradford Island and provided views of the fish ladders, sea lion traps, and was the site of large amounts of sea lion hazing. Site 3 was located on the north western side of Bradford Island and also showed large amounts of sea lion and hazing activity. No sites were on the eastern side of the dam due to a lack of public access for humans.

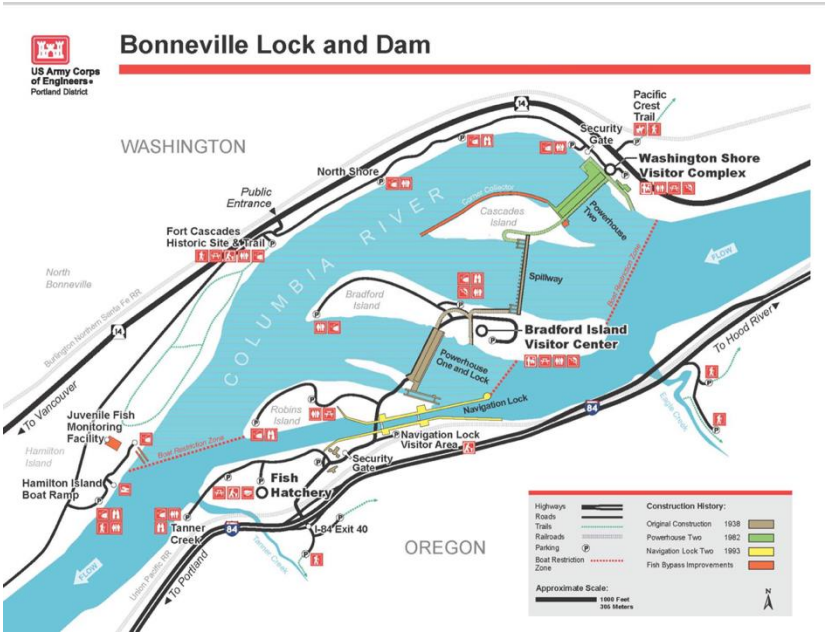


Figure 1: A map of the Bonneville Dam grounds.

Analyses ran for three hours at a time over four days during spring salmon runs. Each date aligned with some portion of the salmon run. The first date (April 12th 2019) was not long before the start of the major fish run, April 25th 2019 and May 3rd 2019 (days two and three) were during the spring fish run, and the final date (May 9th), was as the fish run was ending for the season. Researchers took data by hand, including information on when sea lions were seen, their location, their species if identifiable, what behaviors they were exhibiting, and if feeding occurred. Data also including hazing information such as when shots were heard or if boat chases were seen. All data were conducted at above water viewing locations. Sea lions often bring prey to the water's surface to feed, making it the most accurate way to collect feeding information (Keefer, 2012). Data were later compiled into a list for analysis. Data on fish runs were added to the sea lion data later from the U.S Army Corps of Engineers (USACE) online fish counter. These numbers were used in conjunction with the sea lion data to determine alignment between sea lion data and fish counts.

## Results:

Day 1- April 12th

12:00pm-3:00pm. No sea lions were seen during this study period. Although there was no sea lion activity seen, two hazing boats were seen at 1:15pm and 2:00pm. The hazing boat at 1:15pm was seen at Site 2 near the sea lion traps. The second boat was seen from Site 3 near the Washington coastline, just west of powerhouse 2. During this date, 8 Chinook and 20 Steelhead salmon travelled through the area ("Adult Fish Counts for Portland District"). See Figure 3 for raw fish count data.

Day 2- April 25th
11:00am-2:00pm. During this data collection period, 21 sea lions were seen. 7 were identified as *Z. californianus*, 10 as *E. jubatus*, and 4 were unidentifiable. No feeding was observed and all were seen swimming. Hazing boats were used both for boat chases and to deploy explosive devices. One sea lion was seen interacting with a bald eagle. Fish run data for this date showed 161 Chinook and 4 Steelhead salmon travelled through the ladders ("Adult Fish Counts for Portland District"). See Table 1 and Figure 4 for raw data.

