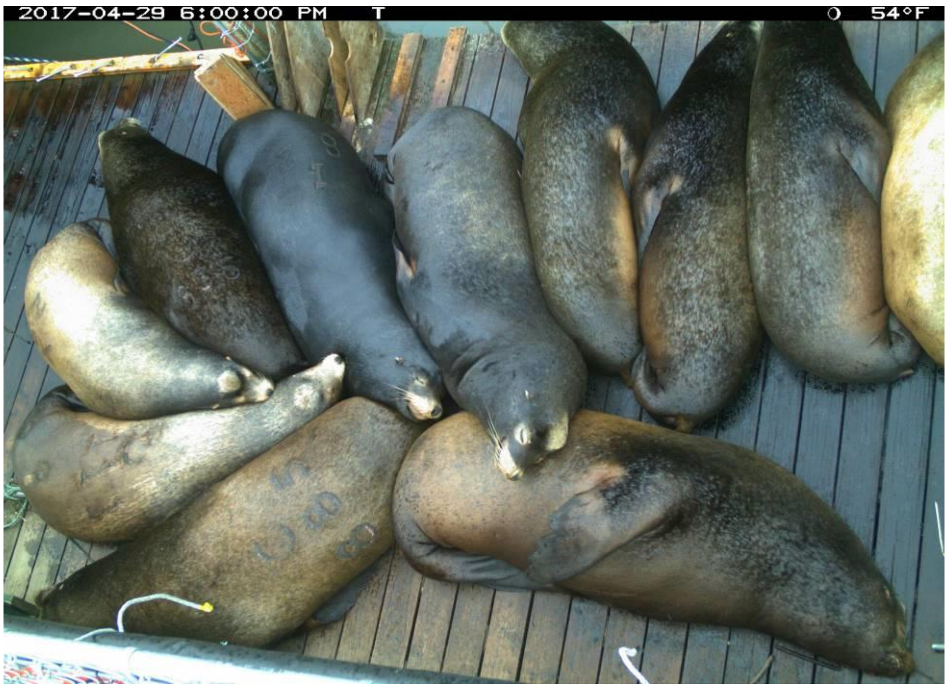
WILLAMETTE FALLS PINNIPED MONITORING PROJECT, 2017

November 7, 2017



California sea lions hauled out on docks by Sportcraft Landing, Oregon City

Oregon Department of Fish and Wildlife

Project staff: Bryan Wright, Tom Murtagh, Robin Brown, and Susan Riemer

Field crew: Clifford Owen and Theresa Tillson

TABLE OF CONTENTS

TABLE OF CONTENTS i

LIST OF FIGURES ii

LIST OF TABLES iii

LIST OF APPENDICES iv

INTRODUCTION 1

METHODS 2
Study area 2
Pinniped species accounts 2
Fish species accounts 2
Sampling design 3
Assignment of salmonid predation events to run 4
Pinniped abundance estimation 5
Scat and spew analysis 5
Trapping 6
Additional activities 6

RESULTS 6
Salmonid abundance and river conditions 6
Pinniped abundance 6
Predation 7
Salmonid predation by run 7
Scat and spew analysis 7
Trapping 8

DISCUSSION 8

LITERATURE CITED 10

LIST OF FIGURES

Figure 1. Illustration of the spatial component of the sampling frame for 2017. Sites 1-6 ("Falls" stratum) were each approximately 0.9-ha in area. 12

Figure 2. Illustration of spatial (left) and temporal (right) coverage of sampling frame by year. Red shaded areas depict time and area included in frame; dark black lines on the graph at right indicate sunrise and sunset, adjusted for daylight savings. 13

Figure 3. Daily fish counts at Willamette Falls by run and year. Vertical lines indicate study start and end dates; final run size is inset upper left of each graph (*counts through 9/30/2017). 14

Figure 4. Daily run composition at Willamette Falls by year. Vertical dashed lines indicate study dates. (2/29/16 not shown). 15

Figure 5. Willamette River height (a) and temperature (b) by year.......... 16

Figure 6. Weekly residency of branded California sea lions (n = 48 total) at Willamette Falls sorted by year and week of first detection (darker hue = more days detected). Capture location at branding denoted by 'A' (Astoria) or 'B' (Bonneville Dam); X denotes animal was removed under MMPA Section 120; * indicates animal documented at Bonneville Dam; ** indicates animal on MMPA Section 120 list for removal. Brands recorded less than three days per year were considered unconfirmed and are not included unless photographed. [Note that this graphic will be updated once image processing from automated cameras is competed.] 17

LIST OF TABLES

Table 1. Summary of all predation events observed below Willamette Falls from January 9 to June 11, 2017. Includes events from anecdotal observations as well as those seen during probability-based sampling assignments. 18

Table 2. Summary of estimated predation by California sea lions below Willamette Falls from January 9 to June 11, 2017 based on stratified, three-stage cluster sampling design. These estimates only apply to the sampling frame for 2017 depicted in Figure 2 and therefore are likely minimum estimates due to undercoverage of the target population. 19

Table 3. Estimated California sea lion predation on salmonids at Willamette Falls by run, 2017. These estimates only apply to the sampling frame for 2017 depicted in Figure 2 and therefore are likely minimum estimates due to undercoverage of the target population.. 20

Table 4. Scat (feces) and spew (regurgitation) analysis of 49 samples collected at Sportcraft Landing from 10/26/2016-4/24/2017.. 21

Table 5. Summary of California sea lion predation on salmonids extrapolated to river strata in 2017 based on relative amounts of predation observed between the two strata in 2014-2015. Note, however, that the 2014-2015 estimates themselves represent less temporal coverage than 2016-2017 (see Figures 1-3 and Appendix A). 22

LIST OF APPENDICES

Appendix A. Design data describing the Willamette Falls sea lion monitoring program, 2014-2017 23

Appendix B. Simplified example illustrating three-stage cluster sampling design. Each observed cell has a sampling weight of 3.38 or equivalently an inclusion probability of 0.30. The population estimate is the sum of the observations multiplied by their sampling weights. The estimator is unbiased over all possible samples. Variance, confidence interval, and CV are calculated using appropriate sampling formulas. 24

Appendix C. Estimated California sea lion predation on salmonids at Willamette Falls by run, 2014. These estimates only apply to the sampling frame for 2014 depicted in Figures 2 and 3 and therefore are likely minimum estimates due to undercoverage of the target population. 25

Appendix D. Estimated California sea lion predation on salmonids at Willamette Falls by run, 2015. These estimates only apply to the sampling frame for 2015 depicted in Figures 2 and 3 and therefore are likely minimum estimates due to undercoverage of the target population. 26

Appendix E. Estimated California sea lion predation on salmonids at Willamette Falls by run, 2016. These estimates only apply to the sampling frame for 2016 depicted in Figures 2 and 3 and therefore are likely minimum estimates due to undercoverage of the target population. 27

Appendix F. Known incursions into ladder leg one (LL1) fishway by California sea lions. Sea lions were documented going over and presumably through Sea Lion Excluder Device (SLED) (see images below). 28

INTRODUCTION

In 1972, the Marine Mammal Protection Act (MMPA) provided protection for all marine mammals in U.S. waters, ending centuries of exploitation for many species. As one result, the U.S. stock of California sea lions (*Zalophus californianus*) has increased steadily to the point that it is now likely within its optimum sustainable population range, thus meeting the conservation objective of the MMPA. Over this same period many salmon and steelhead (*Onchorynchus* spp.) populations in the Pacific Northwest experienced significant declines in abundance and were subsequently listed as threatened or endangered under the Endangered Species Act (ESA). These declines were initially and primarily the result of multiple factors unrelated to predation by pinnipeds but in areas where salmonid abundance is low and California sea lion numbers are now high, increased predation levels can result in serious negative impacts to the survival and recovery of individual salmonid populations.

One such area is Willamette Falls on the Willamette River, approximately 128 miles upstream from the Pacific Ocean. While the first known record of a California sea lion at Willamette was of a single animal in the 1950s (Beach et al. 1985), by the mid-1990s there were frequent observations of California sea lion foraging for winter steelhead and spring Chinook salmon below Willamette Falls (Oregon Department of Fish and Wildlife [ODFW], unpublished data). Concerned that Willamette Falls would become another "Ballard Locks"—a site in Washington where California sea lions effectively extirpated a run of steelhead (*Oncorhynchus mykiss*) (Fraker and Mate 1999)—ODFW began a predation monitoring program at Willamette Falls in 1995, as well as a California sea lion marking program at Astoria in 1997 to identify and track California sea lions in the Columbia River basin.

Intermittent predation monitoring at the falls by ODFW occurred from 1995-2003, after which the agency's limited resources shifted to Bonneville Dam on the Columbia River where California sea lion predation on salmonids began increasing significantly in the early 2000s (e.g., Keefer et al. 2012). Attention soon returned to Willamette Falls, however, as winter steelhead passage declined, coupled with an increase in sea lion activity. This combination led ODFW to conduct non-lethal hazing programs at the falls in 2010, 2011, and 2013 in an attempt to deter sea lions from consuming threatened winter steelhead near the fish ladder entrances. However, as had been seen elsewhere (e.g., see review in Scordino 2010), non-lethal deterrents had only limited and short-term effects as pinnipeds eventually adapted to or ignored them.

