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2024 Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace

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Cover Photos: Steller sea lions rest on traps near the old navigation lock at Bonneville Dam (left). A Steller sea lion surfaces in the Powerhouse One tailrace (center). A biologist conducts a point count at Powerhouse One (right).

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Past reports and more information on the Pinniped Monitoring Program at Bonneville Lock and Dam can be found at the following link:

http://pweb.crohms.org/tmt/documents/FPOM/2010/Task%20Groups/Task%20Group%20Pinnipeds/

Executive Summary

California sea lions (CSL; *Zalophus californianus*), Steller sea lions (SSL; *Eumetopias jubatus*), and harbor seals (PVI; *Phoca vitulina*) seasonally aggregate at the base of Bonneville Dam to feed on Pacific salmon and steelhead (*Oncorhynchus spp.*), and White Sturgeon (*Acipenser transmontanus*). Due to predation on several species listed as threatened or endangered under the Endangered Species Act, the Federal Columbia River Power System 2020 Biological Opinion continued the requirement for the U.S. Army Corps of Engineers to monitor the seasonal presence, abundance, and predation activities of sea lions at Bonneville Dam. Per requirements of the National Oceanic Atmospheric Administration, we monitored and report data for the fall and winter period of 2023 and the spring period of 2024. Abundance was monitored daily, and predation sampling began when there were ≥ 20 pinnipeds in the tailrace of Bonneville Dam.

Daily abundance monitoring began just prior to the fall season (Aug. – Dec.) on 25 July 2023 and continued through 31 December 2023. There was an average of 5.1 ±SD 4.2 SSL each day, no CSL observed, and two observations of a single PVI on separate days. Fall fish predation monitoring began on 27 August 2023 when the abundance of pinnipeds was consistently ≥ 20 and continued variably at the Powerhouse Two tailrace during daylight hours until 9 September 2023.

Monitoring continued during the traditional spring season (January – May). Daily abundance monitoring was recorded from 1 January through 31 May with an average of 6.9 ±SD 10.2 SSL and 3.5 ±SD 5.6 CSL observed per day. Predation sampling across the Spillway and Powerhouse Two tailraces was initiated on 24 March 2024 upon reaching the 20-animal trigger and concluded on 13 May 2024 when pinnipeds were nearly absent from the dam.

Sea lion predation on Pacific salmon, steelhead, and White Sturgeon was monitored during the fall and spring seasons to estimate the number of fish killed and to determine the percentage of the yearly run of each fish species that was consumed by SSL and CSL during each observation period. The following consumption estimates with 95% confidence intervals and associated percent of run consumed are derived from observed predation events and probability-based adjustments for hours not observed.

- Fall 2023 Chinook Salmon: 192 (74 – 294); 0.1%
- Spring 2024 Chinook Salmon: 2218 (1858 – 2546); 2.8%
- Fall 2023 steelhead: 36 (6 – 60); 0.2%
- Spring 2024 steelhead: 39 (0 – 76); 3.8%
- Fall 2023 Coho Salmon: 55 (6 – 93); 0.1%
- Fall 2023 White Sturgeon: 17 (0 – 33); N/A
- Spring 2024 White Sturgeon: 19 (0 – 38); N/A

For 22 years the USACE pinniped monitoring program has provided data to managers and supported management actions at Bonneville Dam. Albeit predation is still documented on many species of fish below the dam, impact to the species reported upon herein are of special concern to regional entities and environmental sustainability as a whole, and are therefore noteworthy during this reporting period. Though recent efforts by state and tribal management agencies to lethally remove sea lions may lessen these impacts, the persistent and evolving impacts to these fish populations should be noted by fish managers.

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Introduction and Background

Centuries of interspecific competition for anadromous salmonids between marine mammals and humans (SBFC, 1889; Thwaites, 1969) has contributed to the persecution of some marine mammal species in the Pacific Northwest (Braje & Rick, 2011; Newby, 1973; Scheffer, 1950). Chief among these competing species, the pinnipeds (seals and sea lions) in Oregon and Washington were targeted for population reduction through bounty-incentivized removal programs by state wildlife managers which contributed to reducing populations to all-time lows in the early-mid 20th century (NOAA, 2016a; Pearson & Verts, 1970; Peterson & Bartholomew, 1967). In response to the universal decline of marine mammal stocks, the Marine Mammal Protection Act (MMPA) was enacted in 1972 and effectively buoyed some northwest pinniped stocks to record levels in the following 30 years (Brown et al., 2005; Jeffries et al., 2003). Concomitant to the success of the MMPA (Magera et al., 2013), salmonid stocks declined to a point where many are now listed under the Endangered Species Act of 1973 (ESA), especially those of the Columbia River and its tributaries (NFSC, 2015). The flux of predator and prey in the Columbia River has now transitioned to high numbers of protected pinnipeds, and low numbers of threatened and endangered salmonids.

Historical pinniped distribution in the Columbia River system has been detailed through archaeological records, whereby seal (Family: Phocidae [true seals]) remains were documented at river kilometer 314 (river mile 195) near Celilo Falls (Lyman et al., 2002), an area that was inundated after the completion of The Dalles Dam in 1957. Sea lions (Family: Otariidae [eared seals]) have historically frequented the lower portions of the Columbia River system (i.e., the Columbia Estuary), but there is no evidence of congregations of these animals in the river section of what is now Bonneville Dam (BON) in the time preceding dam construction (i.e., 1938) nor in the six decades following construction (Keefer et al., 2012). The dam is largely impassable for pinnipeds, but its tailrace area is now commonly frequented by sea lions and an occasional harbor seal (*Phoca vitulina*).

Sea lions were first documented at BON in the late 1980s when California sea lions (CSL; *Zalophus californianus*) were sporadically observed depredating spring Chinook Salmon (*Oncorhynchus tshawytscha*) (Stansell, 2004). Steller sea lions (SSL; *Eumetopias jubatus*) were first documented at BON in 2003 (Keefer et al., 2012). Anecdotal observation suggested the duration of residency and amount of salmonid predation by pinnipeds increased in subsequent years, leading fish managers to question the potential impact such predators may be having on migrating adult salmonid fish runs, including Chinook Salmon *O. tshawytscha*, steelhead trout *O. mykiss*, Coho Salmon *O. kisutch*, Chum Salmon *O. keta*, and White Sturgeon *A. transmontanus* (NMFS, 1997).

Analyses of pinniped-salmonid interactions in or near the Columbia River suggest that all life stages of salmonids are at risk of predation by pinnipeds (Brown et al., 2017; Chasco et al., 2017), and that some salmonid runs are at greater risk of predation and potential extinction than others (Falcy, 2017; Keefer et al., 2012). As such, pinniped predation on imperiled salmonids in the Columbia River has garnished considerable attention and continues to be a focus of concern and research (Kinsey, 2007).

Potential impacts of fish predators at hydroelectric dams have long been of concern to fish managers (Evans et al., 2016; Schilt, 2007) and can present challenges to management agencies (Friesen & Ward, 1999; McKinney et al., 2001). The Columbia River System of hydroelectric dams is one of the most advanced hydropower systems in the world and has been subject to in-depth study and analysis of fish predator activities and deterrence (Roscoe & Hinch, 2010; Patterson et al., 2017). Focus was historically given to the predation of out-migrating juvenile salmonids given the extensive suite of predators that can depredate these younger age classes including warm water fish (Mesa et al., 1994; Poe et al., 1991; Sorel et al., 2016) and piscivorous birds (Collis et al., 2002). However, attention has now been turned to upstream migrating adult fish exposed to pinniped predation. Like natural fish passage impediments (e.g., waterfalls, cascades, chutes), hydroelectric dams can delay upstream fish passage and cause fish to congregate while searching for ladder entrances (Kareiva et al., 2000; Quinones et al., 2015). These delays increase the time that fish are vulnerable to predation by pinnipeds (Naughton et al., 2011; Stansell, 2004), a clade which includes several efficient predators of Pacific Northwest fishes (Weise & Harvey, 2005).

Because BON is the lowermost Columbia River dam, it passes a greater diversity and number of anadromous migrants than any other dam on the river and therefore has the potential to have the largest impact on fish passage (Evans et al., 2016). Pinniped predation at the dam has spurred concern for impacts to ESA listed salmonids for almost two decades. The U.S. Army Corps of Engineers (USACE) Fisheries Field Unit (FFU) initiated a pinniped monitoring program in the early 2000s in response to these concerns and to fulfill requirements established through various ESA consultations with National Marine Fisheries Service (NMFS), regarding the operation and maintenance of the Federal Columbia River Power System. This monitoring effort, pinniped predation deterrence measures, and NMFS Biological Opinion (BiOp) requirements have been adjusted and refined over the past 22 years.

In November 2018, USACE, Bonneville Power Administration (BPA) and the U.S. Bureau of Reclamation (USBR) – collectively, the Action Agencies – reinitiated consultation with NMFS and submitted a Biological Assessment (BA) that included certain pinniped monitoring and management activities as part of the Proposed Action. The purpose of this consultation was to provide ESA coverage for operation and maintenance of the Columbia River system until the Columbia River System Operations (CRSO) Environmental Impact Statement (EIS) and the associated Record of Decision (ROD) and ESA consultations were completed. The interim BiOp issued by NMFS on 29 March 2019 shaped USACE pinniped monitoring and management actions through much of the 2020 passage season. In association with the CRSO EIS, a new Biological Assessment was submitted by the Action Agencies in January 2020 and NMFS issued a new BiOp in July 2020 (NMFS 2020). The CRSO ROD was signed on 28 September 2020 and USACE began operating under the 2020 BiOp on that date (NOAA 2022). Overall requirements were similar under these two consultations.

In accordance with these ESA requirements, USACE implemented the following pinniped monitoring and management activities from July 2023 to June 2024:

- Installed sea lion exclusion devices (SLEDs) at all adult fish entrances at BON year-round.
- Continued to fund dam-based hazing of pinnipeds observed in the vicinity of fish ladder entrances at BON and on an ad hoc basis at The Dalles Dam. Hazing at BON is no longer required prior to removal of sea lions but was implemented to fulfill requirements of the BiOp during the 2023-2024 season.
- Provided support to state wildlife management agencies and the Columbia River Inter-Tribal Fish Commission (CRITFC) pursuant to their sea lion management programs, including crane support and project access.
- Monitored predation by sea lions at BON when abundance was ≥ 20 sea lions and reported results to NMFS and other regional partners via the Fish Passage Operations and Maintenance (FPOM) work group. This report meets the requirement to submit an annual report to NMFS.

In 2023-2024, our objectives for the FFU pinniped monitoring program were to:

1. Determine the seasonal timing and abundance of pinnipeds present at the BON tailrace, documenting CSL and SSL presence and predation activity when possible.

2. Monitor the spatial and temporal distribution of pinniped predation attempts, estimate the number of adult salmonids (*Oncorhynchus spp*.), White Sturgeon (*Acipenser transmontanus*), Pacific Lamprey (*Entosphenus tridentatus*), and other fishes consumed by pinnipeds in the BON tailrace.

3. Estimate the proportion of the adult salmonid run consumed by pinnipeds.

4. Monitor the effectiveness of pinniped deterrent actions (e.g., exclusion gates, acoustics, hazing, and other measures) and their timing of implementation on runs of anadromous fish passing BON.

Of note is the altered sea lion management scope of the states of Oregon, Washington, and Idaho (collectively: the States) and the Columbia Inter-Tribal Fish Commission (CRITFC) since the passage of the Endangered Salmon Predation Prevention Act (S. 3119) which allows these management agencies to lethally remove SSL and CSL at select areas on the Columbia River including below Bonneville Dam without the restrictions of the previous lethal removal authority for CSL. This change in authority removes the reporting requirements and documentation required previously. Specifically, requirements of residency and abundance metrics are no longer needed. As such, the reporting metrics presented this year will not have some data that have previously been reported.