Day 3- May 3rd
12:15pm-3:15pm. 19 sea lions were seen on this day. Of the 19, 3 were identified to be *Z. californianus,* 15 as *E. jubatus,* and one was unidentifiable. No feeding was observed and all were seen swimming. Boat chasing was seen and eight shots heard. Fish stocks showed 2,640 Chinook and 17 Steelhead travelled through the ladders ("Adult Fish Counts for Portland District"). See Table 2 and Figure 5 for raw data.

Day 4- May 9th
12:00pm-3:00pm. On this date, nine sea lions were seen. None were identified as *Z. californianus*, 7 were identified as *E. jubatus*, and 2 were unidentifiable. No feeding was observed and all were seen swimming. Boat chasing was seen and eight shots heard. Run numbers showed 2,402 Chinook and 14 Steelhead salmon passed through the dam ("Adult Fish Counts for Portland District"). See Table 3 for raw data (no daily fish count charts available) .

## Discussion:

This study found sea lions at Bonneville Dam to be exhibiting only a few general behaviors. Every sea lion seen was swimming and no occurrences of feeding were observed. Hazing did occur, mostly consisting of boat chases and projectiles. While it is known that other types or hazing are used, such as taste aversion or acoustic deterrents, the study did not document them due to its limited time length. Considering that this research only was conducted for four observation periods, it acts as a starting point for further studies.

These data highlight some main points for future research. Any future studies should include a longer time scale and more observation days. Given more time, it's likely that more behaviors would be exhibited and there would be a better idea of the frequency of these observations. While these data are limited, it does provide a basis for sea lion feeding at Bonneville and the impact of the hazing programs. It gives a broad scope of what behaviors look like at various times during the salmon run, how often hazing occurred, and in turn how effective the hazing was in deterring sea lions from the dam.

# Conclusions

It's clear that hazing techniques utilized by USACE and ODFW at Bonneville Dam are having little success in deterring either *E. jubatus* or *Z. californianus* from feeding on salmonid species. Sea lions are learning new behaviors that are shared through social interactions outside of the feeding season and they still continue to feed on similar percentages of the yearly fish run, no matter the use of deterrent

methods. This overall leads to the question: Should we be conducting hazing or culling programs at Bonneville Dam? Based on the data, it seems that these programs provide little success while costing large sums of tax payer dollars and lead to unwanted effects on the species that are meant to be protected. Not only are these programs causing ecological damage, but bring the people involved into a state of legal and moral questionability. Morally, who decides which species are more important than another? Overall, these programs are proving to be large money sinks that ultimately are inefficient and harmful to the natural habitat.

To take this study a step back, are the sea lions truly taking a large proportion of the salmonid yearly run? As discussed previously, sea lions are known to take a percentage ranging from 0.4-5.8% annually between 2002-2018, with this percentage encompassing a mixture of various salmonid species (Tidwell, 2019). The Columbia River is recreationally and commercially fished every year, both by treaty groups and non-treaty entities. In a 2019 report from ODFW and WDFW, the total yearly wild harvest of Chinook in the upper Columbia River ranged from 8.1-16.8% of the run size from 2002-2018. On the Snake River side, the total yearly wild catch of Chinook ranged from 8.1-16.7% of the run size in 2002-2018 (Joint Columbia River Management Staff, 2019). This percentage range is over twice as large as that of the sea lions and only covers one species which fisheries harvest, as well as only one season. If the argument stands that sea lions are having a negative effect on the salmonid population at Bonneville Dam, then fisheries also must make an adjustment to their catch numbers for the recovery of the various salmon species. Although, it simply seems that sea lions have become the target for fisheries frustrations, when overfishing and human impact may have larger parts to play in the cause of salmonid mortality. When visiting the dam, there are no signs to discuss the species of pinnipeds that travel to the dam or to discuss the hazing that is happening within the public view. During the field study, I experienced tension filled conversations when confronted by officials at the dam during the course of the behavior analyses. The dam harbors an attitude of anger and annoyance towards these species, clearly outlined within the programs and decisions they create.