Hazing was discontinued after 2013 in order to shift limited resources to a rigorous monitoring effort (see Wright et al. 2014, 2015, 2016). Monitoring from 2014-2016 showed that California sea lion abundance had increased from the late 1990s and early 2000s and was continuing to increase annually. Similarly, California sea lion predation had increased and had become particularly acute for threatened winter steelhead populations. This report summarizes monitoring efforts for 2017. Due to limited staff time, however, this report will be less comprehensive than past reports; an updated version will be issued at a later date when image processing and additional analyses can be completed.

METHODS

Study area

The study area was located from Willamette Falls on the Willamette River, downstream to the mouth of the Clackamas River (Figure 1), although formal observations were only conducted in the immediate vicinity of the falls (i.e., sites 1-6). The falls are located 26 miles upriver from the confluence with the Columbia River and 128 miles from the ocean. It is the second largest waterfall in the United States by volume behind Niagara Falls (ECONorthwest 2014).

Pinniped species accounts

Three species of pinnipeds are known to occur seasonally at Willamette Falls: California sea lions, Steller sea lions (*Eumatopias jubatus*), and Pacific harbor seals (*Phoca vitualina*):

California sea lions—The total U.S. stock of California sea lions was recently estimated to number approximately 300,000 animals and is not listed as "endangered" or "threatened" under the Endangered Species Act (ESA), nor "depleted" or "strategic" under the Marine Mammal Protection Act (MMPA) (Caretta et al. 2017). The sub-adult and adult male component of the population—numbering perhaps 50,000-75,000—are seasonal migrants to the Pacific Northwest, arriving in August and departing in June each year on way their back and forth from the breeding grounds in southern California and Mexico (Odell 1981, Wright et al. 2010, Elorriaga-Verplancken et al. 2014).

Steller sea lions— Steller sea lions have been observed sporadically at the falls over the last decade, albeit more consistently in recent years. Steller sea lions in Oregon belong to the eastern Distinct Population Segment (DPS). The eastern DPS was delisted from ESA "threatened" status in 2013 but it remains classified as "depleted" under the MMPA and is therefore a "strategic" stock (Muto et al. 2016).

Harbor seals—Harbor seals, while abundant throughout coastal Oregon and the lower Columbia River, are relatively rare and inconspicuous visitors to upriver sites such as Willamette Falls.

Fish species accounts

Fish species preyed upon by pinnipeds at Willamette Falls include winter and summer steelhead, hatchery and wild spring Chinook salmon (*Oncorhynchus tschawytscha*), Pacific lamprey (*Entosphenus tridentatus*), and white sturgeon (*Acipenser transmontanus*). All of these species are of conservation or management concern and two—naturally spawning wild winter steelhead and wild spring Chinook salmon—are listed as "threatened" under the ESA.

Winter steelhead—All naturally produced winter-run steelhead populations in the Willamette River and its tributaries above Willamette Falls to the Calapoolia River are part of the ESA-listed Upper Willamette River (UWR) steelhead DPS (ODFW and National Marine Fisheries Service [NMFS] 2011, NMFS 2016). These fish pass Willamette Falls from November through May, co-occurring, to some extent, with introduced hatchery summer steelhead which pass the falls from March through October. While there is no directed fishery for winter-run steelhead in the upper Willamette River, hatchery origin summer steelhead are not ESA-listed and support popular recreational fisheries in the Santiam, McKenzie and Middle Willamette subbasins.

Spring Chinook salmon—All naturally produced populations of spring Chinook salmon in the Clackamas River and in the Willamette Basin upstream of Willamette Falls are part of the ESA-listed UWR Chinook salmon Evolutionary Significant Unit (ESU) (ODFW and NMFS 2011, NMFS 2016). These fish pass Willamette Falls from about April to August and co-occur with a more abundant run of hatchery-origin spring Chinook salmon. Hatchery-produced spring Chinook salmon support economically and culturally important fisheries in the lower Columbia and Willamette rivers, part of which takes place in the study area below Willamette Falls. Illegal take of unmarked fish is thought to be low and hooking mortalities are generally estimated to be 10 percent (NMFS 2016).

Migrating salmonids pass Willamette Falls by entering one of four entrances to three fishways through the falls. Video cameras and time lapsed video recorders are used to record fish passage which is later reviewed to produce passage counts. Salmonid species are partitioned to run (e.g., winter/summer, wild/hatchery) based on passage date and the presence or absence of a hatchery fin clip.

Sampling design

While pinnipeds can consume small prey underwater they usually must surface to manipulate and consume larger prey such as an adult salmonid (Roffe and Mate 1984). We utilized this aspect of their foraging behavior (i.e., surface-feeding), in conjunction with statistical sampling methods (e.g., Lohr 1999) to estimate the total number of adult salmonids consumed by sea lions over a spatio-temporal sampling frame.

The variable of interest was a surface-feeding event whereby a sea lion was observed to initiate the capture and/or consumption of prey within a given spatio-temporal observation unit. We included both predation on free swimming fish as well as depredation of hooked fish in the recreational fishery (collectively referred to as "predation" hereafter unless specifically noted). We assumed that the probability of detecting an event, given that it occurred, was one. Surface-feeding observations were conducted from shore by visually scanning a given area with unaided vision and with 10 x 42 binoculars. For each event, observers recorded the time, site, sea lion species, prey species, and whether the fish may have been taken from an angler. If prey appeared to escape without mortal wounds then the event was noted but not included in the tally used for estimation.

Observers followed a schedule of when and where to observe based on a probability sample generated from a three-stage cluster sampling design, with repeated systematic samples at each stage (see Figures 1-3 and Appendices A and B for descriptions of the design; see Lohr 1999 and Scheaffer et al. 1990 for background on sampling; see Wright et al. 2007 for implementation of this design elsewhere). The first stage or primary sampling units (PSUs) were "days of the week" (i.e., Sunday, Monday, etc.). The second stage or secondary sampling units (SSUs) were "site-shifts" within a day of the week (e.g., 0700-1530 at specified site(s)). The third stage or tertiary sampling units (TSUs) were 30-min observation bouts within a site-shift (i.e., three out of every four 30-min periods at a given site). Due to constraints imposed by work schedules (e.g., lunch breaks, days off), some deviations from a truly randomized design were unavoidable. However, since there is no reason to believe that sea lion foraging behavior should vary systematically with observer breaks or days off, then imposing some restrictions on randomization is unlikely to introduce bias into estimation.

The spatial component of the sampling frame consisted of six sites in a single stratum (Figure 1). This is identical to the 2016 study but in contrast to the 2014 and 2015 studies which had sites spread over two strata (Figure 2). The reduction in spatial coverage was due to funding constraints which reduced staffing from four to two observers. Sites 1-6 were each approximately 0.9 ha in area and occurred immediately below the falls where predation activity is typically greatest. The temporal component of the sampling frame increased in 2017, as it has every year of the study, and consisted of a subset of daylight hours, ranging from 0800-1630 (8.5 hours) on January 9 to 0600-1900 (13 hours) on June 11 (Figure 2).

There were 1,413 half-hour observation units (i.e., elements) in the sample out of a sampling frame of 21,000 units, resulting in an element-wise sampling fraction of 6.7%; the cluster-wise sampling fraction was 6.7% (120 clusters out of 1792; see Appendix A). The sampling weight was 14.93, meaning that each observed predation or depredation event represented itself and 13.93 additional unobserved events. Based on previous pilot testing of the design against simulated data it was anticipated that the total salmonid predation estimate would have a coefficient of variation (CV) of 10% or less (estimates with CVs over 33% are generally considered unreliable). Missing elements (e.g., due to holidays, missed assignments, etc.) were assumed to be missing-completely-at-random but imputed as zeros, which likely contributed to small negative bias in the predation estimates.

Assignment of salmonid predation events to run

Observed salmonid predation events were assigned to a run (i.e., summer/winter steelhead, wild/hatchery spring Chinook salmon) based on a combination of field observations, fishway window counts, and Monte Carlo methods. We did this using a two-step approach. In the first step, we either used observer identification of salmonids to species (if available) or we treated all salmonid as unknown regardless of whether they may have been identified in the field to species. In the second step, we assumed prey consumption was proportional to the run composition derived from window counts which we computed by pooling counts over 1, 7, or 14 days subsequent to an observed event (e.g., see Keefer et al. 2004).

As an example, if a steelhead was killed on Monday and the window count composition for steelhead on Tuesday was 50% winter steelhead and 50% summer steelhead, then the observed kill would be assigned to a run based on a metaphorical coin toss. For the case of "unknown" salmonids, if a salmonid was killed on Monday and the window count composition on Tuesday was 90% winter steelhead, 5% summer steelhead, 4% hatchery spring Chinook salmon, and 1% wild spring Chinook salmon, then the observed kill would be assigned to a run based on a metaphorical toss of a 100-sided die where 90 sides were winter steelhead, 5 were summer steelhead, etc.