This report is a summary of abundance and predation monitoring and deterrence efforts implemented from 1 June 2023 to 31 May 2024 by, or coordinated with, the aforementioned agencies.

For brevity and ease of communication we have appended the study design, description of the BON tailrace system, life history of the pinniped and fish species studied, and the general study approach to Appendix 1. We present a brief overview of the study design and methods to help orient readers then present current data partitioned by species and, where possible, contrast it to previous estimates to elucidate the trends of pinniped presence and predation on adult migratory fish at BON. We encourage readers not familiar with the previous 22 years of reports to read the material in the Appendix before reviewing the new data.

Study Design

Summary of Methods

We sample the cumulative abundance of pinnipeds in the three tailraces below BON using daily visual encounter surveys from multiple vantage points on the dam. Trained observers watch for predation events in the tailraces during sampled daylight hours using a stratified sampling design to enable estimates of predation during times not observed. Bootstrap sampling of these estimates provides bounded estimates of predation by week, for each fish species, and by each species of pinniped and therein allow bounded estimates on impact to each fish run. The methods are briefly expanded on below, though we encourage all readers not familiar with the data to reference Appendix 1 for a detailed description of methodological approach.

Pinniped abundance was documented daily to ensure predation sampling began as soon as the 20-animal trigger was met, at which time sampling for pinniped depredation of fish in the tailrace began. Predation sampling continues each week after reaching the 20-animal trigger until the daily abundance of pinnipeds drops and remains below 20 animals. The priority powerhouse for power generation influences fish ladder access and dictates which tailraces are sampled. A lack of power generation at a given powerhouse has been documented as diminishing the attraction of salmonids and other migratory fish species to the corresponding spillway. This in turn reduces the likelihood of a pinniped to hunt fish, or lack thereof, in said tailrace. While Powerhouse One was monitored periodically throughout the season, no official observations were recorded due to lack of activity from this known phenomenon. During the fall and winter period of 2023 sampling occurred at Powerhouse Two based on dam operations that impact fish passage. During the spring period of 2024 the Spillway and Powerhouse Two tailraces were observed for predation sampling each week based on dam operations. These methods are consistent with prior years in which sampling location was dependent on powerhouse priority and dam outflows.

Quantification of Abundance

We conducted independent point counts once per day in the three tailraces of BON and at known haul-out locations using field glasses. The point count includes the mouth of Tanner Creek, a preferred salmonid spawning tributary just downstream of BON that is a known location of pinniped predation on adult salmonids. Counts were conducted in a short period of time (e.g., ≤ 20 minutes) to reduce the possibility of counting animals transiting between locations more than once. Point counts were conducted during morning or evening civil twilight when most pinnipeds are hauled out to ensure a more accurate count. We derived a daily maximum pinniped abundance by summing the individual count data at each location and for each species. Linear interpolation was used for days that counts were not taken (i.e., weekends and holidays), and in doing so, we present the maximum number of animals observed at the dam on each day irrespective of time of day. As management requirements have changed, we did not attempt to describe the residency or recruitment metrics for each species of sea lion. For more specifics regarding methodological assumptions and techniques see Appendix 1.

Quantification of Predation

Surface observations of pinniped-fish interactions have been utilized to measure the number of fish and species consumed by pinnipeds at several locations including the last 22 years at BON and 11 years at Willamette Falls (Roffe & Mate, 1984; Tidwell et al., 2021; Wright et al., 2018,). Trained observers documented all surface predation events that occurred within a select sampling location and period using binoculars We employed a stratified random sampling design with bootstrap analyses to estimate the number of fish consumed per strata (week) with confidence intervals (Tidwell et al., 2018).

We provide estimates of fish run predation during the fall and winter period for the Powerhouse Two tailrace by assessing fish passage at the Washington Shore fish ladder. Due to dam operations, powerhouse prioritization, and low abundance of sea lions, we monitored predations at Powerhouse Two from 27 August to 9 September 2023. For analysis of impacts to fish species, we present the number of fish crossing these fish ladders during the respective times (www.FPC.org) and provide an estimate of the percentage of these fish that were consumed during the study period. Any inference of these data to the entire tailrace area or locations downstream need be made with caution.

Similarly, estimates of fish predation during the spring period were confined to the Spillway and Powerhouse Two tailraces due to the no-flow operation of Powerhouse One and subsequent observations of almost no pinnipeds using that tailrace. We present the number of each fish species that cross the Washington Shore fish ladder at Powerhouse Two and the Bradford Island fish ladder at Powerhouse One between 24 March and 13 May 2024. This period was historically 1 January – 31 May, but the 20-animal trigger truncated the sampling period as it has in recent years. Though no observations were made at Powerhouse One, some fish from the Spillway pass the Bradford Island fish ladder and are therefore included in calculations. We analyze the impact to each fish species by estimating the percent of these fish consumed during the study period.

All data were compiled and manipulated in the USACE Pinniped Access Database. Data were exported to Microsoft Excel and analyses were performed in Program R (Version 4.2.2).

Results

Abundance

Pinnipeds have historically been absent from BON between the end of the spring reporting season and the beginning of the next season's fall reporting season. This period of known absence is the basis for the typical fall (August – December) and spring (January – May) observation seasons used in this report. While the tailraces are still monitored for abundance during this period, in 2023 no formal point counts were performed between 3 June and 24 July. During this time there were no reported incidental sightings of pinnipeds at BON. Daily abundance counts, and the abundance data presented herein began on 25 July 2023 at which time one SSL was present.

Fall Abundance

We documented 21 SSL and one PVI between 25 July and 31 December 2023. No CSL were observed in the fall observation season. Across the fall and winter period, the daily average abundance of SSL was 5.1 ±SD 4.2 animals (Table 1). Due to the variable nature of the daily abundance data, we present the median of 4.0 SSL as well. Two observations of one PVI occurred on 18 and 29 August 2023, though it is not known if this was the same individual.

Pinnipeds presented a normal distribution below BON throughout August and September during the fall observation season. Abundance increased gradually through August to a seasonal peak of 21 animals on 29 August, followed by a gradual decline to zero on 18 September. Lower numbers of individuals persisted through 31 December (Figure 1B).

Spring Abundance

We documented 38 SSL and 40 CSL during the 1 January – 31 May 2024 spring observation season (Table 2). No harbor seals were observed during this time. Across the spring season, there were an average of 3.5 ±SD 5.6 CSL per day and an average of 6.9 ± SD 10.2 SSL per day (Table 1).

The first CSL observation was a group of 15 animals on 2 March, after which CSL were consistently observed through late May. The presence of CSL was conspicuously earlier, but abundance was lower than the 10-year average (Figure 1A). A peak abundance of 40 CSL was observed on 13 March with a secondary peak of 17 CSL on 22 March. The mean number of CSL observed per day throughout April and May was 4.0 animals, though very few were observed in the tailrace past 10 May.

The distribution of SSL was similar in timing, but lower abundance relative to the 10-year average. A single SSL was observed on several occasions during January and February, with a daily mean of 0.3 animals during those months. March had a monthly mean of 3.9 animals, after which abundance increased through April with a mean of 21.4 animals. A seasonal peak of 38 SSL was observed on 1 May, and rapidly declined to zero by 13 May. A mean of 8.7 animals were observed through May (Figure 1B).

Table 1: Abundance estimates for pinnipeds observed at BON from 25 July – 31 December and 1 January – 31 May during the 2023-24 reporting period. Minimum estimates are the maximum number of individually identifiable pinnipeds observed on a single day.

Season	Species	Minimum	Mean	SD	Median
Fall 2023	SSL	21	5.1	4.2	4.0
	CSL	0	0	0	0
	PVI	1	-	-	-
Spring 2024	SSL	38	6.9	10.2	1.0
	CSL	40	3.5	5.6	1.0

Table 2. Minimum estimated number of individual pinnipeds observed at Bonneville Dam tailrace areas and the hours of observation during the spring sampling period, 2002 to 2024.

Year	Total Hours Observed	California Sea Lions	Steller Sea Lions	Harbor Seals	Total Pinnipeds
2002	662	30	0	1	31
2003	1,356	104	3	2	109
2004	516	99	3	2	104
2005*	1,109	81	4	1	86
2006	3,650	72	11	3	86
2007	4,433	71	9	2	82
2008	5,131	82	39	2	123
2009	3,455	54	26	2	82
2010	3,609	89	75	2	166
2011	3,315	54	89	1	144
2012	3,404	39	73	0	112
2013	3,247	56	80	0	136
2014	2,947	71	65	1	137
2015	2,995	195	69†	0	264
2016	1,974	149	54†	0	203
2017	1,142	92	63†	1	156
2018	1,410	67	66†	1	134
2019	836	26	50†	0	76
2020	331	34	45†	2	81
2021	132	24	62†	0	86
2022	205	25	62†	0	82
2023	228	50†	54†	0	104
2024	157	40†	38†	0	78

* Observations did not begin until March 18 in 2005.
† In 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, and 2024 the minimum number of individually identifiable Steller sea lions (SSL) was 55, 41, 32, 35, 21, 20, 24, 13, 4, and 1 respectively. In 2023 and 2024 the minimum number of individually identifiable California sea lions (CSL) was 6 and 2 respectively. These counts were less than the maximum number of Steller and California sea lions observed on one day, so the maximum number observed on one day was used as the minimum estimated number. This difference in early years was driven by a focus on CSL and lack of brands or unique markers on SSL.

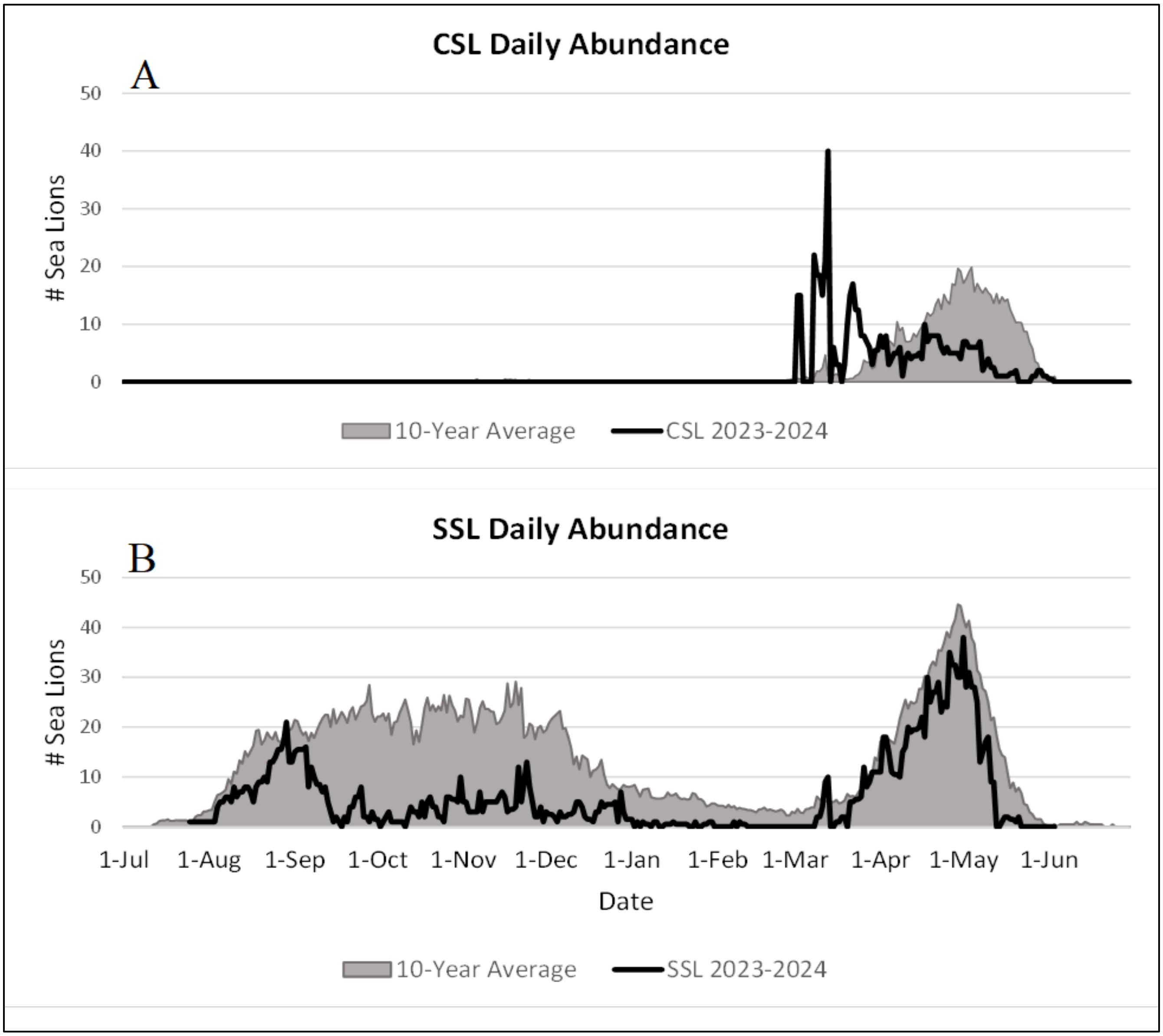

Figure 1. Maximum daily count of pinnipeds by species (SSL: Steller sea lions, CSL: California sea lions) at Bonneville Dam from 1 July 2023 through 30 June 2024 compared to the 10-year maximum daily average from 1 July 2013 through 30 June 2023. For reference: fall and winter sampling period = 25 July – 31 December 2023 and spring period = 1 January – 31 May 2024. * Averages from 6/1 - 12/31 begin in 2013 but are sporadic between years.

