Jennifer Quan   11/29/2024
Regional Administrator, West Coast Region
National Marine Fisheries Service
501 West Ocean Boulevard, Suite 4200
Long Beach, CA 90802

RE: MMPA §120(f) Sea Lion Management Annual Report for the period of July 1, 2023, through June 30, 2024

Dear Ms. Quan:

The following information comprises the 2024 annual report to the National Marine Fisheries Service from the eligible management entities regarding Marine Mammal Protection Act (MMPA) §120(f) management and monitoring activities of sea lions in the Columbia River Basin. This report documents compliance with the Terms and Conditions of our 2020 Authorization for lethal removal of predatory California sea lions (CSLs) and Steller sea lions (SSLs) in the mainstem of the Columbia River between river mile 112 and river mile 292, or in any tributary (below river mile 292) to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead. The current Authorization was granted to the States of Oregon, Washington, and Idaho, the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Grand Ronde Community, and the Confederated Tribes of the Siletz Indians of Oregon (with Eligible Entities having the option to delegate authority to the Columbia River Inter-Tribal Fish Commission) on August 14, 2020 and is valid until August 14, 2025 unless renewed or revoked.

We thank you for your assistance and support of our work to monitor and reduce sea lion predation on threatened and endangered fish in the Columbia River Basin.

Sincerely,

Casey Clark
Lead Marine Mammal Researcher
Washington Department of Fish and Wildlife

This section outlines the Terms and Conditions from the 2020 Authorization and how the Eligible Entities complied with these Terms and Conditions for the period from July 1, 2023, through June 30, 2024. For information regarding how the Eligible Entities complied with these Terms and Conditions during previous reporting periods for this permit, refer to the annual reports for those years (Clark et al. 2021a, Edwards et al. 2022, Clark et al. 2023)

The following are the Terms and Conditions from the 2020 Authorization:

1) <u>Authorization</u>

   This permit authorizes the Eligible Entities, as defined below, consistent with the terms and conditions set forth herein, to lethally remove sea lions that are located in the mainstem of the Columbia River between river mile 112 and river mile 292, or in any tributary (below river mile 292) to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead.

2) <u>Permit Duration</u>

   This permit is valid beginning **August 14, 2020, through August 14, 2025,** unless renewed or revoked.

3) <u>Eligible Entities</u>

   a) For removal of sea lions located in the mainstem Columbia River, from river mile 112 to river mile 292, and its tributaries in the state of Washington and in the state of Oregon above Bonneville Dam, the Eligible Entities are: the state of Washington; the state of Oregon; the State of Idaho; the Nez Perce Tribe; the Confederated Tribes of the Umatilla Indian Reservation; the Confederated Tribes of the Warm Springs Reservation of Oregon; and the Confederated Tribes and Bands of the Yakima Nation.

   b) For removal of sea lions located in the Willamette River and other tributaries of the Columbia River within the state of Oregon below Bonneville Dam, the Eligible Entity is a Committee composed of Oregon Department of Fish and Wildlife, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes of the Grand Ronde Community, and the Confederated Tribes of the Siletz Indians of Oregon.

4) <u>Delegation of Authority</u>

   The Eligible Entities described in paragraph 3(a) above may delegate their removal authority to the Columbia River Inter-Tribal Fish Commission. In order to delegate their authority, the Eligible Entities must submit a request to NMFS in writing, and NMFS will respond in writing either approving or denying the request.

5) Limit on Removals

a) The Eligible Entities shall not remove (i.e., place in permanent captivity or kill) more than **540 California sea lions** and not more than **176 Steller sea lions** over the 5-year period of this permit.

b) The number of sea lions removed under this permit, combined with the number of sea lions removed under any other permits issued by NMFS under MMPA §120(f), may not exceed 10 percent of the potential biological removal (PBR) levels for either the CSL or SSL stocks. If at any time NMFS determines that removals under this permit may result in cumulative removals in excess of 10 percent of PBR, NMFS shall reduce the allowable number of removals under this permit to ensure that cumulative removals under MMPA §120(f) do not exceed 10 percent of PBR levels. If NMFS determines that reducing the number of removals identified in paragraph 5(a) above is required, NMFS shall provide the Eligible Entities with 72 hours' notice of the new removal limits.

6) Manner of Removals

a) The Eligible Entities may capture and remove sea lions by trapping or by live capture of free ranging sea lions using established wildlife darting techniques.

b) The Eligible Entities may capture and remove sea lions at any time of year.

c) Under this permit, lethal removal of sea lions is not contingent on nonlethal measures.

d) The use of firearms by the Eligible Entities to kill sea lions is prohibited.

e) The Eligible Entities shall appoint an Institutional Animal Care and Use Committee (IACUC) composed of veterinarians, marine mammal biologists, and a non-affiliated member who shall represent the community, to advise the Eligible Entities on protocols for capture, darting, anesthetizing, holding, transferring, and euthanasia of sea lions.

f) Prior to implementation, the IACUC shall develop, and NMFS shall approve, the methods for chemical euthanasia of sea lions.

g) Prior to implementation, the IACUC shall develop, and NMFS shall approve, the specific methods and protocols for darting and removal of free-ranging sea lions subject to this authorization.

h) Annually, the IACUC shall reevaluate the methods and protocols and determine any needed modifications.

i) Annually, NMFS will review the IACUC methods and protocols for darting and removal of free-ranging sea lions administered by the Eligible Entities and affirm that lethal removals are consistent with the definition of humane within the meaning of section 3(4) of the MMPA.

j) The Eligible Entities will notify and coordinate with local law enforcement/governments and tribes prior to sea lion removal activities as part of a communications strategy to maximize coordination and public awareness.

k) Any intentional taking must be implemented by qualified individuals. Qualified individuals include the Eligible Entities and their employees and other qualified individuals under contract to such entities.