Each of the six models was run 1000 times and the means were computed for run-specific total predation and associated measures of uncertainty. Predation relative to potential escapement was calculated for passage through September 30, 2017, which captures total escapement for all the runs except summer steelhead, which continue until October 31st. Rates were calculated as the estimated predation total divided by the sum of escapement and estimated predation.

Pinniped abundance estimation

It is generally not possible to obtain unbiased abundance estimates of pinnipeds since they do not all haul out together at the same time and they are often not uniquely identifiable. They also are capable of moving over a 100 km/d so local populations cannot be considered 'closed' for mark-recapture methods. While mark-resight models (e.g., McClintock and White 2012) hold some promise for this situation, we instead estimated pinniped abundance using an approach similar to the area-under-the-curve (AUC) method used to estimate salmonid escapement (e.g., see Parsons and Skalski 2010). In the AUC approach, the total number of individuals is estimated by dividing an estimate of total "animal-days" by an estimate of average "animal residency".

We estimated "California sea lion-days" as follows. First, observers recorded the number and species of pinnipeds in their viewing area at every half-hour during their shift. Second, pictures of pinnipeds hauled out downriver near Sportcraft Landing were taken every half-hour using automated cameras from which pinnipeds were later counted. Both counts were then added together (when appropriate) to obtain estimates for each half hour from which the maximum count was retained to represent the abundance for that day. The maximum daily count for each week was then retained to use as an estimate of weekly abundance. Lastly, a loess model was fit to the weekly maximums to obtain daily estimates of abundance for the entire study period.

We estimated average daily "California sea lion residency" based on observations of branded California sea lions. Given that observer effort varied each day (and was mostly absent on weekends) we could not estimate daily occurrence. We therefore estimated weekly occurrence which we then multiplied by 7 to obtain an estimate of daily occurrence. In order for a branded California sea lion to be considered resident for a given week, we required it to be observed on three or more days. More than three days (out of a typical 5-day work week) would likely be too restrictive given that detectability is less than one, and less than three days might risk including transient animals that were only in the area briefly and wouldn't be contributing significantly to the overall salmonid take.

Scat and spew analysis

We collected scat (fecal) and spew (vomitus) samples opportunistically prior to and throughout the study period from the haul out area at Sportcraft Landing (Figure 1). Samples were collected and processed following methodology described in Lance et al. (2001). Recovered hard parts were examined using a dissecting microscope and identified to lowest possible taxonomic level by comparing all identifiable prey remains (e.g., bones, otoliths, cartilaginous parts, lenses, teeth and cephalopod beaks) to a comparative reference.

Trapping

We built and installed a sea lion trap at the haul-out area at Sportcraft Landing at the end of October 2016. The objective of trapping during the 2016-2017 season was to conduct feasibility tests to see if animals would use the trap and, if so, to mark them and potentially transport them to another location. In the event of trapping animals that were authorized for permanent removal under the state's MMPA Section 120 from Bonneville Dam (see NMFS 2016b) those animals could be transferred for euthanizing or placement in permanent captivity; animals not on that list could be transported to the coast and released.

The trap consisted of a chain-link fence (7 x 9 ft), a transfer cage, and a squeeze cage, all mounted on a wood-decked barge (12 x 30 ft). The trap had two doors: one large vertically sliding door in the front wall, and one small vertically swinging door in the rear wall. The large front door was held open by electromagnet (but padlocked when not in operation), allowing sea lions to haul out on the trap floor. A variety of barriers and exclusion devices were installed on the docks around the trap to try and encourage use of the trap. Automated cameras were installed on and around the trap to provide 24-hr surveillance in order to document use by sea lions and deter trespassing by unauthorized people.

Additional activities

The sampling design in 2017 was implemented using a crew of two staff, working eight hours a day, five days a week. Due to the nature of random sampling, as well as limits on how long one can sustain intense concentration, not all hours of every day were devoted to conducting sample-based observations. Any time not needed for sample-based observations was used for administrative tasks (e.g., data entry), conducting anecdotal observations (e.g., targeting sites with high predation rates or potential for interactions with the fishery), conducting haul-out counts, collecting scat, and photographing brands.

RESULTS

Salmonid abundance and river conditions

Daily and total passage over Willamette Falls for salmon and steelhead is summarized in Figures 3 and 4. Winter and summer steelhead passage in 2017 were at record low levels and spring Chinook salmon passage was later than normal. River temperature and height during 2017 was colder and higher than the past two years (Figure 5) which may have contributed to the delay in spring Chinook salmon passage.

Pinniped abundance

Preliminary analysis of pinniped count and brand data suggest an increase in the total number of sea lions occurring at Willamette Falls over the previous three years of monitoring. While a full analysis is pending and will be reported at a later date, the draft single-day maximum count of California sea lions and Steller sea lions was 41 (on 4/28/2017) and 4 (on 3/28/2017), respectively. A total of 48 branded California sea lions have been documented at Willamette Falls over the 4-year study along with an unknown number of unbranded animals (Figure 6). Of the original 19 brands seen in 2014, six had returned every year through 2017. A total of 8 new brands were recorded in 2017. Fifty-four percent of all brands seen at Willamette Falls were of animals either branded at Bonneville Dam or had been observed there at least once. While formal monitoring didn't start until early January 2017, at least five brands (U117, C742, C885, U605, and U971) were observed at Willamette Falls throughout the fall of 2016 beginning as early as 9/12/2016.

Predation

Observers documented a total of 985 predation events over the course of the project (Table 1). This includes predation events seen at pre-assigned, probability-based observation units, as well as anecdotal observations. Salmonids were the most frequently observed prey item (83%) followed by lamprey (16%), and unknown or other fish (1%). California sea lions accounted for nearly all of the observed predation events (92%). Steller sea lions accounted for all 69 of the sturgeon killed as well as 1 steelhead and 5 unknown/other fish.

An estimated 2,673 salmonids were consumed by California sea lions within the sampling frame from January 9 to June 9, 2017 (Table 2). The only other prey for which sufficient observations were made for reliable estimation was lamprey, of which California sea lions consumed an estimated 747 individuals within the sampling frame. Since these estimates only apply to the sampling frame for 2017 depicted in Figure 2 they are therefore minimum estimates due to known spatial and temporal undercoverage of the target population.

Salmonid predation by run

Estimates of salmonid predation by run (winter/summer steelhead, wild/hatchery Chinook salmon) are presented in Table 3. Averaging across the six run assignment models yielded run-specific predation estimates of: 1,824 hatchery spring Chinook salmon (6% of potential escapement above falls), 399 wild spring Chinook salmon (6% of potential escapement), 181 summer steelhead (8% of potential escapement through 9/30/2017), and 270 winter steelhead (25% of potential escapement). For comparison, run-specific estimates for 2014-2016 are included in Appendices C-E. As noted before, these estimates only apply to the sampling frames depicted in Figures 2 and are therefore minimum estimates due to spatial and temporal undercoverage of the target population.

Scat and spew analysis

We collected a total of 35 scat and 14 spew samples from the Sportcraft Landing haul out area from 10/26/22016 to 4/24/2017 (Table 4). The two most common prey species were salmonids (occurring in 78% of samples) and lamprey (59% of samples), whereas juvenile salmonids (which can be consumed underwater) and other or unknown species only occurred in a few samples. Percentages do not add up to 100% since more than one prey can occur in each scat. Since Steller sea lions intermittently used the haul out area throughout the season we cannot rule out the possibility that some of the samples were from that species. However, given the differences in the relative abundance, haul-out behavior, and foraging behavior between the two species the samples are most likely from California sea lions.

Trapping

California sea lions were documented using the trap sporadically throughout the 2016-2017 season but never consistently enough nor predictably enough to justify a trapping attempt which requires staging multiple agency staff overnight for potentially multiple days in addition to scheduling state and local law enforcement personnel to be on standby to provide security. Exclusion barriers designed to deny access to the preferred haul-out—and encourage use of the trap—appeared to be initially effective but were soon destroyed, presumably by the larger and much heavier Steller sea lions that also hauled out in the same area.

DISCUSSION

Design-based predation estimates (i.e., Table 2) were based solely on sampling units from the three-stage cluster sampling design and do not include anecdotal observations. The 95% confidence intervals reflect the sampling error in the estimates, which arises from taking a sample rather than a census of the population. A different sample would have produced a different estimate and confidence interval, but 95 times out of 100 the procedure will correctly capture the true population total within the interval. Non-sampling errors, however, are often a greater source of uncertainty than sampling errors. In this study, the non-sampling error of greatest concern is likely that of undercoverage (see Figure 2 and Appendix A for design details).

As in previous years, spatial and temporal undercoverage in our sampling frame likely resulted in our estimates of predation being biased low. Spatial undercoverage occurred because, as in 2016, we only had sufficient staffing to cover the "falls" strata whereas we know predation occurs in the "river" strata. In 2014 and 2015, approximately 40% of the total estimated predation occurred in the river strata (see Wright et al. 2014 and 2015). If we assume that the relative amounts of predation seen in 2014 and 2015 also occurred in 2017 then the estimated total predation for this year would be 4,288 salmonids (Table 5). Temporal undercoverage was also evident based our observations of sea lions throughout the fall and by the observations of a local citizen who reported that at least 30 steelhead, 3 coho salmon, and 5 white sturgeon were predated by sea lions in just one section of the river from 10/21/2016 through 1/2/2017.