Predation

We recorded 24 independent one-hour observation periods in the fall season between 27 August and 9 September 2023, and 157 independent one-hour observation periods in the spring season between 24 March and 13 May 2024. Observation hours were limited in both seasons by the 20-animal monitoring trigger described in Appendix 1, which resulted in a limited number of observations. Below we present the predation impact for each study period on Pacific salmon, steelhead, and White Sturgeon (Table 3). As described in Appendix 1, all predation estimates are presented as the bootstrap calculated adjusted estimate (i.e., raw count data expanded for missing hours and adjusted for unidentified fish catches) and are followed by their associated 95% confidence bounds to display the confidence of the estimate. Percent impact to fish run is presented as estimated number of fish consumed divided by the number of fish that passed the dam during the observation strata week. This is noteworthy for proper interpretation of the presented data this year and in previous years. Percent impact is only calculated for species which regularly pass Bonneville Dam, or with known populations above Bonneville Dam. White sturgeon and Chum Salmon are therefore notable exceptions for which calculations cannot be made this year.

Table 3. Estimated fish predation by all pinnipeds at Bonneville Dam within the fall observation period of 27 August – 9 September 2023 and spring observation period of 24 March – 13 May 2024. White Sturgeon do not pass Bonneville Dam, and as such the percent run cannot be calculated.

Fish Species	Number of Fish Killed (95% CI)	Percent Run Consumed During Observation Period
Fall Chinook Salmon	192 (74 – 294)	0.1%
Spring Chinook Salmon	2218 (1858 – 2546)	2.8%
Steelhead – fall sample period	36 (6 – 60)	0.2%
Steelhead – spring sample period	39 (0 – 76)	3.8%
Coho Salmon	55 (6 – 93)	0.1%
White Sturgeon – spring sample period	19 (0 – 38)	N/A
White Sturgeon – Aug. – Oct. 2023	17 (0 – 33)	N/A

Chinook Salmon During Fall

An estimated 192 (74 – 294) fall Chinook Salmon were consumed in the Powerhouse Two tailrace during the observed days between 27 August and 9 September 2023. Across this period a total of 184,899 adult and jack Chinook Salmon crossed the Washington Shore fish ladder, so we estimate that 0.1% of the fall Chinook Salmon run was consumed by pinnipeds. During this time there were only SSL present and as such, SSL accounted for all predation. For historical consumption estimates see Table 4.

Chinook Salmon During Spring

An estimated 2218 (1858 – 2546) spring Chinook Salmon were consumed across the three tailraces sampled during the observed weeks between 24 March and 13 May 2024. Across this period a total of 79,241 adult and jack Chinook Salmon crossed BON, so we estimate that 2.8% of the spring Chinook Salmon run was consumed by pinnipeds (Table 3). We estimate that SSL account for 1402 (1090 – 1712) spring Chinook Salmon consumed, and CSL account for 805 (574 – 1002) spring Chinook Salmon consumed. For historical consumption estimates see Appendix 1a.

Steelhead During Fall

An estimated 36 (6 – 60) steelhead were consumed in the Powerhouse Two tailrace between 27 August and 9 September 2023. During this period 18,350 steelhead crossed the Washington Shore fish ladder, so we estimate that 0.2% of the passing fish were consumed by pinnipeds (Table 3). We emphasize that this estimate was made with a very small sample size of steelhead predation events. We observed four steelhead predation events throughout the fall sampling period during which only SSL were present. As such, SSL accounted for all predation on steelhead in the fall. For historical consumption estimates see Table 4.

Steelhead During Spring

An estimated 39 (0 – 76) steelhead were consumed across the three tailraces sampled between 24 March and 13 May 2024. Across this period a total of 1,014 steelhead crossed BON, so we estimate that 3.8% of the run was consumed by pinnipeds (Table 3). This estimate should be used with caution due the small sample size of steelhead observed being consumed. During the spring sampling period we observed four steelhead predation events. One steelhead was depredated by CSL, and three by SSL. For historical consumption estimates see Appendix 1b.

Coho Salmon

An estimated 55 (6 – 93) Coho Salmon were observed consumed in the Powerhouse Two tailrace during the observed hours between 27 August and 9 September 2023. During this period 41,516 adult and jack Coho Salmon crossed the Washington Shore fish ladder, so we estimate that 0.1% of the run was consumed. For historical consumption estimates see Table 4.

Chum Salmon

No events of pinniped predation on Chum salmon were observed in the Powerhouse Two tailrace between 27 August and 9 September 2023. During this period 0 Chum Salmon passed the Washington Shore fish ladder, with the first observation of passage at BON occurring 10 October 2023. Therefore, pinnipeds were nearly absent from the tailraces when Chum likely arrived. In addition, most of the Columbia River Chum population currently spawns below Bonneville Dam, with a small percentage of the population spawning above the dam (i.e., Annual average between 48 – 141, NOAA 2020). In 2023 there were an estimated 615 Chum Salmon that passed the BON fish ladders.

Fall White Sturgeon

An estimated 17 (0 – 33) White Sturgeon were consumed in the Powerhouse Two tailrace between 27 August and 9 September 2023. During this period there were only SSL present and as such, SSL accounted for all predation. For historical consumption estimates during the fall season see Table 4.

Spring White Sturgeon

An estimated 19 (0 – 38) White Sturgeon were consumed in the Spillway and Powerhouse Two tailraces between 24 March and 13 May 2024. During this period only SSL were observed depredating White Sturgeon, though CSL were present and consuming other fish. For historical consumption estimates during the spring season see Appendix 1c.

Pacific Lamprey

No Pacific Lamprey predation events were recorded in fall of 2023, nor were any recorded in spring of 2024. For historical consumption estimates see Appendix 1d.

Other Fish Species

During the fall and spring reporting periods, we observed three additional predation events of very small fish that could not be identified to species. These fish were likely a mix of juvenile salmonids and native fishes from the families *Catostomidae* and *Cyprinidae*.

Table 4. Fall and winter fish predation estimates with associated Standard Error (SE) for Steller sea lions at Bonneville Dam between 2017 and 2023.

Year	Hours Observed	Location	Chinook Salmon (SE)	Coho Salmon (SE)	Steelhead (SE)	White Sturgeon (SE)
2017	139	PH2	401 (281 - 506)	368 (296 - 432)	123 (63 - 172)	238 (183 - 281)
2018	369	PH1	419 (354 - 484)	269 (214 - 323)	293 (244 - 342)	359 (301 - 416)
2019	341	PH2	1,365 (1,222 - 1,497)	156 (99 - 210)	174 (129 - 217)	762 (583 - 915)
2020	234	PH 1&2*	756 (621 - 879)	292 (200 - 373)	75 (40 - 105)	589 (433 - 724)
2021	188	PH2	1305 (642 – 1746)	297 (200 – 392)	61 (19 – 97)	1119 (786 – 1414)

2022	11	PH2	0	0	29 (3 – 49)	10 (0 – 16)
2023	24	PH2	192 (74 – 294)	55 (6 – 93)	36 (6 – 60)	17 (0 – 33)

* Split sampling due to dam operations changing priority powerhouse mid-season.

Temporal Distribution of Salmonid Passage and Predation Events

Chinook Salmon – Fall 2023. An estimated 184,899 Chinook Salmon passed the Washington Shore fish ladder between 27 August and 9 September 2023. For comparison, during those same dates cumulative Chinook Salmon passage across all fish ladders at BON was 282,663, which is a greater run estimate when compared to the 10-year average of 236,463. No predation observations were performed between 21 May and 26 August 2023 due to the 20-animal trigger not being met, during which time 182,127 adult and jack Chinook passed BON, in addition to 244,571 which passed after 9 September. Thus, the majority of the Chinook run was not monitored for predation in fall, though the peak of the run on 1 September was monitored.

Chinook Salmon – Spring 2024. An estimated 79,241 Chinook Salmon passed BON between 24 March and 13 May; a smaller run estimate compared to the 10-year average of 85,912 during those same dates. While no predation observations were performed between 1 January and 23 March 2024 due to the 20-animal trigger, only 34 Chinook Salmon passed BON during that time. Thus, the majority of the Chinook run was monitored for predation in spring, including the peak of the run on 9 May 2024.

Steelhead – Fall 2023. An estimated 18,350 winter steelhead passed the Powerhouse Two tailrace between 27 August and 9 September 2023. For comparison, during those same dates the cumulative winter steelhead passage across all fish ladders at BON was 24,992, which is a greater run estimate when compared to the 10-year average of 23,661. No predation observations were performed between 21 May and 26 August 2023 due to the 20-animal trigger not being met, during which time 68,369, steelhead passed BON. Thus, the majority of the winter steelhead run was not monitored for predation.

Steelhead – Spring 2024. An estimated 1,014 winter and summer steelhead passed BON between 24 March and 13 May; a lesser run estimate compared to the 10-year average of 1,389 during those same dates. No predation observations were performed between 1 January and 23 March 2024 due to the 20-animal trigger not being met, and 1,405 steelhead passed BON during that time. In addition, the majority of the summer steelhead run passed after 14 May. Thus, the majority of the summer steelhead run was not monitored for predation, including the peak of the run on 23 August 2024.

Coho Salmon 2023. An estimated 41,516 Coho Salmon passed the Powerhouse Two tailrace during the fall 2023 observation season between 27 August and 9 September 2023. For comparison, during those same dates cumulative Coho Salmon passage across all fish ladders at BON was 56,981, which is a greater run estimate when compared to the 10-year average of 31,861. No predation observations were performed between 21 May and 26 August 2023 due to the 20-animal trigger, during which time 3,942 adult and jack Coho Salmon passed BON. An additional 89,099 adult and jack Coho Salmon passed BON between 10 September and 31 December 2023. Thus, the majority of the Coho run was not monitored for predation.

Upstream Observations

During the tenure of this monitoring program, pinnipeds have been documented transiting the navigation lock of BON to the forebay. Although uncommon, it has been documented multiple times in previous reports. Some CSL have even taken up residence in the Bonneville Reservoir and have lived between BON and The Dalles Dam for multiple years. During the spring of 2024 pinniped activity was noted upstream of BON with at least one confirmed CSL and at least one confirmed SSL.