7) <u>Disposition</u>

Sea lions removed under this permit shall be relocated or disposed of as follows:

a) Should NMFS notify the Eligible Entities that a pre-approved permanent holding facility (research, zoo, or aquarium) is willing to accept an animal(s); the Eligible Entities shall maintain the animal in a temporary holding facility approved by the IACUC for up to 48 hours. If the pre-approved research, zoo, or aquarium facility (or their designee) does not collect or make arrangements to collect an animal within 48 hours of its capture, the Eligible Entities may euthanize it.

b) Like other marine mammals, sea lions are susceptible to a variety of environmental contaminants that bioaccumulate upward through marine food webs to high-level predators. These substances include organochlorines (e.g., polychlorinated biphenyls, dioxins, dichloro-diphenyl-trichloroethane and its derivatives, various other pesticides and herbicides), polybrominated diphenyl ethers, heavy metals (e.g., mercury, copper, selenium, zinc), and may have harmful zoonotic organisms, all of which may have negative health consequences if not handled with appropriate protective gear. Thus, to reduce these risks, we recommend that the Eligible Entities use protective gear to reduce the risk of contamination when handling dead marine mammals. The Eligible Entities shall ensure that the disposal of carcasses, tissues, organs, or parts is in accordance with applicable laws.

c) If a tribe that is party to this permit has interest in a sea lion carcass for educational and cultural uses[1], the Eligible Entities may make sea lion carcasses killed pursuant to this permit available to the requesting tribe(s) for educational and cultural uses. *See* 50 CFR 216.22.

8) <u>Monitoring and Reporting</u>.

a) The Eligible Entities may collect biological samples of sea lions killed pursuant to this permit for scientific research or for educational purposes.

b) The Eligible Entities shall report all removals of sea lions (i.e., placed in permanent captivity or killed) to the Regional Administrator, NMFS, West Coast Region, within 3 days following removal.

c) The Eligible Entities shall provide reports to the Regional Administrator, NMFS, West Coast Region, consistent with the marine mammal regulations at 50 CFR 216.22(b) and 50 CFR 216.22(c) regarding all sea lion carcasses provided to tribes for educational and cultural uses.

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[1] As proposed in the June 13, 2019, application.

d) **Annually, on or before December 1st,** the Eligible Entities shall submit a monitoring report to the Regional Administrator, NMFS, West Coast Region, that includes:

> i. The number of sea lions observed in the action area.

> ii. The specific locations (e.g., latitude-longitude or river mile) where the Eligible Entities captured individual sea lions.

> iii. The number of sea lions killed or transferred by species.

> iv. The method of removal.

> v. The number of prey observed[2] taken by sea lions throughout the action area.

> vi. The impacts of sea lion predation (e.g., percent predation) on affected at-risk fish stocks in the Columbia River Basin.

> vii. The preemptive measures, e.g., non-lethal deterrence, taken to reduce sea lion predation on at-risk fish stocks.

> viii. The Eligible Entity's compliance with the terms and conditions of this authorization, and plans for future actions in compliance with this authorization.

e) The Eligible Entities shall evaluate the impacts of sea lion predation on at-risk fish species, and the effectiveness (benefits) of permanent removal of predatory sea lions as a method to reduce mortality on at-risk fish species.

> i. The Eligible Entities shall evaluate key population parameters for at-risk fish species by means of a population viability analysis or equivalent method to estimate the effectiveness of permanent removal of predatory sea lions as a method to reduce or eliminate mortality on at-risk fish species and estimate extinction risks to at-risk fish species.
> ii. **By December 1, 2023,** the Eligible Entities shall submit a 3-year comprehensive report to NMFS on the above-mentioned requirements so NMFS and the Task Force can evaluate the effectiveness of the authorized lethal removal or alternative actions implemented, as required pursuant to section 120(c)(5) of the MMPA.

9) NMFS may modify, suspend, or revoke this authorization at any time with 72 hours' notice to the Eligible Entities

The Eligible Entities' compliance with the Terms and Conditions is listed below:

1. <u>Authorization</u>

All animals were removed within the designated boundaries of the management area as described above. Specifically, removals conducted between July 1, 2023, and June 30,

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[2] When predation impacts cannot be observed, an eligible entity shall use a bioenergetics model or equivalent method.

2024, occurred at Bonneville Dam and in the Willamette River. In total, 30 CSLs and 36 SSLs were removed during this period (Table 2).

2. <u>Permit Duration</u>

This contains an annual report that covers management activities between July 1, 2023, and June 30, 2024. The permit under which this work was conducted was granted on August 14, 2020, and expires on August 14, 2025, unless extended or withdrawn before that time.