There were two additional sources of spatial undercoverage in 2017 that were likely not issues in previous years. First, we received many reports this year from anglers and ODFW staff of sea lions foraging far up the Clackamas River, up to at least 15 miles from the confluence with the Willamette. While we had observed sea lions in previous years occasionally foraging in the lower Clackamas River, this was the first year we received so many reports of foraging sea lions so far and so often upriver. This was likely the result of sea lions having to hunt over a wider geographic area in 2017 due to record low runs of winter and summer steelhead as well as delayed arrival of spring Chinook salmon (see Figure 3).

A second source of potentially significant spatial undercoverage in 2017 that was foraging by multiple sea lions inside the ladder leg 1 (LL1) fishway. In 2015, a California sea lion branded U278 was documented making multiple incursions inside ladder leg 2, presumably entering by climbing over the Sea Lion Excluder Device (SLED) during high flows. That SLED was repaired and has not been breached again as far as we know. However, in 2017 U278 and at least two other California sea lions were periodically observed inside LL1 (Appendix F). Sea lions gained entry during high flows by going over the top of the SLED but they were also inexplicitly observed inside during lower flows when it would have been impossible to go over the SLED. It was only during an inspection during summer low water that a broken vertical bar in the SLED was discovered thus revealing how the sea lions gained entry. This SLED underwent replacement in October 2017.

In conclusion, the results of the past four years of pinniped abundance and predation monitoring at Willamette Falls suggests that the problem of California sea lions taking listed salmonids below the falls is significant. While the absolute number of fish taken by sea lions appeared to decrease in 2017 over previous years, there may have also been significantly more undercoverage due to sea lions having to forage more frequently away from Willamette Falls in order to find adequate prey. Nonetheless, due to the record low run sizes, the proportion of some runs taken in 2017 were significantly higher than in previous years, most notably for threatened winter steelhead.

LITERATURE CITED

Beach, R. J., A. C. Geiger, S. J. Jeffries, S. D. Treacy, and B. L. Troutman. 1985. Marine mammals and their interactions with fisheries of the Columbia River and adjacent waters, 1980-1982. NMFS-AFSC Processed Report 8504. 316 p.

Carretta, J. V., et al. 2017. U.S. Pacific Marine Mammal Stock Assessments: 2016. NOAA-TM-NMFS-SWFSC-577. 407 pp.

ECONorthwest. 2014. Willamette Locks economic potential report. Portland, OR. http://www.econw.com/media/ap_files/V3.LocksReport.pdf (last accessed 2016-09-08).

Elorriaga-Verplancken, F. R., M. T. Tennis, and R. F. Brown. 2014. Unprecedented resighting in Mexico of a male California Sea Lion (*Zalophus californianus*) from Oregon during the 2014 breeding season. Aquatic Mammals 40:364-367.

Fraker, M. A., and B. R. Mate. 1999. Seals, sea lions, and salmon in the Pacific Northwest. Pages 156-178 *in* J. R. Twiss Jr. and R. R. Reeves, editors. Conservation and management of marine mammals. Smithsonian Institution Press, Washington, D.C., USA.

Keefer, M. L., C. A. Peery, T. C. Bjornn, M. A. Jepson, and L. C. Stuehrenberg. 2004. Hydrosystem, dam, and reservoir passage rates of adult Chinook salmon and steelhead in the Columbia and Snake Rivers. Transactions of the American Fisheries Society, 133:1413-1439.

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

Lance, M. M., A. J. Orr, S. D. Riemer, M. J. Weise, and J. L. Laake. 2001. Pinniped food habits and prey identifica¬tion techniques protocol. AFSC (Alaska Fisheries Science Center) Proc. Rep. 2001-04, 36 p. Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

Lohr, S. 1999. Sampling: Design and Analysis, Duxbury. 494 p.

McClintock, B. T. and G. C. White. 2012. From NOREMARK to MARK: software for estimating demographic parameters using mark-resight methodology. Journal of Ornithology 152(2):641-650.

Muto, M. M., V. T. Helker, R. P. Angliss, B. A. Allen, P. L. Boveng, J. M. Breiwick, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, R. G. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2016. Alaska Marine Mammal Stock Assessments: 2015. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-AFSC-323. 300 p.

Naughton, G. P., M. L. Keefer, T. S. Clabough, M. A. Jepson, S. R. Lee, C. A. Peery, and C. C. Caudill. 2011. Influence of pinniped-caused injuries on the survival of adult Chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Oncorhynchus mykiss) in the Columbia River basin. Canadian Journal of Fisheries and Aquatic Sciences 68:1615–1624.

National Marine Fisheries Service (NMFS). 2016. 2016 5-year review: summary and evaluation of upper Willamette River steelhead, upper Willamette River Chinook. http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/salmon_steelhead/2016/2016_upper-willamette.pdf (last accessed 2016-09-15).

National Marine Fisheries Service (NMFS). 2016b. Marine Mammals; Pinniped Removal Authority; Approval of Application. Federal Register 81:44298-44299.

Odell, D. K. 1981. California sea lion, *Zalophus californianus* (Lesson, 1828). Pages 67-97 *in* S.H. Ridgeway and R.J. Harrison, editors. Handbook of Marine Mammals, Volume 1: The Walrus, Sea Lions, Fur Seals, and Sea Otter. Academic Press, London, England.

Oregon Department of Fish and Wildlife (ODFW) and National Marine Fisheries Service (NMFS) Northwest Region. 2011. Upper Willamette River Conservation and Recovery Plan for Chinook salmon and Steelhead.

Parsons, A. L. and J. R. Skalski. 2010. Quantitative Assessment of Salmonid Escapement Techniques. Reviews in Fisheries Science. 18:301-314.

Roffe, T. J., and B. R. Mate. 1984. Abundances and feeding habits of pinnipeds in the Rogue River, Oregon. Journal of Wildlife Management 48:1262-1274.

Scordino, J. 2010. West coast pinniped program investigations on California sea lion and Pacific harbor seal impacts on salmonids and other fishery resources. Pacific States Marine Fisheries Commission. 205 SE Spokane Street, Suite 100, Portland, OR 97202.

Wright, B. E., S. D. Riemer, R. F. Brown, A. M. Ougzin, and K. A. Bucklin. 2007. Assessment of harbor seal predation on adult salmonids in a Pacific Northwest estuary. Ecological Applications 17:338–351.

Wright, B. E., M. J. Tennis, and R. F. Brown. 2010. Movements of male California sea lions captured in the Columbia River. Northwest Science 84:60–72.

Wright, B. E., T. Murtagh, and R. F. Brown. 2014. Willamette Falls pinniped monitoring project, 2014. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Wright, B. E., T. Murtagh, and R. F. Brown. 2015. Willamette Falls pinniped monitoring project, 2015. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Wright, B. E., T. Murtagh, and R. F. Brown. 2016. Willamette Falls pinniped monitoring project, 2016. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