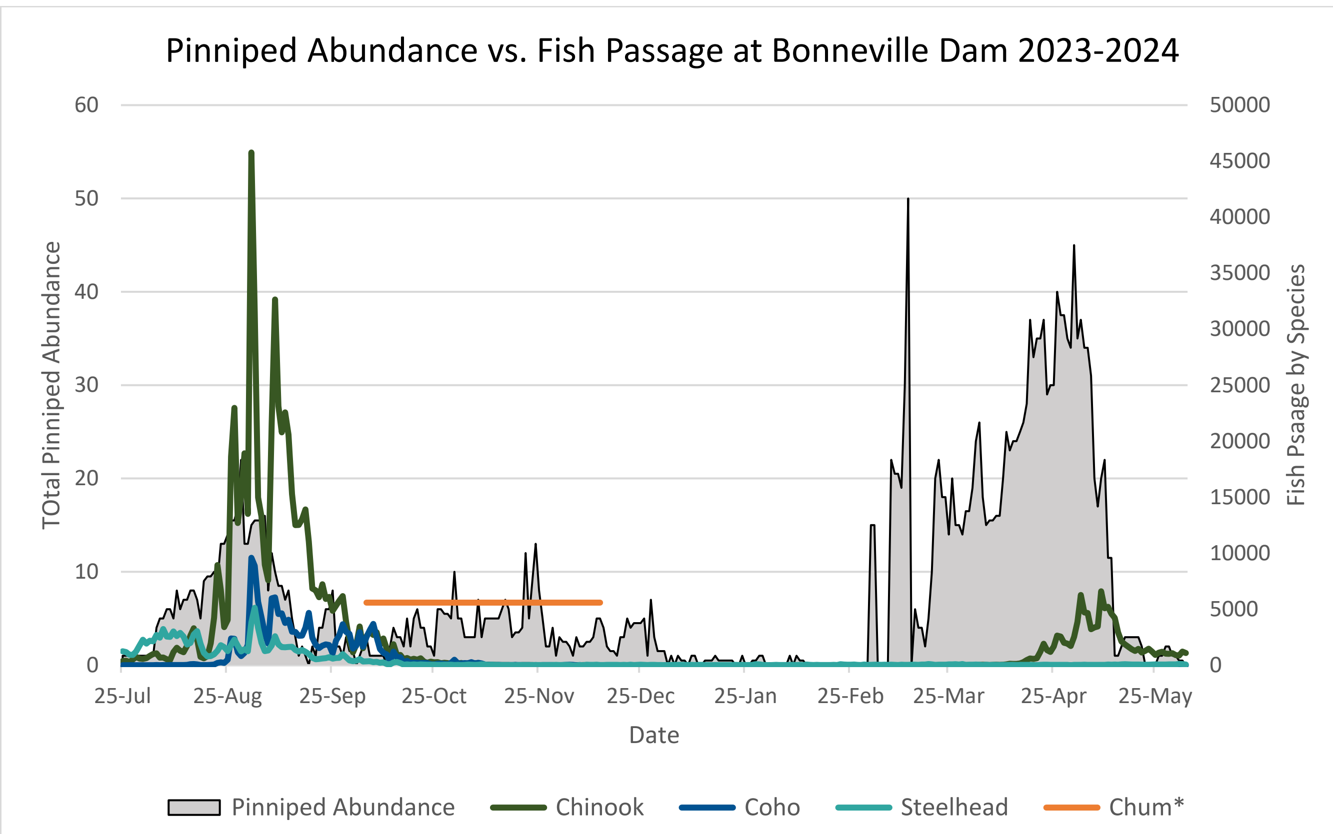

Figure 2: Pinniped abundance vs. fish passage through Bonneville Dam during the 2023-2024 pinniped monitoring season. *Due to most Columbia River Chum Salmon spawning below Bonneville Dam, the Chum Salmon abundance estimates shown here are derived from WDFW population and residence estimates from known spawning grounds within the

Ives/Pierce Island and Hardy/Hamilton Creek complex below Bonneville Dam and visualized as a season total across their expected residency period. The most recent population estimate from 2022 is used here.

Deterrents and Management

Physical Barriers

Due to pinnipeds entering the fishways of BON in years past, physical barriers were developed to preclude entry of pinnipeds into the fishways. Metal grating installed at the fishway entrances, termed SLEDs, were deployed at all entrances for the duration of these monitoring periods. SLEDs continue to be effective at keeping pinnipeds out of the fishways, as none were observed in fishways during this reporting period (Appendix 2).

Non-Lethal Harassment

Hazing of pinnipeds by United States Department of Agriculture (USDA) staff was ongoing from 1 April through 31 July, and 15 August through 31 October 2024. In 2024, USDA staff used 9,867 pyrotechnic rounds hazing avian and pinniped predators at BON, including 7,716 15mm and 2,141 cracker shells (USDA, 2023).

Trapping and Removal

State and tribal management agencies trapped and removed sea lions at Bonneville Dam during this reporting period. Nineteen SSL were removed in fall of 2023, and 44 sea lions were removed in spring of 2024, including 27 CSL and 17 SSL (Clark et al., 2024). For additional information on sea lion management at Bonneville Dam visit https://www.dfw.state.or.us/fish/sealion/.

Discussion

This reporting period the USACE successfully met the monitoring objectives of the BiOp. The following are the salient findings of the monitoring season: relative to past years, pinniped abundance during the 2023-2024 season was lesser for both CSL and SSL. Mean SSL abundance still exceeded CSL abundance throughout the reporting period, and as in recent years, SSL were the only observed predatory species in the fall. PVI were observed on only two occasions, both during the fall season, with zero reported predation events and are therefore not discussed in detail. Salmonid consumption estimates by pinniped species were proportionate to the abundance of each pinniped this period. This is different from the 2022-2023 season wherein CSL consumption estimates were disproportionally high potentially due to kleptoparisitism, cryptic consumption, and increased motivation of individuals. Compounding impacts to several fish species continue to be a topic of concern for sensitive and ESA listed species. Management actions to remove animals has and will likely continue to change the impacts of predatory pinnipeds at BON. Below we explore the data in reference to previous years and discuss continuing and emerging trends.

Abundance

SSL – It appears that SSL abundance and duration of residency are continuing to decrease at BON. The mean fall abundance in 2023 was 4.2 animals between 3 September and 31 December. The mean number of SSL during that time frame in 2023 was less than in the mean of 8.1 in 2022 and lower than the 10-year mean abundance estimate of 20.0 (Figure 1B). The mean of 6.9 SSL in spring 2024 is a slight increase from the 2023 mean of 6.3, but a decrease from the 10-year mean of 12.3 across the dates of 1 January to 31 May. Individual identification of these animals is increasingly difficult due to lethal removal of individuals and the senescence of branded animals from the population, and as such, it is hard to ascertain the number of individuals, but it is likely higher than the daily maxima of 38 this year. Regardless, the daily peak abundance estimate of SSL has also decreased relative to last year and the 10-year average. In contrast to the past several years, no SSL remained at BON through the winter which is the second consecutive instance of this since consistent fall observations began in 2017.

These findings, when evaluated considering management's removal of 56 SSL in the last three years at BON, including 36 in the fall of 2023 and spring of 2024, suggest that removal efforts are working, and the numbers of predatory SSL near BON are diminishing due to management's efforts.

CSL – As in past years, CSL were largely absent from BON between January and February and were consistently seen between March and May. Between 1 March and 31 May a mean of 5.8 CSL were present, lower abundance compared to a mean of 7.1 in 2023 and a 10-year average of 8.1 for those same dates. Mean abundance was lower in 2024 despite the first CSL arriving 23 days earlier in 2024 than 2023. Despite short periods of high CSL abundance we documented a ecrease from the 10-year average between 1 January and 31 May (Figure 1A). The last five years' data suggest that management efforts to remove CSL have resulted in fewer animals coming to BON but doing so in large groups for short periods of time. Removal of 19 CSL in the spring of 2024 likely contributed to the noticeably lower abundance of CSL this year.

Predation

Predation sampling during the 2023-2024 season was constrained by the 20-animal trigger to shorter intervals of time than previously sampled. We emphasize that fish consumption estimates presented herein apply only to the period and tailraces sampled each season and only when there were consistently ≥20 pinnipeds at BON. This season the Powerhouse Two and Spillway tailraces were sampled during the spring observation period, while only the Powerhouse Two tailrace was sampled during the fall and winter observation period based on powerhouse priority and fish passage. Extrapolation of fall and winter consumption estimates to all three tailraces are beyond the scope of the required work. Previous data collected from the fall and winter season as directed by NOAA since 2017 can be found in Table 4, but we caution that inference be made respective of dates and locations sampled. We reiterate that fish passage and the subsequent impact of pinnipeds on each run was assessed using only the date range sampled, rather than the passage dates as defined by the Fish Passage Plan (USACE 2023).

Predation on Spring Chinook Salmon

It has been hypothesized that early returning spring Chinook Salmon are disproportionately consumed relative to later returning fish due to the presence of pinnipeds aggregated at the dam when the fish first arrive (Figure 2). The early arriving spring Chinook Salmon are also hypothesized to be most often composed of ESA listed stocks (Keefer et al., 2012). This season spring Chinook Salmon arrived later relative to the 10-year average, and pinniped presence was similarly delayed until later in the spring passage season. However, low levels of sea lions were present at BON early in the run and no estimates of predation were made due to the 20-animal monitoring trigger (Figure 2). As in previous years, pinnipeds left the dam prior to run cessation and as such, the late running fish were able to pass BON without predator impact in the near-dam environment.

In the weeks sampled between 24 March and 13 May 2024, we estimate 2,218 spring Chinook Salmon were consumed in all three tailraces, which constitutes 2.8% of the run during that time (Table 3 and Appendix 1a). For comparison, the mean 10-year estimate during spring was 4,404 spring Chinook Salmon consumed, and the 10-year average for percent of run consumed was 3.4% (Appendix 1a.). The 2024 consumption estimate is less than the 10-year average of fish consumed and less than the 10-year average percent of run consumed.

Species-specific consumption estimates of spring Chinook salmon were likely impacted by the removal of 27 CSL and 17 SSL in spring of 2024. In 2023, spring Chinook consumption estimates were weighted towards CSL at a ratio greater than 2:1. Kleptoparasitism, cryptic consumption, and increased motivation due to short residence were all proximate explanations (Braun et al., 2024). Conversely, in 2024 spring Chinook consumption estimates were weighted towards SSL at nearly a 2:1 ratio, which aligns to abundance estimates wherein mean daily abundance through the spring observation period was 6.9 for SSL and 3.5 for CSL. Ultimate causation of the difference cannot be determined but should be considered in coming years because unaccounted for differences in behavior or motivation to kill spring Chinook Salmon could impact the monitoring program data and subsequently, the evaluation of the pinniped removal effort.

Predation on Steelhead

Steelhead crossing BON during the spring are functionally recognized as two distinct varieties: the winter run, defined as those steelhead crossing BON between 16 November and 31 March, and the summer run which cross after 31 March (Busby et al., 1996; Withler, 1966). In 2019, we sampled the entire winter period and found that more than 13% of the run was consumed by pinnipeds with the vast majority being consumed by SSL (Tidwell et al., 2019). As in the 2023 season, we cannot produce comprehensive estimates for the 2024 season because sampling did not occur between 10 September 2023 and 23 March 2024 (i.e., much of the winter steelhead passage season). Despite no predation monitoring effort in much of the season, daily abundance estimates suggest that temporal overlap between winter steelhead passage and low but sustained pinniped presence could contribute to higher consumption than is presented here. The dwindling steelhead returns and consistently documented impacts by SSL beget attention be paid to pinniped impact on steelhead at BON.