3. <u>Eligible Entities</u>

All removal efforts were conducted by the Eligible Entities.

a) Staff from the States of Washington, Oregon, Idaho, and the Columbia River Inter-Tribal Fish Commission participated in lethal removal of 27 adult male CSLs and 36 adult male SSLs at Bonneville Dam.

b) Staff from the State of Oregon participated in the lethal removal of 3 adult male CSLs in the Willamette River. No other removals occurred during this reporting period in other tributaries of the Columbia River within the state of Oregon below Bonneville Dam.

4. <u>Delegation of Authority</u>

The Confederated Tribes of the Umatilla Reservation, the Confederated Tribes and Bands of the Yakama Nation, and the Nez Perce Tribe delegated management authority to the Columbia River Inter-Tribal Fish Commission during this reporting period.

5. <u>Limit on Removals</u>

a) The eligible entities did not remove, via permanent placement in captivity or lethal removal, more than 540 CSLs or more than 176 SSLs over the 5-year period of this permit. As of this reporting period (ending June 30, 2024), a cumulative total of 90 CSLs and 95 SSLs have been removed under this authorization.

b) NMFS made no determination that removals under this permit exceeded 10 percent of PBR.

6. <u>Manner of Removals</u>

a) All removals during this reporting period were conducted using live trapping and capture methods (see Methods section).

b) Removals are now permitted at any time of year.

c) Under this permit, lethal removal is not contingent on nonlethal measures.

d) The use of firearms by the Eligible Entities is expressly prohibited and they were not utilized.

e) The Eligible Entities appointed an Institutional Animal Care and Use Committee (IACUC) composed of veterinarians, marine mammal biologists, and a member not affiliated with any of the Eligible Entities who serves to represent the community. Approval by this committee is required for all protocols for capture, darting, anesthetizing, holding, transferring and euthanasia of sea lions used by the Eligible Entities.

f) The IACUC was formed prior to any removal operations and conducted a review and approval of proposed methodologies on August 8, 2024. These protocols were further approved by NMFS before use. The currently approved Animal Care and Use Protocols are included in Appendix 1.

g) The Eligible Entities developed darting protocols, which were considered and approved by the IACUC as part of the protocol review and update on August 20, 2021. To date, no management activities have been conducted using these methods.

h) The IACUC will reevaluate the methods and protocols by December 1, 2025, to determine any needed modifications.

i) NMFS reviewed and approved the IACUC Animal Care and Use Protocols finalized on August 8, 2024, prior to their enactment for management. These methodologies will again be presented to NMFS for annual approval prior to December 1, 2025.

j) The Eligible Entities coordinated with local law enforcement and tribes prior to sea lion removal activities as part of regular communication that maximized coordination and awareness for all parties.

k) All intentional taking was conducted by employees of Eligible Entities.

7) Disposition

a) No requests for permanent placement were made to NMFS for sea lions removed during this management period. Therefore, all captured animals were humanely euthanized.

b) Staff were given safety trainings on handling of wildlife, including possible exposure to zoonoses and transmission of reverse zoonoses. Any staff participating in management or handling of animals utilized the appropriate Personal Protective Equipment, including safety glasses, respirators, nitrile gloves, work gloves, cut-proof gloves, aprons and waterproof sleeves, waterproof boots.

c) Tribes that are party to this permit requested parts from sea lion carcasses killed pursuant to this permit for educational and cultural purposes. The Eligible Entities provided parts from sea lions ZB064, ZB065, ZB073, and ZB074 to The Confederated Tribes of the Warm Springs Reservation of Oregon on April 24, 2024 and May 8, 2024.

8. Monitoring and Reporting

a) The Eligible Entities conducted full necropsies of removed animals and collected biological samples (Appendix 2) for scientific research purposes including food habits, immunology, toxicology, pathogens, biometrics, and general health.

b) The Eligible Entities reported all removals to the Regional Administrator of NMFS within 72 hours of removals. These reports were subsequently forwarded to the Task Force members via NMFS.

c) Sea lion carcasses provided to tribes for educational and cultural purposes under Term 7c) were reported to the NMFS West Coast Regional Administrator.

d) This document fulfills the reporting requirements for the management period beginning July 1, 2023, until June 30, 2024. Monitoring and predation reports for work previously authorized under the MMPA §120 Willamette Falls permit were provided to NMFS in November 2022 and 2023 (Brown et al. 2022, Wright et al. 2023).

i. The number of sea lions observed in the action area are detailed in the Results and Discussion sections of the annual report.

ii. The specific locations where the Eligible Entities captured individual sea lions is detailed in Table 1 of the annual report.

iii. The number of sea lions killed or transferred by species is detailed in Table 1 of the annual report.

iv. The method of removal for all sea lions killed during this reporting period was by chemical euthanasia via overdose of anesthetic. Method details are provided in the attached IACUC documents (Appendix 1).

v. The number of prey observed taken by sea lions throughout the action area are detailed in the Results and Discussion section and Table 2 of the annual report.

vi. Estimates of predation impacts of removed animals are presented in the Results and Discussion sections of the annual report, and in Appendix 3.

vii. Non-lethal deterrence measures taken to reduce sea lion predation on at-risk fish stocks are detailed in the Methods sections of the annual report.

viii. This letter describing our compliance with the terms and conditions of the 2020 Authorization for monitoring and management activities conducted in 2023 – 2024 represents our annual monitoring report to NMFS. The Eligible Entities are currently planning to conduct similar work in 2024 – 2025 under this MMPA §120(f) authority.