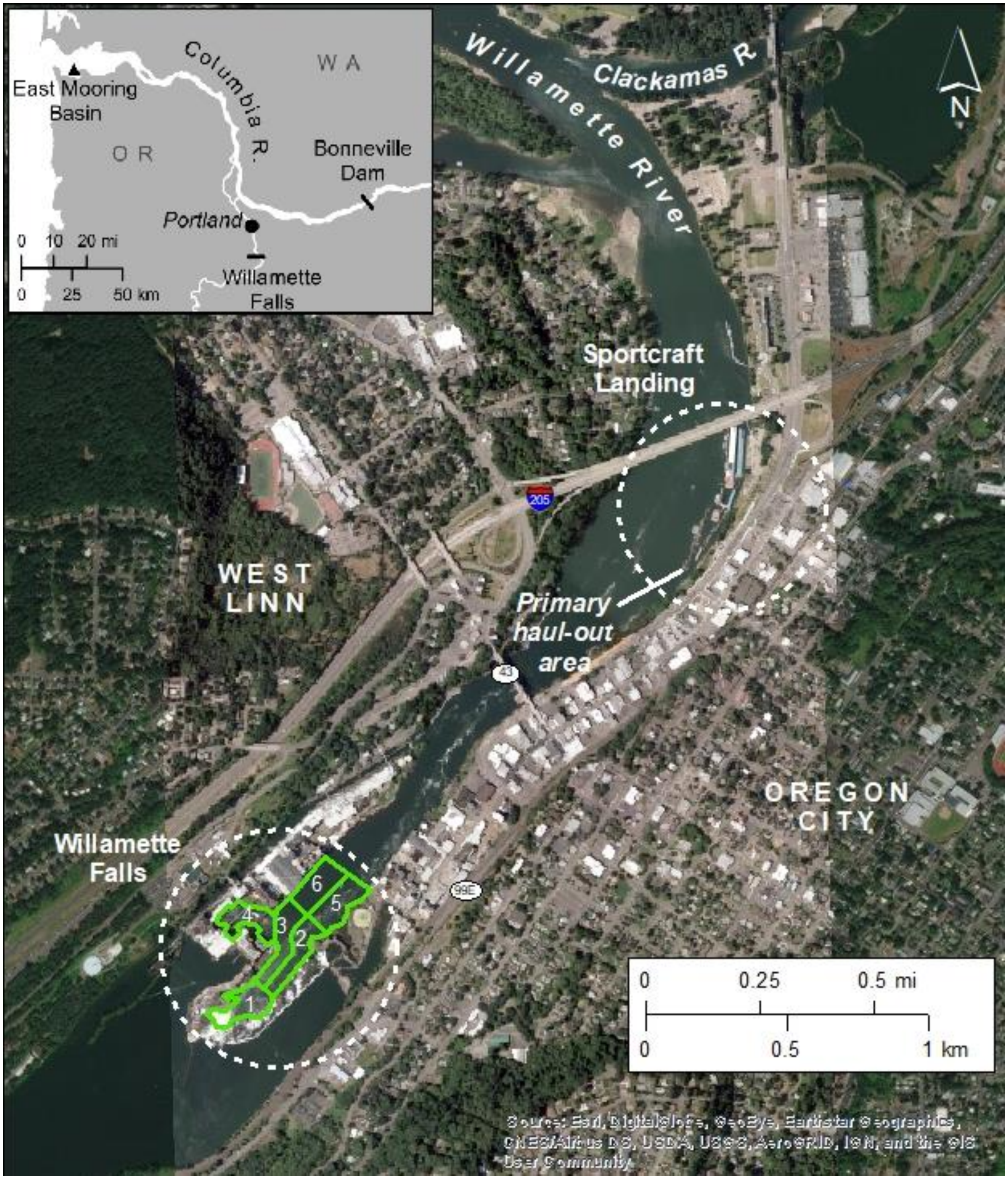


Figure 1. Illustration of the spatial component of the sampling frame for 2017. Sites 1-6 ("Falls" stratum) were each approximately 0.9-ha in area.

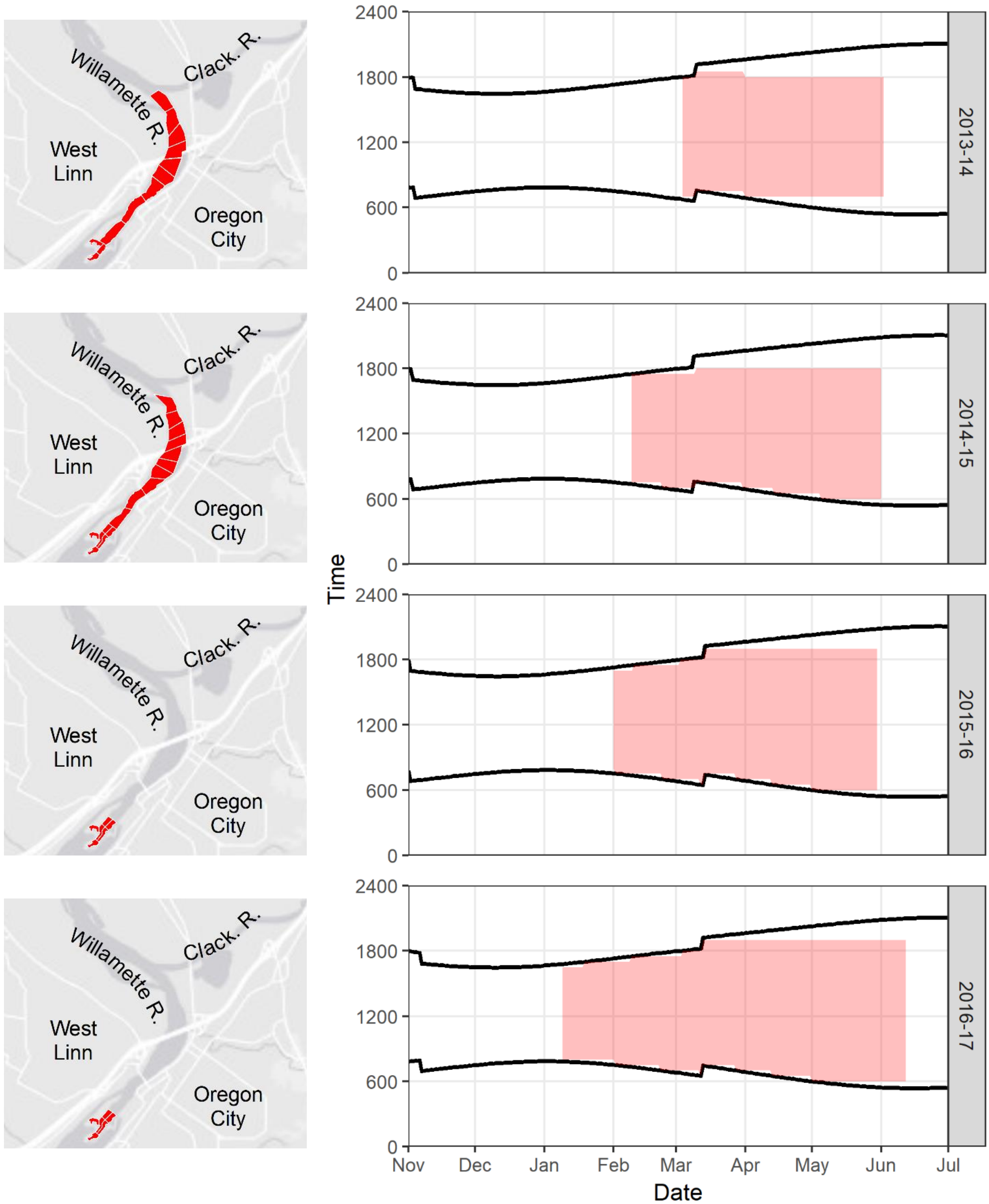


Figure 2. Illustration of spatial (left) and temporal (right) coverage of sampling frame by year. Red shaded areas depict time and area included in frame; dark black lines on the graph at right indicate sunrise and sunset, adjusted for daylight savings.

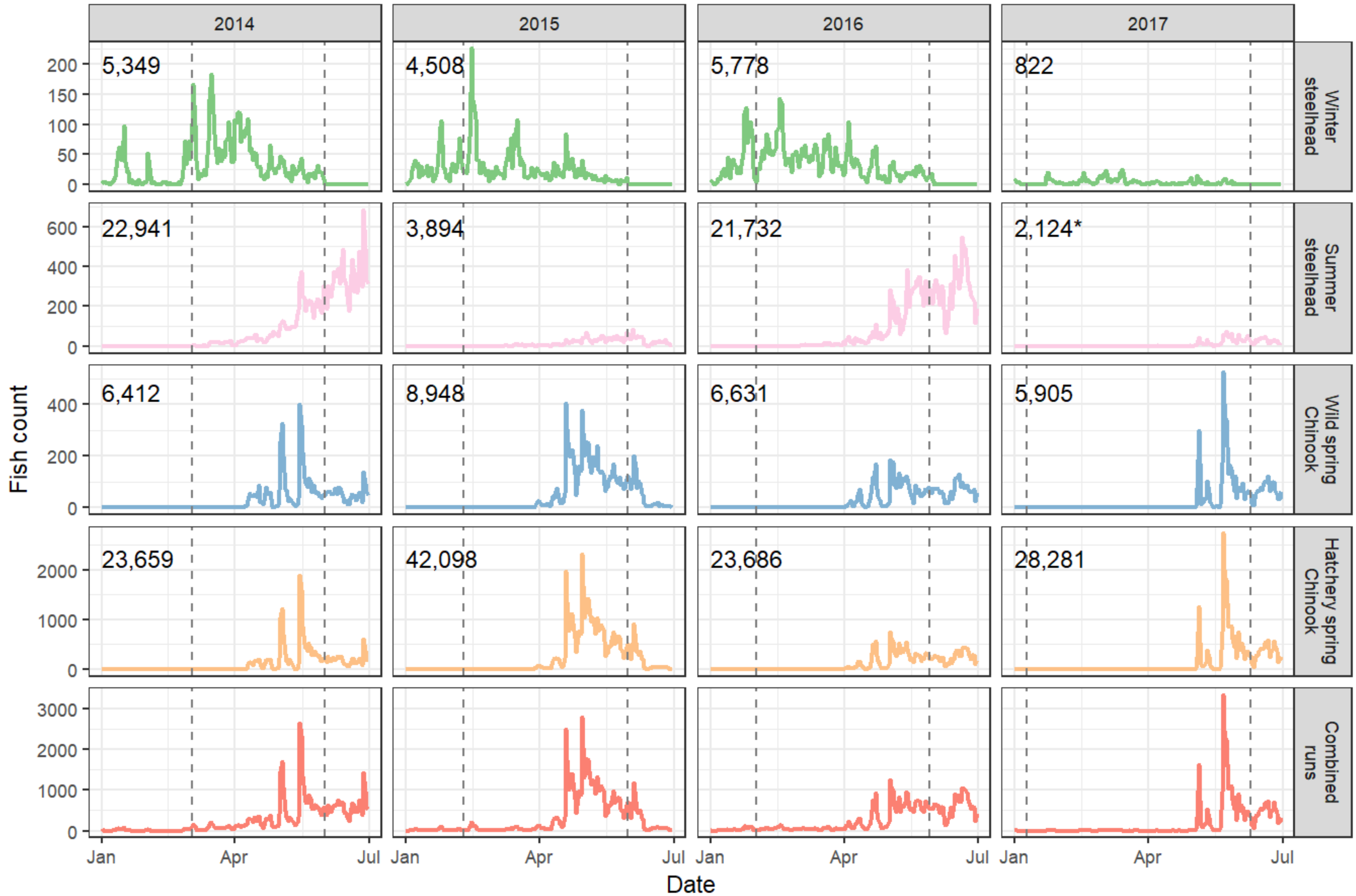


Figure 3. Daily fish counts at Willamette Falls by run and year. Vertical lines indicate study start and end dates; final run size is inset upper left of each graph (*counts through 9/30/2017).