Based on the above information, the next logical question is where do we go from here? Clearly, these programs are ineffective, money/labor intensive, and focus their efforts on only a small portion of salmonid mortality in the area. It may be pertinent to focus future efforts in a different area of salmonid mortality, such as recreational/commercial fishing or death from manmade products. For future behavior studies on this topic, it would be important to include longer behavioral analyses observations that encompass a larger span of the fish run. It may also be important to reevaluate costs of the culling and hazing programs as more financial information becomes available as well as how effective the newly expanded programs are.

This study leaves many questions for evaluation. How endangered are these salmon populations currently or are their numbers increasing? What are the main causes for salmon mortality? How can we allocate our resources better for salmon conservation? Are the lives of salmonids more important than those of the sea lions? All of these could be important topics for continuing research and could help lead towards reforming laws and practices in the state of Oregon and specifically at Bonneville Dam.

## Sources

"Adult Fish Counts for Portland District" http://fpc.org/environment/home.asp (accessed May, 2019).
Salmon run numbers and pinniped consumption rates annually from Stansell, 2010 and Tidwell, 2019.
https://myodfw.com/bonneville-hatchery-visitors-guide (accessed October, 2019).
Brown, R.; Jefferies, S.; Wright, B.; Tennis, M.; Gearin, P.; Riemer, S.; Hatch, D. Field Report—2007 Pinniped Research And Management Activities At Bonneville Dam, 2007.

Cheng, J. One Sea Lion's Worth - Evaluating the Role of Values in Section 120. UCLA Journal of Environmental Law and Policy, 29, 165–213, 2011.

Fisheries Field Unit. March Update: Pinniped Abundance and Salmon Predation at Bonneville Lock and Dam. U.S. Army Corps of Engineers, Bonneville Lock and Dam: Cascade Locks, Or., 2019.

Humane Society of the United States v. Gutierrez. United States Court of Appeals Ninth Circuit, April 23rd 2008.

Humane Society of the United States v. Gutierrez. United States Court of Appeals Ninth Circuit, February 26th 2009.

Humane Society of the United States v. Gutierrez. United States Court of Appeals Ninth Circuit, November 6th 2009.

Joint Columbia River Management Staff. 2019 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species. Oregon Department of Fish & Wildlife, Washington Department of Fish & Wildlife, 2019.

Keefer, M. L.; Stansell, R. J.; Tackley, S. C.; Nagy, W. T.; Gibbons, K. M.; Peery, C. A.; Caudill, C. C. Use of Radiotelemetry and Direct Observations to Evaluate Sea Lion Predation on Adult Pacific Salmonids at Bonneville Dam. Transactions of the American Fisheries Society 2012, 141, 1236–1251.

Morissette, L.; Christensen, V.; Pauly, D. Marine Mammal Impacts in Exploited Ecosystems: Would Large Scale Culling Benefit Fisheries?. PLOS ONE, 7(9), 2012.

Newsome, T.; Eeden, L.V.; Lazenby, B.; Dickman, C. Does Culling Work? Australian Science, 28-30, 2017.

Oregon Department of Fish & Wildlife. 2017-2019 Legislature Approved Budget.

Oregon Department of Fish & Wildlife. Fish Division Marine and Columbia River Fisheries Program. 2015-2017 Biennium, pg. 575-630.

Ostrand, K.G;, Simpson, W.G.; Suski, C.D.; Bryson, A.J.; Behavioral and Physiological Response of White Sturgeon to an Electrical Sea Lion Barrier System. Marine and Coastal Fisheries 1, 363–377, 2009.

Reeves, R.R; Stewart, B.S.; Clapham, P.J; Powell, J.A. National Audubon Society Guide to Marine Mammals of the World. Alfred A. Knopf, 2002.

Schakner, Z.A. Applying principles of animal behavior to issues involving California sea lions interacting with Southern California fisheries and predation of endangered salmonids. UCLA Electronic Theses and Dissertations, 2016.