Steelhead During Fall. In the days sampled between 27 August and 9 September 2023, we estimate that 36 winter steelhead were consumed in the Powerhouse Two tailrace with 18,350 winter steelhead observed passing the Washington Shore fish ladder resulting in an estimated 0.2% of the run consumed during that time (Table 3). We draw inference of consistent inter-year impacts by SSL based on the data collected during the fall/winter sampling periods from 2017 to 2022. During this six-year period the average estimate of winter steelhead consumed was 126 fish and 0.7% of the run (Table 4). The 2023 consumption estimate is lower than the six-year average for fish consumed but presents a lower percent impact to the run.

Both pre-spawn steelhead and post-spawn steelhead kelts are vulnerable to pinniped predation at BON (Tidwell et al., 2018). Due to the magnitude of the kelt outmigration from the Snake and Columbia rivers (Colotelo et al., 2014; Evans et al., 2004,), and because each powerhouse at BON has effective adult downstream passage routes (Wertheimer, 2007), it is likely that the adults consumed include some kelts. Thus, the fish impacts documented herein suggest that pinniped predation has a greater impact on steelhead than on other species of concern. In part due to ecological variables (e.g., cold waters, low fish abundance near BON) and in part due to the steelhead's complex life histories (e.g., iteroparity), the impacts of SSL predation on ESA-listed winter and summer steelhead are an issue of concern that needs to be addressed and managed accordingly.

Steelhead During Spring. In the weeks sampled between 24 March and 13 May 2024, we estimate that 39 summer steelhead were consumed in the Spillway and Powerhouse Two tailraces, which constitutes 3.8% of the run during that time (Table 3). For comparison, the 10-year estimate average was 178 summer steelhead consumed, and the 10-year average for percent of run consumed was 6.2% (Appendix 1b). The 2024 consumption estimate is lower than the 10-year average of fish consumed and lower than the 10-year average percent of run consumed.

Between 2007 and 2024 the average consumption of winter and summer steelhead during the spring observation season has been 6.6% of the run (Appendix 1b). Components of these runs are ESA listed and as such, merit attention from managers. As cautioned, the sampling methods used to provide these estimates produce minimum consumption estimates. Therein, potential impacts to listed steelhead runs are likely higher and suggest that impacts to ESA listed steelhead are twice as severe compared to the impacts on spring Chinook Salmon that initiated concern and have driven policy to manage pinnipeds to protect the fish runs.

Predation on Chum Salmon

In the weeks sampled between 27 August and 9 September 2023, no Chum Salmon predation events were observed in the Powerhouse Two tailrace. Chum salmon crossing BON are classified as the Gorge Major Population Group (MPG) and are a commixture of above dam spawning fish (Upper Gorge populations) and below dam spawning fish (Lower Gorge populations) that have overshot their spawning grounds immediately downstream of BON (NOAA, 2020). Escapement of the Upper Gorge population is thought to be limited, but Chum fry observed in the Bonneville Dam juvenile sampling facility confirm a number of fish still spawn upstream of BON despite historical spawning habitat being largely destroyed when Bonneville Dam was constructed (NWFSC, 2015). It is nearly impossible to parse these populations as they pass through BON, though in 2022 fish ladder counts at BON reported 299 passing Chum, and an estimated 5,582 fish were counted spawning immediately below BON in the Ives area, Hardy Creek, Hamilton Creek, and Hamilton Spring Channel (NMFS, 2022). In 2023 there were 615 Chum reported passing BON, and it is possible that pinniped presence during this time had an impact on the run.

Predation of Chum by pinnipeds has been sporadically observed in the fall during the 22 years of the monitoring program (Madson et al., 2017). Concentrated fall predation monitoring has been ongoing since 2017 and restricted to the 20-animal trigger since 2018. In that time, we have observed predation of Chum in three years: 14 Chum were consumed in a single week between 21 and 28 November 2022 (with a calculated consumption estimate of 138), 10 Chum were consumed between 5 - 24 November 2020, and 11 Chum were consumed between 5 - 27 November 2019 (Tidwell et al., 2020; 2021). These small sample sizes did not lend themselves to robust calculations of expanded predation estimates, but in the 2022-2023 reporting period we elected to calculate the estimated impact to the species as 14 Chum were observed consumed in a single strata week – a sample size large enough to justify probability-based expansion for hours not observed. Our 2022 estimate of 138 Chum consumed merits further discussion as several factors might explain the high level of predation observed last year.

Records of Chum populations below BON have been best documented between 1999 to 2018 (NOAA, 2020; Table 5). More Chum near BON likely equates to more consumption events by sea lions. Perhaps intertwined but worthy of mention is the increased consumption in a short interval. Albeit 14 Chum is not particularly noteworthy, the contracted sampling period and high rate of predation relative to previous years suggests that the totality of impact could have been much higher than previously documented. Further, the predatory impacts of sea lions immediately downstream at the Pierce-Ives Island complex have been documented but not studied. Impoundments can cause fish to concentrate and likely leads to sea lion habituation at BON for access to concentrated prey resources. Chum arrive after most other salmon have passed BON and are therein the most distinctive prey item near the dam in the late fall. The elevated predation of Chum by SSL observed in 2022 may be the result of a learned behavior of SSL that have identified the spawning Chum near BON as a vulnerable and readily accessible prey resource. A stark increase in passage numbers in 2023, and the increasing returns of the last three years suggests that future passage and predation be considered in context of the timing of the run and observation period.

Table 5. The 5-year geometric mean of natural-origin spawner counts for CR Chum Salmon. Number in parenthesis is the 5-year geometric mean of total spawner counts. “% change” is a comparison between the two most recent 5year periods (2014-2018 compared to 2009-2013). "NA" means not available. An “*” indicates that, at the time of drafting this opinion, data for

the Upper Gorge Tributaries population only were available through 2017. No data for Chum Salmon were available for 2019. Source: adapted from Williams (2020e) as cited in NOAA (2020).

MPG	Population	1999-2003	2004-2008	2009-2013	2014-2018	% Change
Columbia Gorge	Lower Gorge Tributaries	NA	978 (995)	1707 (1722)	3540 (3563)	107 (107)
	Upper Gorge Tributaries	48	141	80	68*	-15

Predation on White Sturgeon

White Sturgeon consumption by pinnipeds at BON has changed considerably over the last 22 years, but past trends warrant attention by managers as the dynamics and species compositions have changed and the potential impacts to White Sturgeon are now perhaps more severe. Prior to monitoring during the fall and winter, White Sturgeon predation was exclusively documented by SSL during the spring, when USACE only observed pinniped predation from early January through the end of May. During the years with the highest predation of White Sturgeon, USACE was not required to monitor the BON tailrace during the fall months of September through December. Between 2008 and 2012 more than one thousand White Sturgeon were consumed each spring with a peak in 2011 of over 3,000 fish consumed. After 2012, White Sturgeon predation dropped sharply and between 2015 and 2017 we estimate that less than 100 White Sturgeon were consumed each spring. Fall and winter monitoring was implemented in 2017 and we now document that the decreased springtime consumption of White Sturgeon has been offset by increased and notable fall and winter consumption of the fish. While overall White Sturgeon consumption estimates remain lower than the peak spring periods of 2008-2012, the estimate of 1,119 sturgeon consumed in the fall of 2021 should be considered in-light of a truncated fall observation period in the fall of 2022 and 2023, and an 82% decline in the abundance of White Sturgeon (fork length ≥54 cm) in the Lower Columbia River between 2010 and 2023 (Oregon and Washington Departments of Fish and Wildlife, 2024).

White Sturgeon During Fall. The strata weeks of fall observation in 2023 were outside the range of dates when high White Sturgeon predation has been recorded in past years. Between 2018 and 2023 we recorded 420 White Sturgeon predation events between August and December, only 34 of which occurred between 27 August and 9 September across those six years.

This season we recorded two White Sturgeon predation events, both of which occurred on 5 September 2023. This equated to an expanded estimate of 17 (0 – 33) for the sample strata weeks. Therefore, the period during which most sturgeon predation events would have occurred was not monitored for predation this season. However, it is worth noting that the estimated consumption across these 14 days is still nearly equal to that observed in spring (consumption estimate of 19 [0 – 38]) across 51 days.

Understanding the relationship between pinnipeds and White Sturgeon is imperative to realizing the full extent of the impact that pinnipeds have on fish near BON and lower Columbia River stocks. Unlike salmonids which encounter pinnipeds during migration past the dam, White Sturgeon migrate to, forage, and spawn just downstream of the BON tailraces during the spring (Parsley et al., 1993). Offspring and young fish mature near the dam year-round and are particularly vulnerable to predation during the fall and winter. This temporal relationship to various cohorts based on life history is pertinent to management because our data from the last five years suggests that younger White Sturgeon are being consumed disproportionately during the fall season, whereas larger adult fish consumption has declined, but are still consumed in the spring. While the fall seasons of 2022 and 2023 did not yield a large number of observed White Sturgeon predation events during the observation period, it should not disparage the high predation rates reliably collected during the previous five years of fall observations. During the fall and winter season of 2017 through 2021 a mean estimate of 613 White Sturgeon were consumed during each observation year (Appendix 1e.). The mean 2021 consumption estimate of 1,119 fish was two times higher than the estimated mean consumption range of 238-762 in previous years. While fewer predation events were observed this year, the monitoring period did not cover the period during which most White Sturgeon predation events are typically observed due to the >20 abundance threshold. Therefore, pinniped predation on White Sturgeon across the 2023 fall season was likely much higher than the expanded estimate of 17 that we present here.

White Sturgeon During Spring. In the weeks sampled between 24 March and 13 May 2024, we estimate that 19 White Sturgeon were consumed across all BON tailraces. SSL were responsible for all depredation of White Sturgeon during this time, despite the continuous presence of CSL. This consumption estimate is lower than the 10-year average of 86, and lower than the 2023 estimate of 37.

White Sturgeon depredation by pinnipeds has distinctively changed over the past decade; while 19 estimated predation events during the spring may not be cause for immediate concern, the fall and winter consumption estimates demand more attention from fish managers in the coming years. Our data affirmed our findings of the previous five years which suggests that the impact to White Sturgeon is greater during the fall and winter months than during the spring. Why more fish are killed in the fall and winter than the spring is unclear, but the additive mortality of White Sturgeon over time at BON may be contributing to the questionable status of the stock.

Predation on Lamprey

No Pacific Lamprey predation events were observed during the fall 2023 and spring 2024 observation periods. It is likely that pinnipeds are consuming a number of lamprey in the BON tailrace. Since our observations are limited to above-surface actions, we suspect subsurface predation may be occurring.

Consumption of Pacific Lamprey is supported by WDFW/ODFW dietary analysis of pinnipeds removed from BON. In the fall of 2023 WDFW/ODFW analyzed the gastro-intestinal tracts of 19 sea lions, all SSL. The gastro-intestinal tracts of four SSL included 46 total fish identifiable as Pacific Lampreys, including 33 in a single animal captured on 12 September 2023 (Clark et al., 2024).

Predation on Other Fishes

Across both sampling periods we documented three predation events on other fish species which is consistent with previous years. Smallmouth Bass (*Micropterus dolomieu*), American Shad (*Alosa sapidissima*), and Common Carp (*Cyprinus carpio*) are typically consumed, however, the juvenile salmon documented by Edwards et al., (2022) likely incorporate to this group as well and explain the GI contents described above. As in past years, the consumption of juvenile salmonids and other fish of concern is likely underreported due to factors such as cryptic consumption, wherein, pinnipeds can consume fish entirely underwater and this do not allow opportunity for observation.

Deterrence and Management

Physical Barriers

Physical barriers at fish ladder entrances (e.g., SLEDs, FOGs) continue to be the most effective deterrent mechanism currently employed (Appendix 2). They successfully excluded all pinnipeds from entering the fish ladders this season. Given the near year-round residency of SSL, continuing to deploy the devices year-round is warranted.