e) The Eligible Entities continue to evaluate the impacts of sea lion predation on at-risk fish species, and the effectiveness (benefits) of permanent removal of predatory sea lions as a method to reduce mortality on at-risk species. Monitoring and predation reports to date have been summarized in previous Willamette Falls and Bonneville

Dam sea lion management reports (e.g., Clark et al. 2021b, Wright et al. 2024). This same information for the current MMPA §120(f) permit is included in this report.

    i.   In the 3-year comprehensive report submitted to NMFS on December 1, 2023 (Clark et al. 2023) the Eligible Entities presented an evaluation of key population parameters for at-risk fish species by means of a population viability analysis to estimate the effectiveness of permanent removal of predatory sea lions as a method to reduce or eliminate mortality on at-risk fish species and estimate extinction risks to at-risk fish species.

    ii.   On December 1, 2023 the Eligible Entities submitted a 3-year comprehensive report to NMFS detailing how the on the above mentioned-requirements were met, in fulfillment of the request to submit such a report on or before December 1, 2023.

9) The Eligible Entities understand that NMFS may modify, suspend, or revoke this authorization at any time with 72 hours' notice to the Eligible Entities.

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ANNUAL REPORT:
2024 COLUMBIA RIVER BASIN RESEARCH AND MANAGEMENT ACTIVITIES

Casey Clark[1], John Edwards[1], Mike Brown[2], Shay Valentine[2], Bryan Wright[2], Doug Hatch[3], John Whiteaker[3], and John Powell[4]

December 1, 2024

Submitted on behalf of all MMPA §120(f) Eligible Entities, including:

    The State of Oregon
    The State of Washington
    The State of Idaho
    The Nez Perce Tribe
    The Confederated Tribes of the Umatilla Indian Reservation
    The Confederated Tribes of the Warm Springs Reservation of Oregon
    The Confederated Tribes and Bands of the Yakama Nation
    The Confederated Tribes of the Grand Ronde Community
    The Confederated Tribes of the Siletz Indians of Oregon
    The Columbia River Inter-Tribal Fish Commission

[1] Washington Department of Fish and Wildlife
[2] Oregon Department of Fish and Wildlife
[3] Columbia River Inter-Tribal Fish Commission
[4] Idaho Department of Fish and Game

INTRODUCTION

Bonneville Dam is the lowermost hydroelectric project on the Columbia River, approximately 235 km (146 miles) upriver from the Pacific Ocean. Sea lion presence at this location has historically been minimal, with only one or two California sea lions (*Zalophus californianus*; CSLs) reported annually at the dam during fishway inspections in the 1980s and 1990s (Stansell 2004). The abundance of sea lions at the dam began to increase in the early 2000s, with reports of six CSLs observed at one time in 2001 and 30 CSLs estimated to be foraging on salmonids (*Onchorynchus* spp.) at the dam in 2002 by the U.S. Army Corps of Engineers (USACE). Sea lion presence increased steadily from the early 2000s, with the minimum annual count of CSLs at Bonneville Dam fluctuating between ~30 – 200 individuals and associated predation estimates of 1,000 – 8,000 salmonids per year (Braun et al. 2024). The increase in both sea lion abundance at Bonneville Dam and observations of predation on salmonids raised concerns about impacts to salmon runs, many of which are listed under the Endangered Species Act (ESA).

State, federal, and tribal agencies attempted to deter pinnipeds using a variety of non-lethal methods. Starting in 2005, non-lethal deterrents included aerial and underwater pyrotechnics, acoustic harassment devices, vessel chase, rubber projectiles, and capture-relocation. While hypothetically effective at deterring predation by naïve animals, they have generally been found to be ineffective at deterring predation by habituated individuals (Scordino 2010, Tidwell 2021) and proved ineffective at deterring predation by sea lions at Bonneville Dam.

Increasing predation by CSLs on ESA-listed salmonids, coupled with unsuccessful non-lethal deterrence efforts, led the States of Washington, Oregon, and Idaho in November 2006 to apply under §120 of the Marine Mammal Protection Act (MMPA) for the authority to permanently remove CSLs that were observed preying on salmonids near Bonneville Dam. In March 2008, National Marine Fisheries Service (NMFS) partially approved the States' application and issued a Letter of Authorization (LOA) for the lethal removal of certain CSLs under specific conditions (NMFS 2008). This authority was repeatedly challenged in federal court, which resulted in intermittent removal activity across the first five years of implementation.

A new threat to Columbia River salmonids arose at Bonneville Dam during the initial period of CSL removal efforts. The abundance of Steller sea lions (*Eumetopias jubatus*; SSLs) at Bonneville Dam steadily increased following initial sightings in 2003 to a peak count of 89 individuals in 2011 (Braun et al. 2024). While SSLs initially foraged primarily on white sturgeon (*Acipenser transmontanus*), in recent years they have consumed more salmonids than sturgeon and have increasingly impacted fall and winter salmonid runs. Most notably, in 2017, SSLs consumed nearly as many salmonids as CSLs did in 2006 when authority to lethally remove CSLs at Bonneville Dam was initially requested (Braun et al. 2024). In addition, this species is now present at Bonneville Dam for most of the year, in contrast to CSLs which are present primarily in the spring.