Figure 4. Daily run composition at Willamette Falls by year. Vertical dashed lines indicate study dates. (2/29/16 not shown).

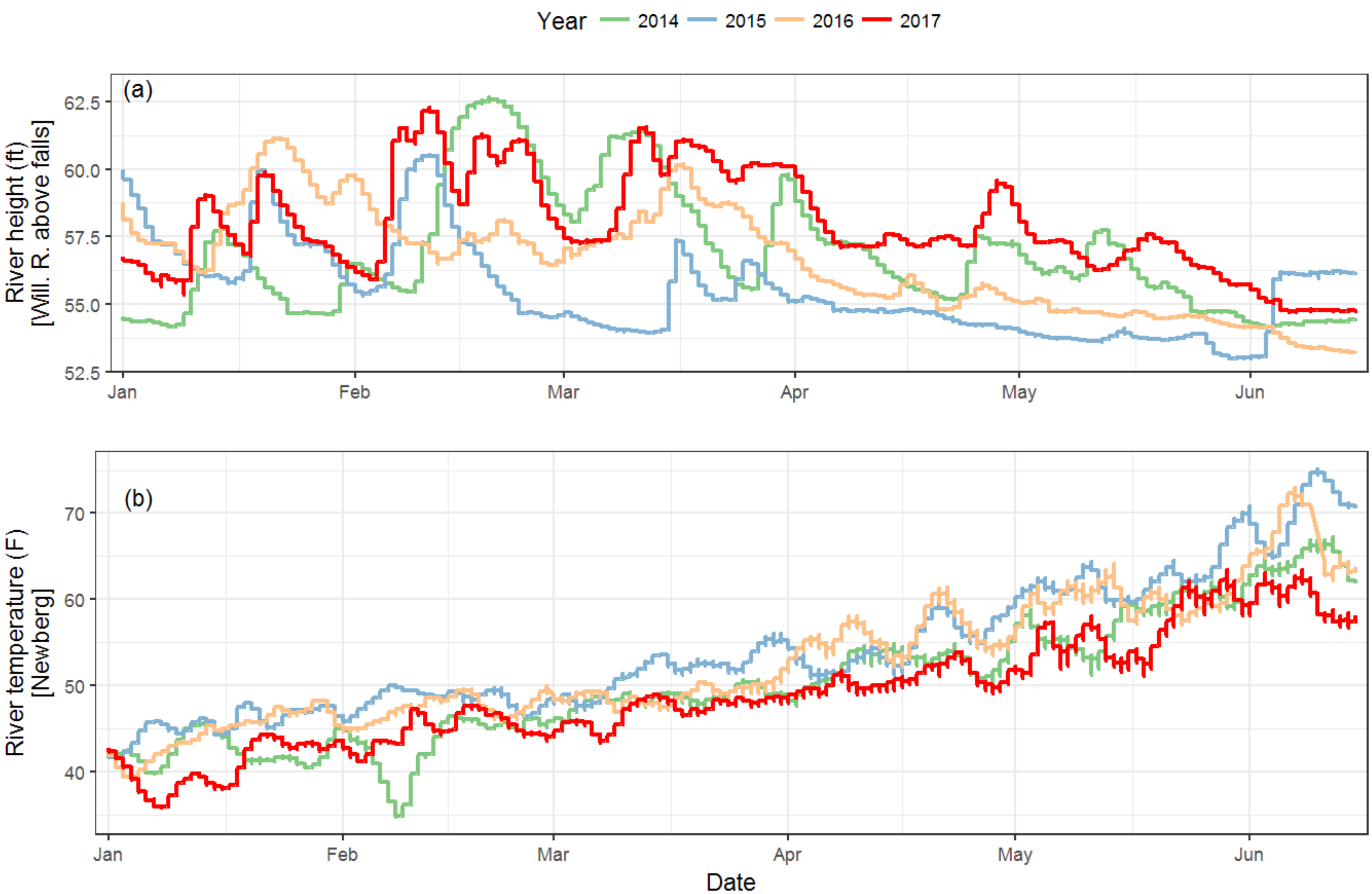


Figure 5. Willamette River height (a) and temperature (b) by year.

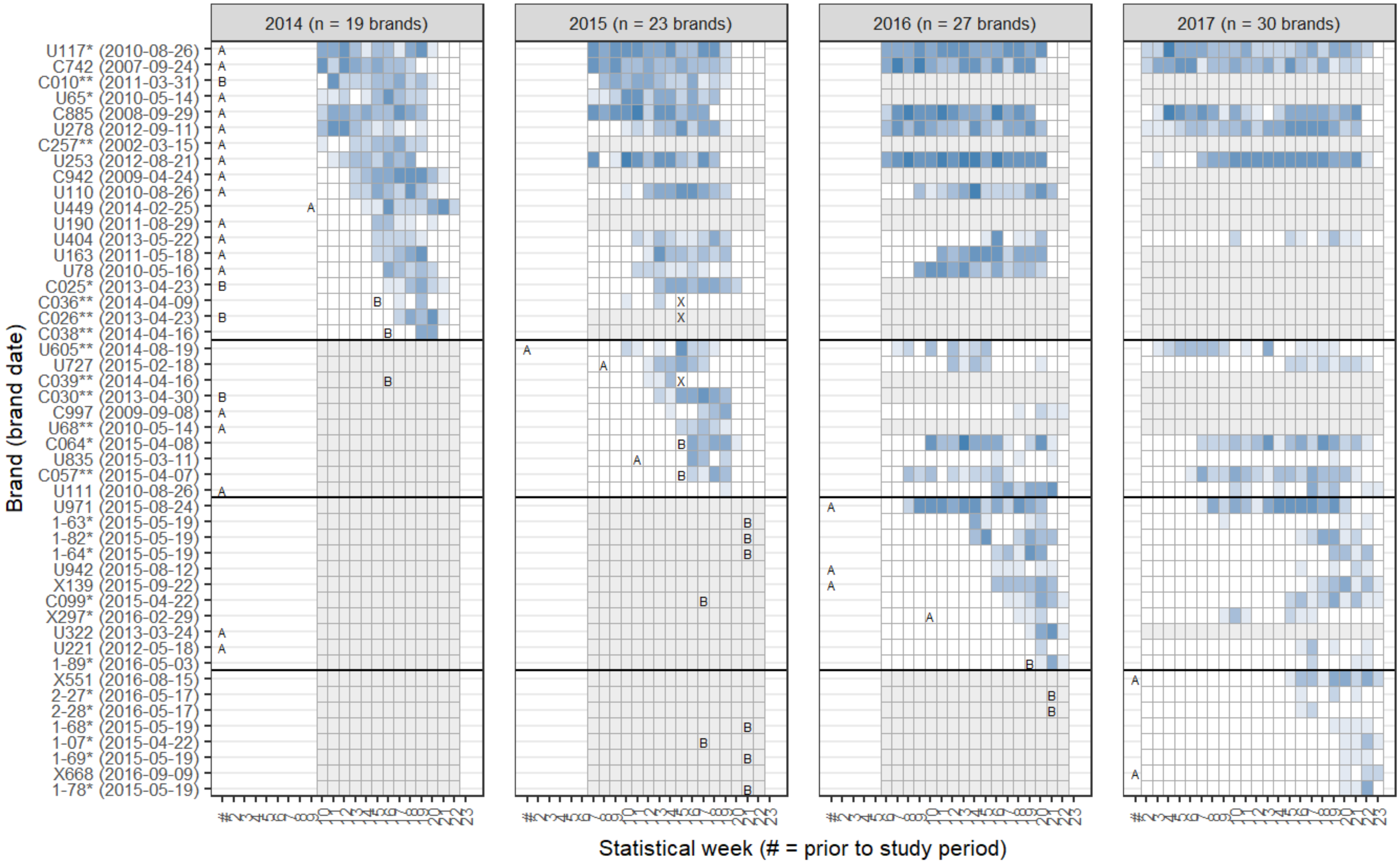


Figure 6. Weekly residency of branded California sea lions (n = 48 total) at Willamette Falls sorted by year and week of first detection (darker hue = more days detected). Capture location at branding denoted by 'A' (Astoria) or 'B' (Bonneville Dam); X denotes animal was removed under MMPA Section 120; * indicates animal documented at Bonneville Dam; ** indicates animal on MMPA Section 120 list for removal. Brands recorded less than three days per year were considered unconfirmed and are not included unless photographed. [Note that this graphic will be updated once image processing from automated cameras is competed.]