Hazing

As discussed in previous reports, the value of hazing pinnipeds with conventional methods continues to be questioned. The recurrence of habituated pinnipeds following increased and prolonged hazing events over the last decade suggest its functionality is minimal. The select benefit of current hazing techniques might be the brief moments of time when active hazing is occurring, which has been found to dissuade active foraging behaviors (Götz & Janik, 2013). A two-year analysis of SSL response to dam-based hazing at BON was published by the authors in 2021 and found that SSL habituate to hazing quickly (Tidwell et al., 2021). The study found that except for the initial application of hazing, SSL did not leave the tailrace, continued foraging, and had levels of vigilance comparable to baseline levels when no hazing was present. Thus, empirical evidence specific to BON now exists to challenge the effort and expense of applying dam-based hazing, but hazing is still applied to ensure requirements of the BiOp are satisfied.

Removal

The passage of the Endangered Salmon Predation Prevention Act gave management the authority to remove SSL and CSL without requirements of predation, hazing, or residency. As shown through fish consumption and CSL abundance data, the removal of CSL over the last decade has contributed to a reduced ESA listed fish impact. The removal of SSL at BON occurred again this year and shows promise as a management tool. The recurrence of highly habituated and identifiable individuals decreased with the removal of each animal and the resultant fish impact by SSL on all fish species has started declining. Future management actions for CSL and SSL are warranted to further reduce the impact to ESA listed salmon and sensitive stocks of other fish.

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Table 6. Consumption of spring Chinook Salmon by pinnipeds at Bonneville Dam tailrace during the spring sampling period from 2002 to 2024. Passage counts of Chinook Salmon includes both adult and jack salmon.

Year	Bonneville Dam Spring Chinook Passage	Chinook Consumption Estimate	Percent of Run Consumed
2002 [x ⊥]	275,290*	880[†]	0.3%
2003 [x ⊥]	210,028	2,313	1.1%
2004 [x ⊥]	179,193	3,307	1.8%
2005 [x ⊥]	78,341	2,742[‡]	3.4%
2006 [x ⊥]	99,366	2,580	2.5%
2007 [x ⊥]	83,252	3,403	3.9%
2008	143,139	4,501	3.0%
2009	181,174	4,360	2.3%
2010	257,036	5,909	2.2%
2011	218,092	3,634	1.6%
2012	165,681	1,959	1.2%
2013	117,165	2,710	2.3%
2014	214,177	4,576	2.1%
2015	233,794	10,622	4.3%
2016	148,357	9,222	5.9%
2017	101,734	4,951	4.6%
2018	94,350	2,813	2.9%
2019	61,385	1,974	3.1%
2020 [˩]	46,822	1,180	2.5%
2021^	63,713	2,079	3.3%
2022**	144,407	4,437	3.1%
2023[†]	100,822	2,181	2.2%
2024[‡]	79,241	2,218	2.8%

[x] Adjusted estimates did not start until 2008 (Tackley et al. 2008), as such these values are expanded estimates.
* 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 the observed catch distribution to divide unidentified salmonid consumption.
[‡] In 2005 pinniped observations did not start until March 18.
⊥ Passage data altered to meet the Fish Passage Plan run criteria of 1 January – 31 May. Data will differ relative to previously published data.
[˩] 2020 sampling occurred between 12 April and 20 May due to COVID 19 pandemic. Fish passage depicts these dates.
^ 2021 sampling occurred between 4 April and 18 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date). Fish passage for 2021 depicts these dates.
** 2022 sampling occurred between 3 April and 21 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date). Fish passage for 2022 depicts these dates.
[†] 2023 sampling occurred between 2 April and 20 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date). Fish passage for 2023 depicts these dates.

‡ 2024 sampling occurred between 24 March and 13 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date). Fish passage for 2024 depicts these dates.

Table 7. Consumption of summer and winter steelhead by pinnipeds at Bonneville Dam tailrace during the spring sampling period from 2007 to 2024.

Year	Bonneville Dam Steelhead Passage	Adjusted Steelhead Consumption Estimate	Percent of Run Consumed
2007[x]	5,188	609 [x]	10.5%
2008	4,367	391	8.2%
2009	4,829	599	11.0%
2010	9,972	413	4.0%
2011	5,279	336	6.0%
2012	5,904	400	6.3%
2013	3,394	218	6.0%
2014	5,696	128	2.2%
2015	5,217	237	4.3%
2016	5,262	302	5.4%
2017	3,241	322	9.0%
2018	3,808	295	7.2%
2019	2,172	208	8.7%
2020*	N/A	N/A	N/A
2021^	375	27	7.2%
2022**	791	68	8.6%
2023†	513	17	3.3%
2024‡	1014	39	3.8%

[x] Adjusted estimates did not start until 2008 (Tackley et al., 2008), as such this value is an expanded estimate.
* 2020 sampling occurred between 12 April and 20 May due to COVID-19 pandemic. Only two steelhead observed killed.
^ 2021 sampling occurred between 4 April and 18 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date). Fish passage for 2021 depicts these dates. Only three steelhead were observed killed.
** 2022 sampling occurred between 3 April and 21 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date). Fish passage for 2022 depicts these dates. Only six steelhead were observed killed.
† 2023 sampling occurred between 2 April and 20 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date). Fish passage for 2023 depicts these dates. Only one steelhead was observed killed.
‡ 2024 sampling occurred between 24 March and 13 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date). Fish passage for 2024 depicts these dates. Only four steelhead were observed killed.

Table 8. Consumption of White Sturgeon by pinnipeds at Bonneville Dam tailrace during the spring sampling period from 2005 to 2024.

Year	Total Hours Observed	Observed Sturgeon Catch	Adjusted Sturgeon Consumption Estimate
2005	1,109	1	N/A
2006	3,650	265	413
2007	4,433	360	664

2008	5,131	606	1,139
2009	3,455	758	1,710
2010	3,609	1,100	2,172
2011	3,315	1,353	3,003
2012	3,404	1,342	2,498
2013	3,247	314	635
2014	2,947	79	146
2015	2,995	24	44
2016	1,974	30	90
2017	1,142	6	24
2018	1,410	46	148
2019	836	22	187
2020*	331	9	57
2021^	132	1	N/A
2022**	205	4	40
2023†	228	4	37
2024‡	157	2	19

* 2020 sampling occurred between 12 April and 20 May due to COVID-19 pandemic.
^ 2021 sampling occurred between 4 April and 18 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date).
** 2022 sampling occurred between 3 April and 21 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date).
† 2023 sampling occurred between 2 April and 20 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date).
‡ 2024 sampling occurred between 24 March and 13 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date).

Table 9. Consumption of Pacific Lamprey by pinnipeds at Bonneville Dam tailrace during the spring sampling period from 2002 to 2023.

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	516	120	816	12.8%
2005	1,109	613	810	25.1%
2006	3,650	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	3,315	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%
2016	1,974	232	501	4.8%
2017	1,142	41	191	1.7%
2018	1,410	16	58	0.04%
2019	836	4	14	0.02%
2020*	331	1	N/A	N/A
2021^	132	0	N/A	N/A
2022**	205	1	N/A	N/A
2023†	228	0	N/A	N/A
2024‡	157	0	N/A	N/A

* 2020 sampling occurred between 12 April and 20 May due to COVID-19 pandemic.
^ 2021 sampling occurred between 4 April and 18 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date).
** 2022 sampling occurred between 3 April and 21 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date).
† 2023 sampling occurred between 2 April and 20 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date).
‡ 2024 sampling occurred between 24 March and 13 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date).

Table 10. Consumption of White Sturgeon by pinnipeds at Bonneville Dam tailrace during the fall sampling period from 2017 to 2023. Please note that only one tailrace is monitored for predation during the fall sampling period, and that hours observed are highly dependent on pinniped abundance, and observations may therefore vary considerably by year.

Year	Total Hours Observed	Observed Sturgeon Catch	Adjusted Sturgeon Consumption Estimate
2017	139	39	238
2018	369	77	359
2019	341	164	762
2020	234	82	589
2021	188	94	1,119
2022	11	1	10
2023	24	2	17

Table 11. Adjusted consumption estimates on adult salmonids (including adults and jacks) by California and Steller sea lions at Bonneville Dam during the spring sampling period from 2002 to 2024.

Year	California Sea Lions	Steller Sea Lions	All Pinnipeds

	Bonneville Dam Salmonid Passage	Adjusted Salmonid Consumption Estimates	% Run	Adjusted Salmonid Consumption Estimates	% Run	Adjusted Salmonid Consumption Estimates	% 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	3.1%
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%
2019	63,591	176	0.3%	2,022	3.1%	2,201	3.3%
2020*	47,074	373	0.8%	813	1.7%	1,182	2.5%
2021^	64,089	726	1.1%	1,390	2.2%	2,141	3.3%
2022**	145,198	2,231	1.5%	2,275	1.6%	4,530	3.1%
2023†	101,339	1,521	1.5%	666	0.7%	2,201	2.2%
2024‡	80,255	810	1.0%	1,439	1.8%	2,253	2.8%

* 2020 sampling occurred between 12 April and 20 May due to COVID-19 pandemic. Fish passage for 2020 depicts these dates.
^ 2021 sampling occurred between 4 April and 18 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date). Fish passage for 2021 depicts these dates.
**2022 sampling occurred between 3 April and 21 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date). Fish passage for 2022 depicts these dates.
†2023 sampling occurred between 2 April and 20 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date). Fish passage for 2023 depicts these dates.
‡ 2024 sampling occurred between 24 March and 13 May based on the 20-animal trigger (start date) and when all pinnipeds had departed the tailrace (end date). Fish passage for 2024 depicts these dates.

Appendix A. Description of the BON tailrace system, life histories of the pinniped and fish species studied, and the methods employed to study pinniped abundance, residency, deterrence & management activities, and the level of fish predation during the fall – winter and spring sampling periods.

Appendix A

Study Area

Bonneville Lock and Dam (BON) is in the Columbia River at river mile 146 (river kilometer 235) from the confluence of the Pacific Ocean. The dam spans the Columbia River between the states of Oregon and Washington and is comprised of three concrete structures separated by islands. Pinniped activities historically occur in the tailraces of the dam between the islands. Using the *a priori* knowledge of pinniped behavioral patterns at the dam, we observed pinniped abundance and predation from each of the three tailrace sub-areas downstream of Powerhouse One (PH1), Powerhouse Two (PH2), and the Spillway (SPW) (Figure A1). Elevated observation platforms at these tailraces were used to observe pinniped activity. To facilitate comparison of predation events by tailrace area and provide continuity to previous reports (Madson et al., 2017), we divided each tailrace sub-area into seven zones (Figure A1). Pinniped abundance counts and brand re-sightings were conducted in the three tailrace sub-areas and at Tower Island, a site historically used as a resting area for pinnipeds (Figure A1). Abundance counts and brand re-sightings were also collected at Tanner Creek, the nearest downstream tributary approximately one mile from the dam. The States anchored three floating sea lion traps in the vicinity of Tower Island to implement their removal and management authorities. In concert with these traps and based on previous experience that aberrant CSL and SSL can occasionally get above the dam, the states at times put a floating collection trap above BON to capture these remnant animals.