Schakner, Z.A.; Blumstein, D. T. Behavioral biology of marine mammal deterrents: A review and prospectus. Biological Conservation, 167, 380–389, 2013.

Schakner Z.A.; Petelle MB.; Tennis MJ.; Van der Leeuw BK.; Stansell RT.; Blumstein DT. 2017 Social associations between California sea lions influence the use of a novel foraging ground. R. Soc. open sci. 4: 160820, 2017. http://dx.doi.org/10.1098/rsos.160820

Scordino, J. West Coast Pinniped Program investigations on California sea lion and Pacific harbor seal impacts on salmonids and other fishery resource, 2010.

Stansell, R. J.; Gibbons, K. M.; Nagy, W. T. Evaluation of pinniped predation on adult salmonids and other fish in the Bonneville Dam tailrace, 2008-2010; U.S. Army Corps of Engineers, Bonneville Lock and Dam: Cascade Locks, Or., 2010.

Stelle, W.W. Jr. MMPA Section 120 2016 LOA Final. National Oceanic and Atmospheric Administration, 2016.

Tidwell, K.S.; Carrothers. B.A.; Bayley, K.N.; Magill, L.N.; van der Leeuw, B.K. Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace, 2018; U.S. Army Corps of Engineers, Bonneville Lock and Dam: Cascade Locks, Or., 2019

"The Marine Mammal Protection Act of 1972 as amended: as amended through 2015"

Thom, B. Appendix 1: 2016 MMPA Section 120 Authorization - Amendment 17, May 20th, 2019. National Oceanic and Atmospheric Administration, 2019.
US Army Corps of Engineers Portland District, Bonneville Lock and Dam https://www.nwp.usace.army.mil/bonneville/ (accessed May, 2019).

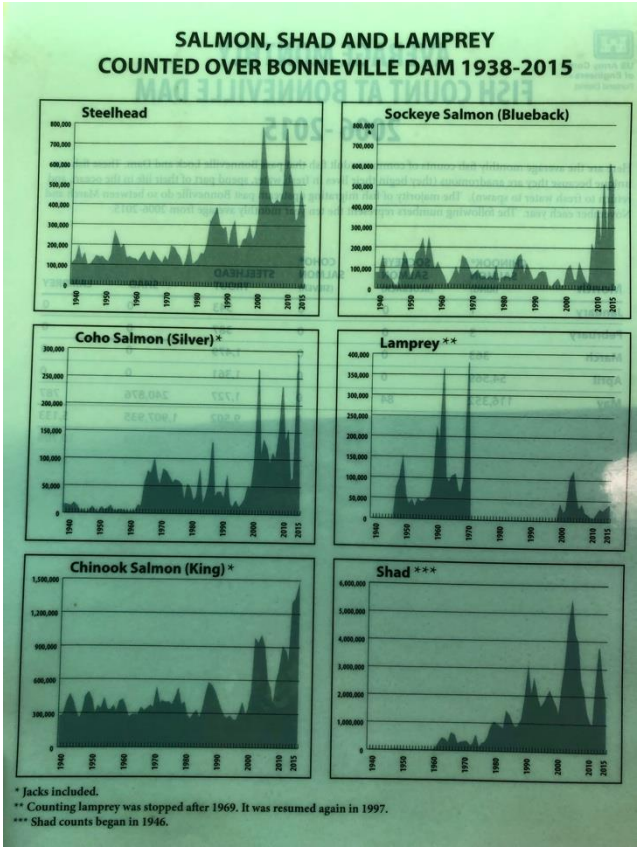


Figure 2: A photo of the fish populations displayed at the Bradford Island Visitor's Center