In 2018, the U.S. Congress passed the Endangered Salmon Predation Prevention Act, which amended MMPA §120(f) to address increasing impacts of predation on listed salmonids in the Columbia River basin by California and Steller sea lions. On August 14, 2020, managing parties

were granted a new permit under §120(f) to conduct pinniped management activities in an extended geographic area (the mainstem of the Columbia River between river mile 112 and river mile 292, or in any tributary (below river mile 292) to the Columbia River that includes spawning habitat of threatened or endangered salmon or steelhead) under a new set of requirements (NMFS 2020). The newest authorization also includes Steller sea lions within the geographic area of management.

This report summarizes pinniped research and management activities between July 1, 2023, and June 30, 2024, in the management area encompassed in this MMPA §120(f) permit. This work was led by the Oregon Department of Fish and Wildlife (ODFW) and the Washington Department of Fish and Wildlife (WDFW), in cooperation with the Columbia River Inter-Tribal Fish Commission (CRITFC) and Idaho Department of Fish and Game (IDFG). This work has been conducted in close coordination and cooperation with USACE and NMFS, as well as numerous other agencies. During the reporting period, management was only conducted at Bonneville Dam and Willamette Falls.

METHODS

Activities conducted under and in association with this authorization included pinniped surveys between Bonneville Dam and the mouth of the Columbia River, pinniped surveys and estimates of fish predation by pinnipeds in the area of Willamette Falls, trapping and lethal removal of predatory CSLs and SSLs, diet analysis from contents of stomachs and intestines recovered from euthanized CSLs and SSLs, and estimation of the effect of removals on salmonid runs (i.e., the number of salmon "saved" as a result of lethal removal of predatory CSLs and SSLs). The methods used for these activities are detailed below.

Non-lethal hazing of sea lions at Bonneville Dam continued to be conducted by USDA staff in 2023 and 2024. These activities will be included in the forthcoming USACE report of activities at Bonneville Dam. Additionally hazing activities conducted near Bonneville Dam by the Eligible Entities in 2024 are outlined below. No non-lethal deterrence measures were conducted at Willamette Falls due to limited animal presence during the reporting period.

Estimation of sea lion abundance in the action area

Sea lion abundance in the action area is monitored using a variety of approaches. At Bonneville Dam, the USACE has taken the lead role in reporting sea lion abundance in the tailraces since 2002 (see Braun et al. 2024 for methods). These data were used in this report by the Eligible Entities to calculate "sea lion days" for both species of sea lions during the fall (August – December) and spring (January – May) management periods, as well as annually (all months). For this metric, a single day with twenty sea lions observed at Bonneville Dam was counted as twenty sea lion days and twenty days with a single sea lion observed were also counted as twenty sea lion days. The USACE counts (both direct observations and interpolated estimates between observations) were summed to provide total sea lion days within a period of interest.

Additionally, the direct observation data were used to calculate the mean (±1 standard deviation) and peak sea lion counts for each species in fall, spring, and annually.

In the mainstem Columbia River, CRITFC conducts periodic river surveys to document and enumerate sea lion abundance and predation activity in the river below Bonneville Dam. Surveys extended from the Bonneville Dam tailrace to the I-205 river crossing in Portland, Oregon. A single boat was crewed by a captain and at least one observer. Sea lion species, observed predation events, and GPS location data were recorded for all sightings. In addition, counts of sea lions hauled out at Phoca Rock were conducted throughout the season.

Lastly, in the lower Willamette River and at Willamette Falls, ODFW staff conduct a variety of observations to monitor abundance including land-based observations, automated camera counts, and boat-based river surveys. See Wright et al. (2024) for methods, but briefly, counts at Willamette Falls were conducted hourly during weekday, daytime observation shifts whereas camera counts were based on hourly images of the trap decks taken 24 hours a day, 7 days a week. Periodic boat-based surveys of the Willamette River were typically conducted in a single 24-ft closed cabin boat travelling downstream at approximately 5 knots with a minimum of two staff per survey. Surveys began in Oregon City below Willamette Falls and proceeded downriver, typically to the confluence with the Columbia River (42 km; 26 mi). Staff recorded the number, behavior, and location of each species of pinniped observed, which were also photographed when possible.

Deterrent activities

Subjecting sea lions to hazing prior to removal is no longer a requirement of the authorizing, therefore boat-based hazing is only deployed to enhance trap use by sea lions. Boat-based hazers used a combination of deterrents (e.g., seal bombs, cracker shells, and vessel chase) to deter sea lions from freely residing in the entirety of the Bonneville Dam tailrace and encourage residence around the sea lion haul out traps. Hazers primarily patrolled the tailrace Boat Restricted Zone (BRZ) at the dam in pursuit of foraging sea lions. The following was recorded for each discrete hazing event: species and number of pinnipeds encountered; starting location, time and direction of travel of pinniped(s); type and number of deterrent devices used; and ending location, time and direction of travel of pinniped(s). Predation observations and identifying marks of pinnipeds were also noted.