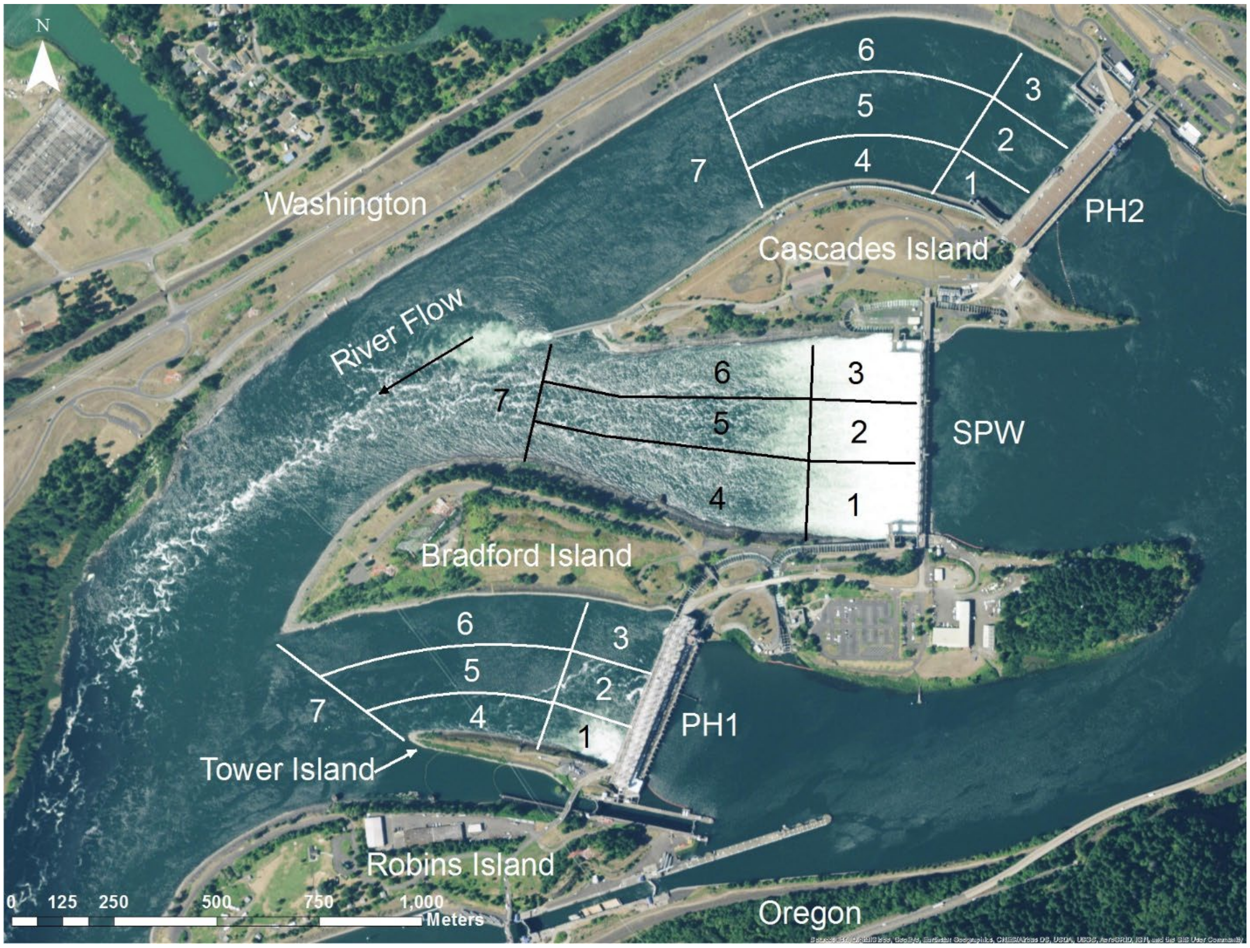

Figure A1. Bonneville Dam study area with Powerhouse One (PH1), Spillway (SPW), and Powerhouse Two (PH2) tailrace sub-areas separated into zones for assigning the location of predation events.

Focal Species

Pinnipeds

The Suborder Pinnipedia evolved ≥ 20 million years ago and has likely overlapped in distribution with anadromous Pacific salmonids for the bulk of this time (Naughton et al., 2011). The co-occurrence and predation of salmonid fish by pinnipeds undoubtedly led to long-standing anthropogenic disdain for the species in the Pacific Northwest, so much so that State wildlife agencies authorized bounty programs to kill as many pinnipeds as possible (Beddington et al., 1985). Since the Marine Mammal Protection Act of 1972, the stocks of CSL and the Eastern stock of the SSL have rebounded (NOAA 2014, 2016b), and are now frequently observed along the Pacific Coast.

The rookeries (i.e., breeding and rearing grounds) for the sea lions entering the Columbia River system are primarily the Channel Islands off the coast of southern California for the CSL, and the Rogue Reef outcroppings off the coast of southern Oregon for the Eastern stock of SSL (B. Wright personal comm.). Males of both species disperse from rookeries after breeding to forage in waters different from that of the females and sub-adults to regain the weight lost during the prolonged terrestrial breeding periods. Thus, all CSL and SSL entering the Columbia River system are males that have left their respective breeding grounds in search of foraging opportunities. Sea lions have been documented at the mouth of the Columbia for several hundred years (Lyman et al., 2002) but have only recently (i.e., < 20 years) been documented consistently traveling to BON to forage. Brand re-sighting and telemetry data suggest that approximately 7% of the CSL occurring near the mouth of the Columbia River travel to BON to forage (NOAA 2017). These animals represent a mixture of several cohorts including juvenile (2-4 years), sub-adult (5-8 years) and adults (> 8 years) (Laake et al., 2016).

Natural History of Pinnipeds at Bonneville Lock and Dam

Pinnipeds that travel to, and forage at, BON consistently forage in the tailraces of the dam during the day and utilize rock outcroppings and riprap infrastructure to rest on, a process called "hauling out" during the night. Hunting forays from the rocks to the tailraces occur by almost all animals just prior to sunrise after which they can be observed transiting between the tailraces and haul-out locations during daylight hours. They return to the haul-out locations just after sundown where they generally remain through the nighttime.

Pinnipeds can be observed periodically surfacing to breathe when foraging then submerging to pursue prey below the surface. The maximum time submerged under normal conditions for CSL is 9.9 minutes (Feldkamp et al., 1989), however, at BON foraging dives are generally less than five minutes for both species of pinniped (KST personal obs.) Once captured, larger prey items are brought to the surface and broken through a series of violent head shakes reducing the prey to multiple pieces of manageable size (Jones et al., 2013). Of note for monitoring purposes is the prey handling time and capacities of each species; adult SSL can swallow sizeable spring Chinook Salmon almost whole in a matter of seconds, whereas adult CSL typically stay at the surface and break the fish into smaller pieces. Thus, handling time differs for each species of sea lion, a difference which likely influences the ability and confidence of observers to document predation and therein may influence inter- and intra-species differences enumerated in this report – SSL predation may be biased low as a result.

Fish Species in BON Tailrace

Pacific salmon and steelhead (*Oncorhynchus spp.*) of the Columbia River system are composed of several species, many of which have distinct evolutionarily significant units (ESU-salmon) or distinct population segments (DPS-steelhead) that have been listed under the ESA. During the fall and winter period the primary salmonid species passing BON are: fall Chinook Salmon (1 August – 15 November), Coho Salmon (15 July – 15 November), summer steelhead (A run: June – August; B run: August – October), and winter steelhead (16 November – 31 March). The primary species passing during the spring sampling period are the spring Chinook Salmon and DPS of winter and summer steelhead. These runs are historically classified by the periods of time at which they cross the dam: spring Chinook Salmon: 14 March – 31 May, ocean-maturing winter steelhead: 16 November – 31 March, and stream-maturing summer steelhead: 1 April – 15 November (Busby et al. 1996).

Due to the temporal overlap of pinnipeds and migrating salmonids, data suggests that early migrating salmonid stocks may be disproportionately impacted by pinniped predation (Keefer et al., 2012), specifically ESU stocks of spring Chinook from the Icicle, Salmon, Deschutes, Clearwater, and Umatilla rivers which have the greatest temporal overlap with pinnipeds. Of these, the Icicle and Salmon River populations are listed as threatened under the ESA (Good et al., 2005).

Different salmonid species and various runs of steelhead and Chinook Salmon are encountered by pinnipeds due to the temporal overlap and misalignment of run chronology as a result of environmental conditions and migration patterns, however the bulk (i.e., > 95%) of salmonids consumed during the spring sampling period are of the spring Chinook and winter steelhead runs (Stansell 2004, Madson et al. 2017). Stocks consumed during the fall and winter include ESA listed B run steelhead, lower Columbia River Coho, select ESUs of the fall Chinook run, and winter steelhead. Analyses of stock specific impacts are beyond the scope of this report but are warranted. Other fish species observed as prey of pinnipeds at BON include: White Sturgeon (*Acipenser transmontanus*), Pacific Lamprey (*Entosphenus tridentatus*), American Shad (*Alosa sapidissima*), and various warm water and introduced fishes (e.g., *Micropterus spp., Cyprinus spp.*). Our monitoring program focus primarily on the number of salmonids, Pacific Lamprey, and White Sturgeon consumed.

Sampling Methods

The pinniped monitoring project has evolved since its initiation in 2002 to better capture the information required by the Biological Opinion and to facilitate research efforts by the States and collaborative agencies. Data informed modifications to sampling schemes and observer effort have produced a robust and cost-effective system to estimate salmonid consumption and pinniped abundance. In short, biological observers trained in fish and pinniped identification use field glasses (8 X 42 magnification) to document pinniped activity at predetermined locations above the tailraces of the dam (Figure A1) at a scheduled interval to develop estimates of predation and abundance.

Monitoring: Abundance, Residency, and Recurrence

We quantified the number of pinnipeds present at the BON project each day by conducting point counts of animals from a distance using field glasses. Sampling began when the first pinniped was observed in the summer and terminated when the last pinniped left in the spring. To maximize the accuracy of point counts, we used historical data and pinniped behavior to inform the optimal times at which to perform point counts. Previous data revealed a strong diel pattern (Stansell 2004, KST unpub. data), whereby, the greatest number of pinnipeds are consistently observed hauled out during the evening and crepuscular hours, a pattern consistent with some pinniped natural foraging cycles (Boehme et al., 2016, but see: Watts, 1996, Sepulveda et al. 2012). As such, we generally conduct one point count per day during the morning or evening civil twilight.

The abundance data provided herein represent a conservative estimate of pinnipeds at BON on any one day collected by the point count. All pinnipeds in the three tailraces and on Tower Island were counted, however, submerged animals, animals in transit between locations but out of sight, and the ingress and egress of animals to BON occurs and may potentially influence our abundance estimates. To avoid double counting animals transiting between count locations, we sampled all locations in one five-minute period at each site, a period short enough to individually count animals before they could move between sites and long enough to ensure submerged animals will have surfaced and could be counted.

Abundance – The daily pinniped abundance for each species is presented as the highest point count taken for each species each day irrespective of time of day. For periods when FFU staff were not present to collect point count data (i.e., weekends, holidays), linear interpolation between the most recent days surrounding the missing period was used to estimate abundance. In doing so, we present the estimated maximum number of pinnipeds that could have been near BON each day.

Yearly maximums of individually identifiable animals are presented to document how many pinnipeds of each species were observed throughout the season. Since not all CSL are branded and very few SSL are branded, we present the yearly maximum count as either: 1) the greatest number of animals in any single point count (sum of all three sub-tailraces, Tower Island, and Tanner Creek), or 2) the cumulative number of uniquely identifiable animals observed during the season, whichever is higher. This approach combines two metrics (annual individual accounts or daily high counts) and provides the estimated yearly maximum because either, all the animals were individually identified at some point or were observed in one point count and thus were mutually exclusive counts of individuals. However, the latter method does have the potential to be biased low, as a non-identifiable individual could have been to BON during the season but was not present during the highest daily point count of the season. This is most often applied to the SSL due to the limited brands on the animals. Thus, the yearly maximum abundance is a conservative measure of the most animals documented throughout the year.

Residency – Historically this metric was required to facilitate management of CSL in the BON tailrace. With the passing of the Endangered Salmon Predation Prevention Act these data are no longer required and therein were not reported this year. However, the data exist and if requested can be furnished.

Recurrence – Similar to Residency, this metric is no longer required but the data are available upon request.