**Daily Adult Fish Counts**
**Friday, April 12, 2019**

**U.S. Army Corps of Engineers**
Portland District
csv format

| Ladder | All Chinook | Adult Chinook | Jack Chinook | All Steelhead | Clipped Steelhead | Unclipped Steelhead | All Coho | Adult Coho | Jack Coho | Sockeye | Chum | Pink |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bonneville** | | | | | | | | | | | | |
| Bradford Island | 4 | 4 | 0 | 11 | 4 | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| Washington Shore | 4 | 4 | 0 | 9 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 8 | 8 | 0 | 20 | 9 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| **The Dalles** | | | | | | | | | | | | |
| East | 1 | 1 | 0 | 5 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| North | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 1 | 1 | 0 | 5 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| **John Day** | | | | | | | | | | | | |
| South | 0 | 0 | 0 | 9 | 1 | 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| North | 2 | 1 | 1 | 7 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 2 | 1 | 1 | 16 | 4 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| **McNary** | | | | | | | | | | | | |
| Oregon Shore | 0 | 0 | 0 | 13 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Washington Shore | 0 | 0 | 0 | 1 | 2 | -1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 0 | 0 | 0 | 14 | 15 | -1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Ice Harbor** | | | | | | | | | | | | |
| South | 0 | 0 | 0 | 17 | 16 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| North | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 0 | 0 | 0 | 18 | 17 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Lower Monumental** | | | | | | | | | | | | |
| South | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| North | 0 | 0 | 0 | 17 | 14 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 0 | 0 | 0 | 17 | 14 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Little Goose** | | | | | | | | | | | | |
| LGS ladder | 0 | 0 | 0 | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 0 | 0 | 0 | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Lower Granite** | | | | | | | | | | | | |
| LGR ladder | 0 | 0 | 0 | 28 | 20 | 8 | 0 | 0 | 0 | 0 | 0 | 0 |

Figure 3: Daily fish counts for Day 1 from USACE ("Adult Fish Counts for Portland District")

**Daily Adult Fish Counts**
**Thursday, April 25, 2019**

**U.S. Army Corps of Engineers**
Portland District
csv format

| Ladder | All Chinook | Adult Chinook | Jack Chinook | All Steelhead | Clipped Steelhead | Unclipped Steelhead | All Coho | Adult Coho | Jack Coho | Sockeye | Chum | Pink |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bonneville** | | | | | | | | | | | | |
| Bradford Island | 29 | 29 | 0 | -1 | 0 | -1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Washington Shore | 132 | 132 | 0 | 5 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 161 | 161 | 0 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Lower Granite** | | | | | | | | | | | | |
| LGR ladder | 0 | 0 | 0 | 19 | 8 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 0 | 0 | 0 | 19 | 8 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Ladder** | **All Chinook** | **Adult Chinook** | **Jack Chinook** | **All Steelhead** | **Clipped Steelhead** | **Unclipped Steelhead** | **All Coho** | **Adult Coho** | **Jack Coho** | **Sockeye** | **Chum** | **Pink** |

Report Run: 4/27/2019 7:13:32 PM
Content POC: Fish Field Unit, FFU_Fish_Count_Info@usace.army.mil

Figure 4: Daily fish counts for Day 2 from USACE ("Adult Fish Counts for Portland District").

**Daily Adult Fish Counts**
**Friday, May 03, 2019**

**U.S. Army Corps of Engineers**
Portland District
csv format

| Ladder | All Chinook | Adult Chinook | Jack Chinook | All Steelhead | Clipped Steelhead | Unclipped Steelhead | All Coho | Adult Coho | Jack Coho | Sockeye | Chum | Pink |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bonneville** | | | | | | | | | | | | |
| Bradford Island | 583 | 563 | 20 | 6 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Washington Shore | 2,057 | 2,029 | 28 | 11 | 10 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 2,640 | 2,592 | 48 | 17 | 12 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| **The Dalles** | | | | | | | | | | | | |
| East | 958 | 951 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| North | 28 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 986 | 979 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **John Day** | | | | | | | | | | | | |
| South | 183 | 172 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| North | 59 | 59 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 242 | 231 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **McNary** | | | | | | | | | | | | |
| Oregon Shore | 33 | 33 | 0 | 3 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Washington Shore | 57 | 55 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 90 | 88 | 2 | 3 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Ice Harbor** | | | | | | | | | | | | |
| South | 30 | 27 | 3 | 3 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| North | 16 | 16 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 46 | 43 | 3 | 5 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Lower Monumental** | | | | | | | | | | | | |
| South | 5 | 4 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| North | 33 | 31 | 2 | 8 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 38 | 35 | 3 | 9 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Little Goose** | | | | | | | | | | | | |
| LGS ladder | 9 | 9 | 0 | 15 | 14 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **total** | 9 | 9 | 0 | 15 | 14 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Lower Granite** | | | | | | | | | | | | |
| LGR ladder | 12 | 11 | 1 | 15 | 2 | 13 | 0 | 0 | 0 | 0 | 0 | 0 |