Table 1. Summary of all predation events observed below Willamette Falls from January 9 to June 11, 2017. Includes events from anecdotal observations as well as those seen during probability-based sampling assignments.

Prey	California sea lion	Steller sea lion	Total
Chinook salmon	393	0	393
Unknown salmonid	221	0	221
Steelhead	139	1	140
Lamprey	145	0	145
Unknown/other fish	12	5	17
Sturgeon	0	69	69
Total	910	75	985

Table 2. Summary of estimated predation by California sea lions below Willamette Falls from January 9 to June 11, 2017 based on stratified, three-stage cluster sampling design. These estimates only apply to the sampling frame for 2017 depicted in Figure 2 and therefore are likely minimum estimates due to undercoverage of the target population.

Prey*	Observed total	Estimated total	Standard error	Coefficient of variation	95% confidence interval	
					Lower bound	Upper bound
Salmonids	179	2,673	518	0.19	1,658	3,688
Lamprey	50	747	169	0.23	415	1078

*All prey taken by California sea lions.

Table 3. Estimated California sea lion predation on salmonids at Willamette Falls by run, 2017. These estimates only apply to the sampling frame for 2017 depicted in Figure 2 and therefore are likely minimum estimates due to undercoverage of the target population.

Escapement over falls	Run assignment model	Pooled lag-days	Estimated predation (means from 1000 simulations)					% of potential escapement**		
			Total	SE	CV	95% CI LB	95% CI UB	Total	95% CI LB	95% CI UB
Hatchery spring Chinook salmon (28,281	Window count only	1	1724	358	0.21	1022	2426	6%	3%	8%
		7	1757	360	0.20	1052	2462	6%	4%	8%
		14	1885	402	0.21	1098	2672	6%	4%	9%
	Observer ID then window count	1	1814	394	0.22	1042	2586	6%	4%	8%
		7	1870	402	0.22	1081	2658	6%	4%	9%
		14	1893	414	0.22	1082	2705	6%	4%	9%
	Mean		1824	388	0.21	1063	2585	6%	4%	8%
Wild spring Chinook salmon (5,905)	Window count only	1	402	103	0.26	200	604	6%	3%	9%
		7	381	97	0.26	190	572	6%	3%	9%
		14	385	98	0.26	193	576	6%	3%	9%
	Observer ID then window count	1	445	116	0.26	218	671	7%	4%	10%
		7	398	106	0.27	190	606	6%	3%	9%
		14	383	100	0.26	188	579	6%	3%	9%
	Mean		399	103	0.26	196	601	6%	3%	9%
Summer steelhead (2,124*)	Window count only	1	208	68	0.33	75	341	9*%	3*%	14*%
		7	243	78	0.33	89	396	10*%	4*%	16*%
		14	173	53	0.32	68	277	8*%	3*%	12*%
	Observer ID then window count	1	134	47	0.36	41	227	6*%	2*%	10*%
		7	163	48	0.30	68	257	7*%	3*%	11*%
		14	166	50	0.30	68	264	7*%	3*%	12*%
	Mean		181	57	0.32	68	294	8*%	3*%	12*%
Winter steelhead (822)	Window count only	1	339	78	0.23	186	493	29%	18%	37%
		7	293	73	0.25	150	435	26%	15%	35%
		14	231	55	0.24	122	339	22%	13%	29%
	Observer ID then window count	1	281	55	0.20	172	389	25%	17%	32%
		7	243	57	0.24	131	355	23%	14%	30%
		14	231	56	0.24	122	340	22%	13%	29%
	Mean		270	62	0.23	147	392	25%	15%	32%

*Through 9/30/2017 (run ends 10/31/2017).

** Equals estimate / (estimate + escapement)

Table 4. Scat (feces) and spew (regurgitation) analysis of 49 samples collected at Sportcraft Landing from 10/26/2016-4/24/2017.

Date	Scat	Spew	Salmonid, non-juvenile	Lamprey spp.*	Salmonid, Juvenile	Unknown/ other
10/26/2016	1		1	1		
12/1/2016	1	1	2	1		
12/13/2016	1		1			
1/19/2017	2		2			1 (mackerel)
1/24/2017	2		2	1		
1/26/2017	2		2	1		
2/1/2017	7		7	3	1	
2/2/2017	4		4			
2/10/2017	2		2	2		
2/16/2017	1		1	1		
2/24/2017	1		1			
3/1/2017	2		2	2		
3/15/2017	4		4	3		1 (unknown)
3/31/2017	4	1	5	2	1	
4/4/2017	1	1	1	1		1 (rockfish)
4/14/2017		9		9		
4/24/2017		2	1	2		
Total (%)	35	14	38 (78%)	29 (59%)	2 (4%)	3 (6%)

*Primarily Pacific lamprey but also other lamprey remains that could not be identified to the species level.

Table 5. Summary of California sea lion predation on salmonids extrapolated to river strata in 2017 based on relative amounts of predation observed between the two strata in 2014-2015. Note, however, that the 2014-2015 estimates themselves represent less temporal coverage than 2016-2017 (see Figures 1-3 and Appendix A).

Year	Stratum	Estimated California sea lion salmonid take	% California sea lion salmonid take	Site-adjusted % California sea lion salmonid take
2014	Falls	1,842	50%	60%
	River	1,848	50%	40%
		3,690	100%	100%
2015	Falls	3,620	63%	
	River	2,156	37%	
		5,775	100%	
2016	Falls	4,585		
	River	*2,870**		
		*7,455**		
2017	Falls	2,673		
	River	*1,615**		
		*4,288**		

*Extrapolations based on 2014 and 2015 estimates.

Appendix A. Design data describing the Willamette Falls sea lion monitoring program, 2014-2017.

Year	Stratum	Sites	Staff	Dates	Weeks	Hours	*N* PSUs	*M* SSUs	*K* TSUs	Frame clusters	*n* PSUs	*m* SSUs	*k* TSUs	Sample clusters	Sampling fraction	Weight	Frame elements	Sample elements	Elements per cluster	Missed elements
2014	F	3	2	Mar 3-Jun 1	13	1,001	7	7	16	784	5	2	12	120	15.3%	6.53	6,006	929	7.66	
	R	9	2	Mar 3-Jun 1	13	1,001	7	20	16	2,240	5	2	12	120	5.4%	18.67	18,018	966	8.04	
			4							3,024				240	7.9%		24,024	1,895		89
2015	F	6	2	Feb 9-May 31	16	1,239	7	14	16	1,568	5	2	12	120	7.7%	13.07	14,868	1,101	9.48	
	R	10	2	Feb 9-May 24	15	1,155	7	22	16	2,464	5	2	12	120	4.9%	20.53	23,100	1,122	9.37	
			4							4,032				240	6.0%		37,968	2,223		53
2016	F	6	2	Feb 1-May 29	17	1,389	7	16	16	1,792	5	2	12	120	6.7%	14.93	16,668	1,114	9.30	45
2017	F	6	2	Jan 9-Jun 9	22	1,750	7	16	16	1,792	5	2	12	120	6.7%	14.93	21,000	1,413	11.71	61

Appendix B. Simplified example illustrating three-stage cluster sampling design. Each observed cell has a sampling weight of 3.38 or equivalently an inclusion probability of 0.30. The population estimate is the sum of the observations multiplied by their sampling weights. The estimator is unbiased over all possible samples. Variance, confidence interval, and CV are calculated using appropriate sampling formulas.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1		1st stage				2nd stage				3rd stage							
2		Primary sampling units (PSUs)				Secondary sampling units (SSUs)				Tertiary sampling units (TSUs)				Observed samples - y			
3		0	0	0		0	0	0		0	0	0		0		0	
4		0	0	1		0	0	1									
5		3	3	0		3	3	0		3	3	0		3	3		
6																	
7		1	1	2		1	1	2		1	1	2			1	2	
8		1	1	3		1	1	3		1	1	3		1		3	
9		3	3	3		3	3	3									
10										Cells within rows							
11		2	3	0		Rows within tables				K	3						
12		1	2	3		M	3			k	2						
13		0	1	2		m	2							SUM(N3:P8)	13	sum y	
14														(C15/C16)*(G11/G12)*(K10/K11)	3.38	sampling weight	
15		Tables												1/O14	0.30	inclusoin probability	
16		N	3														
17		n	2											O13*O14	43.9	population total estimate	
18														SUM(B3:D13)	39	true population total	
19														O17-O18	4.9	difference	

Appendix C. Estimated California sea lion predation on salmonids at Willamette Falls by run, 2014. These estimates only apply to the sampling frame for 2014 depicted in Figures 2 and 3 and therefore are likely minimum estimates due to undercoverage of the target population.