Monitoring: Chronology of Fish Passage, Methods of Estimating Fish Predation

Estimating Fish Predation

Surface observations of pinniped-prey interactions were used to enumerate the number and species of each fish killed by each pinniped species. This method is useful and has been employed elsewhere (see Roffe and Mate, 1984; Wright et al., 2014), and consistently applied at BON for > 19 years. All attempted (i.e., loss) and successful (i.e., catch/stolen) predation events were recorded, as well as the time and location of the predation event, species of fish, species of pinniped, unique pinniped identification (if possible), length of Sturgeon (if applicable), and interactions with other pinnipeds during the predation event (i.e., kleptoparasitism).

Sub-surface predation and consumption has been documented previously, particularly with the larger SSL and smaller fish, and may artificially truncate the estimated number of fish consumed (Stansell 2004). However, as noted, this is almost exclusively an SSL issue and likely only influences the counts of the smallest spring Chinook (i.e., jacks) and smaller steelhead. However, we recognize that some CSL sub-surface predation may occur. Due to the nature of observing wild animals *in situ* with field glasses, not all predation events were easily recognizable. In instances when fish were too mangled, actively being swallowed, or too far from the observer to be recognized, the predation event was recorded with all pertinent data and the fish species was listed as "unidentifiable."

The process of accounting for the unidentifiable fish in the predation estimate has evolved over the years. Historically, the program monitored pinniped activity extensively (i.e., all daylight hours and some nighttime observations) and therein justified using the raw data of observed predation events with a correction factor applied based on *a priori* knowledge of observer skill level, program structure, and pinniped behavior (Stansell, 2004). Presently we use the "adjusted consumption estimate" developed by Tackley et al. (2008) which incorporates the unidentifiable fish predation events evenly across other predation events based on the number and species of fish consumed that day. For example, assume 24 fish were caught in one day, 20 identified, and four unidentified. Of the identified fish, 10 were Chinook Salmon and 10 steelhead. The four unidentified fish catches would be proportionally distributed to two Chinook Salmon and two steelhead. In this manner we provide the adjusted estimate – a parsimonious estimate of how many of each fish species were consumed each day – which is the functional unit utilized to estimate the total number of fish consumed for the season.

Being readily identifiable and not easily mistaken for any other fish in the Columbia River, the Pacific Lamprey was not applied to the adjusted estimates. Therein, Pacific Lamprey consumption estimates reported here are merely expanded for hours not observed and have not been adjusted. It is possible that Pacific Lamprey are consumed underwater albeit observers rarely report Pacific Lamprey being brought to the surface in a mostly consumed state. However, since it is possible, the estimates provided here are minimum consumption estimates. Moreover, based on the tendency for Pacific Lamprey to pass at nighttime and the lack of night-time predation monitoring there is potential for Pacific Lamprey predation to go unrecorded, again indicating that the estimates provided herein, are minimal estimates.

Sampling Design for Predation Estimates

As in previous years, a Stratified Random Sampling design (SRS) (Cochran, 1977) was implemented to account for hours not observed across the three tailraces of the dam each week (Madson et al., 2017). This season we elected to consistently apply a systematic sampling design with even coverage within each strata week, a design that is different from last season which involved a combination of simple and stratified random sampling within weeks. We describe the methods and assumptions of these designs below.

Each seven-day week (arbitrarily assigned as Sunday-Saturday) served as a stratum. For example, in 2019 the fall and winter sampling period had 18 strata weeks from 26 August – 31

December and the spring sampling period of 2020 had 6 strata weeks between 12 April and 20 May. Five of seven days (Monday-Friday) were sampled during each stratum except for federal holidays. These missing samples were incorporated with weighting (sampling effort to sample total) to the predation estimate. Given the diel foraging activity of the pinnipeds at BON, the sample coverage for each stratum was based on civil twilight (morning), sunrise, sunset, and civil twilight (night) for Cascade Locks, OR (six miles east of BON). We conducted observations for the maximum number of two conjoined 30-minute sampling units between morning and night. If the 60-minute sampling unit was ≥ 15 minutes before or after civil twilight, the first 30-minute interval was removed from the daily sample and the next sample block was used. Doing so ensured enough light to facilitate positive identification of both pinniped and fish species and maximized the potential to randomly select a sampling unit during all hours of daylight. The sample rate is expressed as the percentage of daylight hours sampled per total daylight hours available in the week (i.e., stratum).

During predation sampling, the distribution of observations was selected by assigning a number to each tailrace and randomly selecting one of the tailraces for sampling. Once the initial tailrace was selected, the sampling occurred in a systematic stepwise progression across each tailrace for that day. The process was then repeated for every Monday – Friday of each week for the entire season. This random systematic process facilitates two important components of the sampling design: first, it eliminates travel between sites which, therefore, allows assumptions of equal and complete coverage to be upheld, and second, ensures equal and random assignment of sampling to all tailrace areas during all daylight hours.

Given that the levels of pinnipeds and fish fluctuate across the sampling seasons (i.e., high heterogeneity), but remain relatively consistent within weeks (i.e., high homogeneity), we utilized a bootstrap resampling method, a technique widely applied to provide more robust measures of confidence for stratified sampling designs (Efron 1982), to estimate the mean catch and associated confidence intervals (CI) of fish consumed during the focal sampling period.

We elected to bootstrap across the entire sample due to the highly stochastic runs of fish and pinniped numbers. We treated the hourly observation samples as the target population and sampled, with replacement, 999 times from the observations over the focal sampling period to measure the population parameter of interest, the mean number of (adjusted) fish consumed. With this approach, some data points can appear at multiple times during the resampling. Among the 999 resampled data sets, the entire sample (all observation data) and the total observations during each week were kept constant. For example, if there were 35 and 40 observations during week 1 and week 2, respectively, our resampling maintained the same observation size for each of the 22 weeks (e.g., 35 for week 1, 40 for week 2, etc.).

We estimated the total catch of every resampled table (999 estimates) and calculated the confidence intervals for the true mean (μ) using the distribution of delta [$\delta^* = \overline{x}^*$ -$\overline{x}$)]. $\overline{x}^*$ is the mean of the bootstrap sample and $\overline{x}$ is the sample mean. The bootstrap 95% confidence intervals for μ is as: [$\overline{x} - \delta^*_{0.025}, \overline{x} - \delta^*_{0.975}$].

In doing so, we provide the bootstrap estimated number of each fish caught by pinniped species with bootstrapped measures of variance for each estimate. If confidence intervals overlapped zero as a result of small sample sizes, we report the estimated number of fish consumed as the lower bound of variation and the calculated 95% confidence boundary as the upper level of predation.

All calculations and comparisons of consumptions were conducted with the adjusted consumption data unless otherwise noted.

Calculation of Predation Estimates for Percent of Run Taken

To facilitate inter-year comparisons and determine estimated total predation by pinnipeds and by fish run size, we present the percentage of each fish species taken by each species of pinniped calculated as the estimated number of fish consumed by pinnipeds divided by the total passage count (i.e. estimated number of fish that successfully passed BON) from the beginning of the sample period to the end of the sample period multiplied by 100. Salmon count data (daytime counts, all adult salmonids including jacks) were obtained from the USACE Fish Counts and Reports adult fish count website (WWW.FPC.ORG).

The calculation of fish consumed divided by fish that passed only during the monitored interval is an adopted change based on last year's analysis that required calculation of pinniped impact to several species in-light of constraints to sampling not previously accounted for (see Tidwell and van der Leeuw, 2021). That is, since predation is now monitored across the entire year when 20 pinnipeds or more are present, there is disjunct monitoring across runs. Moreover, run timing and species composition is much more dynamic with year-round sampling. As such, reporting on the impact to the run of estimated fish consumed divided by the number of fish that passed during the observation period is the most conservative measure of interpreting the data and provides parsimony.

Steelhead Passage is enumerated, in part, for management practices and as a result fish take is calculated from the fish that are observed passing BON. The calculation for the percent of a given fish run consumed is calculated as the estimated consumption estimate divided by the number of fish that passed BON. This method more accurately reflects fish consumption as it relates to management practices and accounts for impacts to fish which successfully return to BON but are unsuccessful in spawning solely due to pinniped predation. The method by which consumption as a percent of a particular run is calculated was updated in the 2018 pinniped report to reflect the impact of predation by pinnipeds more accurately.

Justification for this method of calculation can be described a few ways. Fish managers base fishing seasons and catch limits on the number of fish that pass Bonneville Dam. To include fish that are taken before passing this threshold in the total run would result in overestimation of fish available to catch, thereby resulting in higher catch limits and longer seasons that are inappropriate compared to the number of fish available to catch. This impact could compound over years and result in fish stocks declining more rapidly than they already are, with emphasis on natural origin stocks that are not replenished by hatcheries on a seasonal basis. Furthermore, with other calculation methods fish spawning immediately downstream of BON remain wholly unaccounted for – predation should encompass both upriver populations and populations which reside near BON just downstream. It should be noted that these changes were employed first in 2020 and are used again this year with the intent to continue to calculate in a similar fashion moving forward.

Chronology of Fish Passage

We present passage for each sampling period of each year and when needed, compare to the ten-year average to inform how the passage and abundance of salmonids may interact with the estimated consumption by pinnipeds. With these passage estimates, we also recognize that environmental co-factors have been shown to influence passage rates (Keefer et al., 2008; Evans et al., 2016).

Data Analysis and Reporting

Descriptive statistics are reported throughout with the mean and associated standard error as the measure of spread (i.e., $\bar{x}$ ± S.E.). Adjusted estimates of predation are reported as the bootstrapped mean with associated 95% confidence intervals (CI). Analyses were performed with Program R (version 3.3.2).

Deterrents and Management Activities

Deterrents to Fish Predation

A variety of methods have been implemented to deter pinnipeds from eating salmonids near priority areas (Jeffries and Scordino, 1997; Gotz and Janik, 2013; Schakner and Blumstein, 2013). Presently, hazing and physical exclusion devices are used in concert to deter pinnipeds at BON. Hazing consists of a combination of non-lethal deterrents including cracker shells (small charges of explosive ordinance), rubber buckshot, boat chasing, and underwater percussive devices known as seal bombs. USDA personnel haze from the face of the dam to deter pinnipeds from approaching the fish ladder entrances and boat-based CRITFC crews haze the pinnipeds in the dam tailraces and attempt to push them downstream and away from the fish ladder entrances. We report the descriptive statistics of these efforts and discuss their use throughout the season.

Due to the repeated entry of pinnipeds to the fish ladders at BON, physical exclusion devices were constructed starting in 2006 to block pinnipeds but allow fish passage. Specially designed gates called Sea Lion Exclusion Devices (SLEDs) are now installed throughout the season at all eight fishway entrances of BON (Appendix 2). In addition to the eight SLEDS, there is smaller physical exclusion grating installed on the 16 Floating Orifice Gates (FOGs) along the face of Powerhouse Two that allow fish to enter the collection channel and pass via the Washington Shore fishway. The FOGs at Powerhouse Two provide additional fishway entry points for migrating adult salmonids, but the installed gratings are sized to preclude pinniped entry. Temporary Sea Lion Incursion Barriers (SLIBs) were constructed for the purpose of providing additional height on top of the FOGs. We detail the chronology of installation and efficacy of these physical exclusion devices herein.

Management Activities

Pursuant to the Section 120 authorization of the Marine Mammal Protection Act issued to the States, and to facilitate detailed studies of pinniped population dynamics at BON, the USACE supported the States operation of floating pinniped traps in the tailrace and forebay of the dam. From these traps, alphanumeric “hot” brands were placed on otherwise non-branded CSL and SSL. The traps also serve to allow for lethal removal of CSL listed for removal. For specificity to state managers actions, we direct attention to the involved agencies for further details about sea lion management activities (e.g., http://www.dfw.state.or.us/fish/sealion/).

Appendix B. Sea lion exclusion device (SLED) at Bonneville Dam fishway entrance (A) and installed (B), floating orifice gate (FOG) (C), and sea lion incursion barriers on top of FOGs (D).

A.

B.

C.

D.