For personnel safety, boat access within the BRZ was limited to approximately 30 m from all Bonneville project structures and 50 m from main fishway entrances. No seal bombs were used within 100 m of fishways, floating orifices, the Powerhouse-2 corner collector flume or the smolt monitoring facility outfall. In addition, seal bombs use was halted once salmon passage exceeded 1,000 fish per day. Hazing activities were coordinated daily with the USACE Control Room and Fisheries Field Unit (FFU) personnel, as well as with USDA Wildlife Services staff, who were conducting additional sea lion hazing activities from project ground facilities. VHF-radio contact was maintained with Control Room staff while boat-hazing crews were active in the BRZ.

Motion-activated sprinkler systems were deployed as a means of non-lethally deterring sea lions from haulout spaces. These sprinklers are used as a means to move sea lions from preferred terrestrial haulout habitat to floating traps, to potentially move animals to haulouts downriver away from the dam, and by pushing the animals to spend more time in the water may have the potential to dissuade residency in the area by making it more energetically costly. Sprinklers were deployed on Tower Island, adjacent to the trap array at Bonneville Dam, and at Phoca Rock, a haulout 12 miles downstream of the dam. Deterrent sprinklers were used in both Fall 2023 and Spring 2024 seasons, and deployment occurred after animals had been consistently using a haulout location.

Trapping

Sea lions at both Bonneville Dam and Willamette Falls are trapped using haul-out traps placed in areas that the sea lions prefer to haul out. Sea lions use these traps as haul-out sites, entering and exiting traps by way of a vertically sliding door, which was padlocked open when trapping was not actively underway (e.g., weekends and months when fieldwork did not occur). Tailrace traps were monitored by state, federal, and private security staff. In addition, wireless trap monitoring sensors were installed on all trap doors to automatically notify project staff by text in the event of an unplanned trap closure. In Spring 2019, real-time trap monitoring was introduced using in-trap cellular cameras. This allowed co-managers to determine whether animals were on the traps, which was particularly important in the event of an unplanned trap closure.

Tailrace trap doors were closed using a remote-controlled magnetic release mechanism. Once sea lions were captured, they were herded into holding cages on a barge built specifically to handle sea lions. If a NMFS-approved zoo or aquarium facility was available to receive candidate sea lions for permanent holding, then captured animals would be given a health screening by field staff and veterinarians, including members of the Eligible Entities' Institutional Animal Care and Use Committee. If an animal passed the health screening, it would be transferred to an approved temporary housing facility prior to shipment to a zoo or aquarium. If an animal failed the health exam, or if there were no approved facilities prepared to accept an animal, then it was chemically euthanized. Euthanized animals were necropsied and various samples (e.g., teeth, tissue, blood, whiskers) were collected and stored for later analysis (Appendix 2).

Estimation of predation rates and diet analysis

As with abundance monitoring, estimation of predation rates varies by location. At Bonneville Dam, the USACE has taken the lead role in estimating sea lion predation in the tailraces since 2002 (see Braun et al. 2024 for methods). In addition, estimates of total salmonid consumption at Bonneville Dam by year, and season, were made by multiplying the estimated sea lion days by species by the daily consumption estimates from the agent-based model (Appendix 3). At Willamette Falls, ODFW has estimated sea lion predation since 2014; see Wright et al. (2024) for methods.

Diet analysis is based on the identification of undigested prey remains from the stomachs and large intestines of euthanized CSLs and SSLs following the procedures in Lance et al. (2001). Briefly, undigested remains were washed through a series of nested sieves (2 mm, 1 mm, and 0.05 mm) and all parts were collected for later identification. Samples were identified to the lowest possible taxonomic level using a dissecting microscope by comparing all identifiable prey remains (e.g., bones, otoliths, cartilaginous parts, eye lenses, teeth, and cephalopod beaks) against a reference collection of fish and invertebrates from the northeastern Pacific Ocean and Oregon estuaries. Prey were enumerated by examining all structures (otoliths, tail structures, cephalopod beaks, etc.) to determine the minimum number of individual prey items in the sample. This enumeration process accounts for paired structures (i.e., left vs. right side structures) and differences in size of recovered prey remains that may indicate they originated from different individual prey items.

Effect of removals

The effect of removals was characterized by estimating how many salmonids would have been required over the expected post-removal lifetimes of individual sea lions had they not been removed. This was accomplished using an agent-based modeling (ABM) approach (see Appendix 3 for details).

RESULTS AND DISCUSSION

Estimation of sea lion abundance in the action area

Bonneville Dam

Results of USACE sea lion monitoring efforts at Bonneville Dam will be included in their annual report in early 2025; however, the Corps has shared preliminary data with the Eligible Entities to be reported here. The information included here can be used to infer timing and trends in sea lion abundance in the vicinity of Bonneville Dam, but these numbers should not be treated as final until they are published in the next USACE annual report[3].

Sea lion monitoring efforts at Bonneville Dam are conducted during the period of sea lion presence at the dam, typically extending from August until May. This timeframe is officially broken into two monitoring periods, with fall monitoring extending from August to December, and the spring period from January to May. The Fall 2023 monitoring efforts began on July 25, 2023, and concluded on December 31, 2023, consisting of 111 separate counts. Only SSLs were present at Bonneville Dam during the fall, and animals were observed during the entire reporting period. Peak SSL abundance during Fall 2023 was 21 animals and occurred on August 29, 2023. Average SSL abundance during the entire Fall 2023 monitoring period was 5 ± 4 individuals.