Run (escapement)	Run assignment model	Pooled lag-days	Estimated predation (means from 1000 simulations)					% of potential escapement		
			Total	SE	CV	95% CI LB	95% CI UB	Total	95% CI LB	95% CI UB
Hatchery spring Chinook salmon (23,659)	Window count only	1	1,534	168	0.11	(1,204	1,864)	6%	(5%	7%)
		7	1,650	148	0.09	(1,359	1,941)	7%	(5%	8%)
		14	1,730	139	0.08	(1,457	2,003)	7%	(6%	8%)
	Observer ID then window count	1	1,758	149	0.08	(1,467	2,050)	7%	(6%	8%)
		7	1,760	141	0.08	(1,483	2,037)	7%	(6%	8%)
		14	1,783	143	0.08	(1,502	2,063)	7%	(6%	8%)
	Mean		1,703			(1,412	1,993)	7%	(6%	8%)
Wild spring Chinook salmon (6,412)	Window count only	1	450	74	0.16	(305	594)	7%	(5%	8%)
		7	480	74	0.16	(336	625)	7%	(5%	9%)
		14	485	73	0.15	(342	628)	7%	(5%	9%)
	Observer ID then window count	1	529	77	0.15	(378	679)	8%	(6%	10%)
		7	526	78	0.15	(374	678)	8%	(6%	10%)
		14	505	75	0.15	(357	652)	7%	(5%	9%)
	Mean		496			(349	643)	7%	(5%	9%)
Summer steelhead (22,941)	Window count only	1	794	98	0.12	(602	987)	3%	(3%	4%)
		7	751	88	0.12	(578	924)	3%	(2%	4%)
		14	747	92	0.12	(567	927)	3%	(2%	4%)
	Observer ID then window count	1	621	114	0.18	(399	844)	3%	(2%	4%)
		7	656	124	0.19	(413	899)	3%	(2%	4%)
		14	701	130	0.19	(447	955)	3%	(2%	4%)
	Mean		712			(501	923)	3%	(2%	4%)
Winter steelhead (5,349)	Window count only	1	912	130	0.14	(657	1167)	15%	(11%	18%)
		7	810	114	0.14	(587	1032)	13%	(10%	16%)
		14	728	110	0.15	(512	944)	12%	(9%	15%)
	Observer ID then window count	1	782	105	0.13	(576	988)	13%	(10%	16%)
		7	748	106	0.14	(541	956)	12%	(9%	15%)
		14	702	103	0.15	(500	903)	12%	(9%	14%)
	Mean		780			(562	998)	13%	(10%	16%)

Appendix D. Estimated California sea lion predation on salmonids at Willamette Falls by run, 2015. These estimates only apply to the sampling frame for 2015 depicted in Figures 2 and 3 and therefore are likely minimum estimates due to undercoverage of the target population.

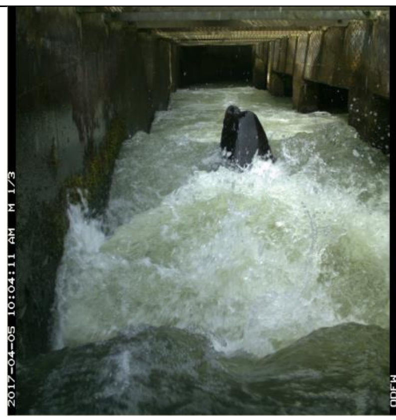
Run (escapement)	Run assignment model	Pooled lag-days	Estimated predation (means from 1000 simulations)					% of potential escapement		
			Total	SE	CV	95% CI LB	95% CI UB	Total	95% CI LB	95% CI UB
Hatchery spring Chinook salmon (42,098)	Window count only	1	3,885	271	0.07	(3,354	4,415)	8%	(7%	9%)
		7	4,058	279	0.07	(3,511	4,605)	9%	(8%	10%)
		14	4,217	287	0.07	(3,654	4,779)	9%	(8%	10%)
	Observer ID then window count	1	4,174	276	0.07	(3,633	4,716)	9%	(8%	10%)
		7	4,237	280	0.07	(3,688	4,787)	9%	(8%	10%)
		14	4,324	284	0.07	(3,768	4,879)	9%	(8%	10%)
	Mean		4,149			(3,601	4,697)	9%	(8%	10%)
Wild spring Chinook salmon (8,948)	Window count only	1	876	119	0.14	(643	1,109)	9%	(7%	11%)
		7	871	114	0.13	(647	1,095)	9%	(7%	11%)
		14	859	113	0.13	(638	1,081)	9%	(7%	11%)
	Observer ID then window count	1	954	126	0.13	(708	1,200)	10%	(7%	12%)
		7	941	119	0.13	(707	1,175)	10%	(7%	12%)
		14	891	116	0.13	(664	1,119)	9%	(7%	11%)
	Mean		899			(668	1,130)	9%	(7%	11%)
Summer steelhead (3,894)	Window count only	1	230	58	0.26	(117	343)	6%	(3%	8%)
		7	201	54	0.28	(95	307)	5%	(2%	7%)
		14	188	51	0.28	(87	289)	5%	(2%	7%)
	Observer ID then window count	1	146	47	0.33	(54	238)	4%	(1%	6%)
		7	130	45	0.36	(42	217)	3%	(1%	5%)
		14	134	45	0.35	(46	222)	3%	(1%	5%)
	Mean		172			(74	269)	4%	(2%	6%)
Winter steelhead (4,508)	Window count only	1	785	112	0.14	(565	1,005)	15%	(11%	18%)
		7	645	98	0.15	(453	838)	13%	(9%	16%)
		14	512	87	0.17	(341	682)	10%	(7%	13%)
	Observer ID then window count	1	502	99	0.20	(308	695)	10%	(6%	13%)
		7	468	97	0.21	(279	657)	9%	(6%	13%)
		14	427	93	0.22	(244	609)	9%	(5%	12%)
	Mean		557			(365	748)	11%	(7%	14%)

Appendix E. Estimated California sea lion predation on salmonids at Willamette Falls by run, 2016. These estimates only apply to the sampling frame for 2016 depicted in Figures 2 and 3 and therefore are likely minimum estimates due to undercoverage of the target population.

Run (escapement)	Run assignment model	Pooled lag-days	Estimated predation (means from 1000 simulations)					% of potential escapement		
			Total	SE	CV	95% CI LB	95% CI UB	Total	95% CI LB	95% CI UB
Hatchery spring Chinook salmon (23,686)	Window count only	1	1,852	232	0.13	(1,398	2,306)	7%	(6%	9%)
		7	1,975	227	0.11	(1,530	2,419)	8%	(6%	9%)
		14	2,013	231	0.11	(1,560	2,466)	8%	(6%	9%)
	Observer ID then window count	1	2,527	288	0.11	(1,962	3,093)	10%	(8%	12%)
		7	2,560	282	0.11	(2,008	3,112)	10%	(8%	12%)
		14	2,586	289	0.11	(2,019	3,153)	10%	(8%	12%)
	Mean		2,252			(1,746	2,758)	9%	(7%	10%)
Wild spring Chinook salmon (6,631)	Window count only	1	543	101	0.19	(345	740)	8%	(5%	10%)
		7	579	100	0.17	(384	774)	8%	(5%	10%)
		14	574	100	0.18	(377	771)	8%	(5%	10%)
	Observer ID then window count	1	732	123	0.17	(490	973)	10%	(7%	13%)
		7	751	120	0.16	(515	986)	10%	(7%	13%)
		14	719	114	0.16	(495	943)	10%	(7%	12%)
	Mean		650			(434	865)	9%	(6%	12%)
Summer steelhead (21,732)	Window count only	1	1,076	144	0.13	(793	1,358)	5%	(4%	6%)
		7	1,052	144	0.14	(770	1,334)	5%	(3%	6%)
		14	1,137	150	0.13	(843	1,432)	5%	(4%	6%)
	Observer ID then window count	1	421	79	0.19	(266	575)	2%	(1%	3%)
		7	433	82	0.19	(273	593)	2%	(1%	3%)
		14	487	87	0.18	(316	657)	2%	(1%	3%)
	Mean		768			(544	992)	3%	(2%	4%)
Winter steelhead (5,778)	Window count only	1	1,114	150	0.13	(820	1,408)	16%	(12%	20%)
		7	979	152	0.16	(680	1,277)	14%	(11%	18%)
		14	860	136	0.16	(593	1,128)	13%	(9%	16%)
	Observer ID then window count	1	905	143	0.16	(625	1,184)	14%	(10%	17%)
		7	841	143	0.17	(561	1,121)	13%	(9%	16%)
		14	793	136	0.17	(526	1,060)	12%	(8%	15%)
	Mean		915			(634	1,196)	14%	(10%	17%)

Appendix F. Known incursions into ladder leg one (LL1) fishway by California sea lions. Sea lions were documented going over and presumably through Sea Lion Excluder Device (SLED) (see images below).

Date	ID
3/2/2017	U278
3/9/2017	U278
3/16/2017	Unknown
3/20/2017	Unbranded
3/21/2017	U278
3/22/2017	U278
3/22/2017	Unbranded
4/3/2017	U117
4/5/2017 10:04 am	Unknown
4/7/2017	U278
4/13/2017	U278
4/28/2017 8:35 pm	Unknown
5/11/2017	Unknown

 California sea lion going over top of LL1 SLED at high water (3/16/2017)	 Broken LL1 SLED revealed at low summer water (7/23/2017)
 Camera trap photo of California sea lion in upper portion of LL1 (4/5/2017)	 U278 with fish heading down LL1 (3/9/2017)
 New LL1 SLED being installed (10/4/2017)	

Appendix F (cont.).