Figure 5: Daily fish counts for Day 3 from USACE (“Adult Fish Counts for Portland District”).

Table 1: Behavioral analysis Day 2 raw data.

| Time: | Description |
|---|---|
| 11:14am | One sea lion spotted, *Z. californianus*, hazing boat following, Site 1 |
| 11:35am | One sea lion spotted, *Z. californianus,* bald eagle seen in same area, Site 1 |
| 12:20pm | One sea lion, *E. jubatus*, swimming, Site 3 |
| 12:26pm | Shots heard but not seen, no sea lion sightings |
| 12:36pm | Four sea lions, two *E. jubatus* one *Z. californianus* and one unknown, hazing boat following, Site 2 |
| 12:40pm | Boat moved west, shots heard but not seen |
| 12:43pm | One sea lion, unknown species, hazing boat following, Site 2 |
| 12:46pm | Three sea lions, two unknown species and one *Z. californianus,* swimming, Site 2 |
| 12:47pm | One sea lion, *E. jubatus*, Site 2 |
| 1:00pm | One sea lion, *E. jubatus*, swimming, Site 2 |
| 1:05pm | All sea lions seen from 12:46pm-1:00pm still at Site 2 |
| 1:11pm | One sea lion, *E. jubatus*, swimming, Site 3 |
| 1:16pm | Shots heard but not seen |
| 1:17pm | Two sea lions, unknown species, Site 3 |
| 1:22pm | Three sea lions, two *E. jubatus* and one *Z. californianus*, Site 3 |
| 1:25pm | One sea lion, unknown species, hazing boat following, Site 3 |
| 1:26pm | One sea lion, *Z. californianus*, Site 3 |
| 1:29pm | One sea lion, *E. jubatus,* Site 3 |
| 1:32pm | Two sea lions, one *E. jubatus* and one *Z. californianus*, Site 3 |

Table 2: Behavioral analysis Day 3 raw data.

| Time: | Description: |
|---|---|
| 12:27pm | Shots heard (2), no boats or sea lions spotted |
| 12:59pm | Two sea lions, *E. jubatus,* swimming, Site 1 |
| 1:30pm | Three sea lions, *E. jubatus,* swimming, Site 3 |
| 1:31pm | One sea lion, *E. jubatus*, Site 3 |
| 1:34pm | One sea lion, *E. jubatus*, hazing boat following, swimming, Site 3 |
| 1:35pm | Shots fired (7), hazing boat seen, Site 2 |
| 1:39pm | Shots fired (5), hazing boat seen, Site 2 |
| 1:42pm | One sea lion, *Z. californianus,* swimming, Site 3 |
| 1:44pm | Shots heard (3), no boats or sea lions seen |
| 1:47pm | One sea lion, *E. jubatus*, Site 3 |
| 1:48pm | One sea lion, *E. jubatus*, Site 3 |
| 1:52pm | One sea lion, *E. jubatus*, Site 3 |
| 2:00pm | One sea lion, *Z. californianus*, swimming, Site 3 |
| 2:05pm | One sea lion, *E. jubatus*, swimming, Site 2 |
| 2:06pm | Three sea lions, all *E. jubatus*, near traps, Site 2 |
| 2:18pm | One sea lion, unknown species, swimming, Site 2 |
| 2:27pm | One sea lion, *Z. californianus,* near spillways, Site 2 |
| 3:08pm | One sea lion, *E. jubatus*, near spillways, Site 2 |