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[3] When completed, the 2023-2024 USACE annual report will be available here:
http://pweb.crohms.org/tmt/documents/FPOM/2010/Task%20Groups/Task%20Group%20Pinnipeds/

Both CSLs and SSLs were present at Bonneville Dam during the Spring 2024 monitoring period, which began on January 1, 2024, and extended until June 3, 2024, consisting of a total of 107 separate counts. Whereas SSLs were present at the dam for much of Spring 2024 (January 3 – May 21), CSLs were not observed until March 2 and were last seen on May 31. Peak SSL abundance during Spring 2024 was 38 animals and occurred on May 1, 2024. Average Spring 2024 SSL abundance was 7 ± 10 individuals. Peak CSL abundance during this same period was 40 individuals, which were recorded on March 13, 2024. The average CSL abundance in Spring 2024 was 4 ± 6 animals; however, if only the period beginning with the first CSL observation is considered, the average was 6 ± 7 individuals per count.

The metric of "sea lion days" closely tracks the mean number of sea lions present at the dam since 2017 in spring, fall, and annually (Figure 1). During the period from 2017 – Spring 2024, SSLs greatly outnumbered CSLs based on the sea lion days metric, which is driven by a combination of a greater abundance and a longer duration of presence by SSLs than CSLs at Bonneville Dam. Finally, the presence of, and therefore likely impact on salmonids by, SSLs is substantially greater during the fall than the spring.

The patterns observed in sea lion occupancy and abundance since the initiation of the current permit in August 2020, which reduced the requirements for a sea lion to be eligible for removal and allowing removals of SSLs, indicate the removals are successfully reducing habitat use by sea lions at Bonneville Dam. This is particularly true for SSLs and for the fall management season. In Fall 2020, when the first six SSLs were removed under the new permit, we estimated 4,484.5 Steller sea lion days, an average of 29 ± 14 SSLs, and a peak of 68 SSLs at the dam, and in Fall 2023 we estimated 802.0 Steller sea lion days, an average of 5 ± 4 SSLs, and a peak of 21 SSLs. This represents an 82% decrease in sea lion days, an 83% decrease in mean counts, and a 69% decrease in peak counts for SSLs at Bonneville Dam in fall over the course of this permit. The patterns of SSL presence and abundance in the spring have followed a similar, if less pronounced, trajectory decreasing from an estimated 1,646.0 Steller sea lion days, an average count of 11 ± 17 SSLs, and a peak count of 62 SSLs in Spring 2021 to an estimated 1053.5 Steller sea lion days, an average count of 7 ± 10 SSLs, and a peak count of 38 SSLs in Spring 2024. This represents a decline of 36%, 36, and 39% for these three metrics, respectively.

California sea lion presence at Bonneville Dam in the fall is minimal and patterns of presence and abundance are not interpreted here. In spring, however, the metrics of sea lion day, mean abundance, and peak abundance all reflect an upward trend that peaked in 2023 (Figure 1). Large and protracted eulachon runs in the Columbia River in Spring 2023 were likely responsible for the increase in observations of CSLs at that time, but relaxation of competition with SSLs for haulout space and foraging opportunities due to removals of SSLs may also have caused CSLs to visit the dam in greater numbers.

Mainstem Columbia River

Weekly boat river surveys between the Bonneville Dam tailrace and the I-205 crossing in Portland, Oregon, peaked with 24 sea lions counted on April 12 and maintained an average 13.8 sea lions per week (range: 4 – 24) throughout the spring survey season (Figure 2).

Willamette River

Pinniped counts based on automated cameras and incidental observations by staff at the Sportcraft haulout area began July 2023 before sea lions migrated into the study area and continued through June 2024 when sea lions had migrated out of the study area. Counts based on formal observations at Willamette Falls began in January 2024 and continued through May 2024. Boat-based river surveys began late September 2023 and continued through May 2024.

California sea lions—There were no known occurrences of CSL in the study area during the last half of 2023 (Figures 3 and 4). The first CSL sighting occurred on January 8, 2024, but that animal only appeared to stay for three days. The next subsequent sighting was February 15, but that animal only appeared to stay for one day. It wasn't until March 11 that the spring cohort of CSL began arriving. They increased from one animal to a high of at least 12 on April 16th, with the last sighting on May 17th. Although boat survey effort was relatively low in 2024, results showed a similar phenology and relative abundance throughout the river as what was seen at the falls.

Only one individually identifiable CSL was documented at Willamette Falls in 2024: X834. Originally marked in Astoria on April 3, 2017, this animal recruited into the Willamette Falls population in spring 2023. After mistakenly thought to have died on the southern Oregon coast in the fall of 2023 it returned to Willamette Falls for a second consecutive spring and was sighted from April 4 to May 16.

Steller sea lions— There were no known occurrences of SSL in the study area during the last half of 2023 although it seems likely at least one animal may have been intermittently present but undetected based on the river surveys (Figures 3 and 4). The first individual to be detected at the falls was on the first formal observation day, January 2, 2024. This animal, while not branded, had uniquely identifiable scar patterns identifying it as an animal that had been seen at the falls previously for several consecutive years. The maximum number of SSL observed on a single day was three, occurring on March 27, April 3, and April 12. The last date a SSL was observed was April 23rd.

Boat-based deterrent activities

The boat based hazing crew from CRITFC did not haze sea lions during this reporting period.