Table 3: Behavioral analysis day 4 raw data.

| Time: | Description: |
|---|---|
| 12:45pm | One sea lion, *E. jubatus*, swimming, Site 3 |
| 12:50pm | Two sea lions, one *E. jubatus* and one unknown species, near spillway, Site 2 |
| 1:03pm | Shots fired (8), hazing boat chasing sea lion |
| 1:17pm | One sea lion, unknown species, Site 3 |
| 1:20pm | One sea lion, *E. jubatus*, swimming, Site 3 |
| 1:26pm | Shots heard, no hazing boat seen |
| 1:27pm | One sea lion, *E. jubatus*, swimming, Site 3 |
| 1:39pm | One sea lion, *E. jubatus*, swimming, Site 3 |
| 1:44pm | One sea lion, *E. jubatus*, swimming, Site 3 |
| 1:46pm | One sea lion, *E. jubatus*, Site 3 |

Table 4: Pinniped population numbers at Bonneville Dam from Stansell, 2010 and Tidwell, 2019.

| Year: | California Sea Lions | Steller Sea Lions | Harbor Seal | 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 |
| 2016 | 149 | 54 | 0 | 203 |
| 2017 | 92 | 63 | 1 | 156 |
| 2018 | 67 | 66 | 1 | 134 |

Table 5: Salmon run numbers and pinniped consumption rates annually from Stansell, 2010 and Tidwell, 2019.

| Year: | Bonneville Dam Salmonid Passage | California Sea Lion Adjusted Salmonid Consumption Estimates | California Sea Lion % Run | Steller Sea Lion Adjusted Salmonid Consumption Estimates | Steller Sea Lion % Run | All Pinnipeds Adjusted Salmonid Consumption Estimates | All Pinnipeds % Run |
|---|---|---|---|---|---|---|---|
| 2002 | 284,732 | 1,010 | 0.4% | 0 | 0.0% | 1,010 | 0.4% |
| 2003 | 217,934 | 2,329 | 1.1% | 0 | 0.0% | 2,329 | 1.1% |
| 2004 | 186,771 | 3,516 | 1.9% | 7 | 0.0% | 3,533 | 1.9% |
| 2005 | 81,252 | 2,904 | 3.5% | 16 | 0.0% | 2,920 | 3.4% |
| 2006 | 105,063 | 3,312 | 3.1% | 85 | 0.1% | 3,401 | 3.2% |
| 2007 | 88,474 | 4,340 | 4.7% | 15 | 0.0% | 4,355 | 4.7% |
| 2008 | 147,558 | 4,735 | 3.1% | 192 | 0.1% | 4,927 | 3.2% |
| 2009 | 186,056 | 4,353 | 2.3% | 607 | 0.3% | 4,960 | 2.7% |
| 2010 | 267,167 | 5,296 | 1.9% | 1,025 | 0.4% | 6,321 | 2.4% |
| 2011 | 223,380 | 2,689 | 1.2% | 1,282 | 0.6% | 3,970 | 1.8% |
| 2012 | 171,665 | 1,067 | 0.6% | 1,293 | 0.7% | 2,360 | 1.4% |
| 2013 | 120,619 | 1,497 | 1.2% | 1,431 | 1.2% | 2,928 | 2.4% |
| 2014 | 219,929 | 2,747 | 1,2% | 1,874 | 0.8% | 4,621 | 2.1% |
| 2015 | 239,326 | 8,324 | 3.3% | 2,535 | 1.0% | 10,859 | 4.3% |
| 2016 | 154,074 | 6,676 | 4.1% | 2,849 | 1.7% | 9,525 | 5.8% |
| 2017 | 109,040 | 2,142 | 1.9% | 3,242 | 2.8% | 5,384 | 4.7% |
| 2018 | 100,887 | 746 | 0.7% | 2,368 | 2.3% | 3,112 | 3.0% |