Trapping

All animals captured during this reporting period (July 1, 2023, until June 30, 2024) were captured using the trap array within the Boat Restricted Zone at Bonneville Dam, Columbia River Mile 146 (45.6392°, −121.9521°), or the trap array at Willamette Falls (45.3511°, −121.6193°) (Table 2).

In total, 30 adult male CSL and 36 adult male SSL were humanely euthanized between July 1, 2023, and June 30, 2024 (Table 2). Seven weeks of trapping occurred in Fall 2023 from

September 12 through November 30, and 7 weeks of trapping took place in Spring 2024, from April 2 through May 16 (Table 2). Two weeks of trapping occurred at Willamette Falls in Spring 2024, from May 8 through May 16 (Table 2, Figure 3).

The average weight of CSLs humanely euthanized between July 1, 2023, and June 30, 2024, ($n = 30$) was approximately 244 kg (539 lbs), with a range 84 – 420 kg (186 – 925 lbs). The average length of euthanized CSLs was approximately 219 cm (7.2 ft), with a range of 174 – 260 cm (5.7 – 8.5 ft). For SSLs humanely euthanized between July 1, 2023, and June 30, 2024, ($n = 36$), the average weight was approximately 518 kg (1143 lbs) with a range of 264 – 786 kg (581 – 1733 lbs) The average length of euthanized SSLs was approximately 276 cm (9.0 ft), with a range of 229 – 305 cm (7.5 – 10.0 ft). Age data based on sectioned teeth are not yet available for the reporting period.

Estimates of predation rates and diet analysis

Bonneville Dam

Predation—As with the sea lion abundance data, the USACE shared preliminary results of their predation monitoring efforts with the Eligible Entities to be included in this report. Statistically expanded estimates for unsampled times and locations will be included in the final USACE report. Predation monitoring was also divided into a Fall 2023 and Spring 2024 period, though these efforts were more discrete than the abundance estimation periods, as predation monitoring occurs once a trigger of 20 animals present is met. Fall 2023 predation monitoring extended from August 27 through September 9 and was focused on the tailrace below Powerhouse 2 at Bonneville Dam. Only SSLs were present at the dam during the Fall 2023 predation monitoring period. The raw data based on 24 hours of sampling contained 33 predation events (Table 2), consisting in order of abundance of fall Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), steelhead (*Oncorhynchus mykiss*) and white sturgeon.

Predation monitoring in Spring 2024 began on March 24 and continued until May 13, when abundance of sea lions at the dam declined. Spring predation sampling occurred at the spillway and Powerhouse 2 tailraces. Both SSLs and CSLs were present at Bonneville Dam during this period and observers collected 157 hours of predation monitoring data consisting of 258 predation events (Table 2). Observed prey consumed by both SSLs and CSLs consisted almost entirely of Chinook salmon (*Oncorhynchus tshawytscha*). Other observations of predation consisting in order of abundance were steelhead and white sturgeon.

Estimated salmonid consumption below Bonneville Dam has declined since the initiation of management efforts in 2008 for CSL and 2020 for SSL (Figure 5). Whereas consumption of salmonids in the Bonneville Dam tailrace has declined markedly in the three years of management implementation during the fall season, there was more variability in the estimate of salmonids consumed by both species of sea lions in spring (Figure 5). This is likely due, at least in part, to a strong marine heatwave ("The Blob") that impacted the northeastern Pacific Ocean in 2014 – 2016 and drove a substantial increase in sea lion numbers at Bonneville Dam, with consequences that appeared to linger for several years.

<u>Diet—GI tract summary</u>

Sixty-six gastro-intestinal (GI) tracts were collected from humanely euthanized CSLs and SSLs between July 1, 2023, and June 30, 2024. Nineteen Steller sea lions were lethally removed in Fall 2023, and 47 sea lions were lethally removed in Spring 2024 (17 SSL, 30 CSL). All 19 of the fall 2023 SSL GI tracts contained identifiable prey (Table 4). Remains included 55 adult salmonids (unidentified to species), 46 Pacific lamprey (*Entosphenus tridentatus*), 13 white sturgeon (*Acipenser transmontanus*), 2 Cyprinidae (minnows and carp), 1 American shad (*Alosa sapidissima*) and for the first time catfish remains from the family Ictaluridae were recovered in 2 GI tracts. Spring 2024 GI tracts are being processed and will be reported later. Spring collections included 3 CSL removed at Willamette Falls and 44 collected at Bonneville Dam (27 CSL, 17 SSL).

<u>Willamette Falls</u>

California sea lions—The estimated number of salmonids consumed by CSL over the 6-site, 1,710-hour sampling frame was 1,030 fish (95% confidence interval: 688-1373). In addition, we estimated that they consumed a total of 329 lamprey (95% confidence interval: 77-580 fish). Partitioning salmonids to run based on Monte Carlo modeling, we estimated that CSL consumed 237 winter steelhead (2.6% of potential passage), 389 summer steelhead (2% of potential passage), 110 unmarked spring Chinook salmon (2.2% of potential passage), and 295 marked spring Chinook salmon (1.7% of potential passage).

Steller sea lions— The estimated number of salmonids consumed by SSL over the 6-site, 1,710-hour sampling frame was 299 fish (95% confidence interval: 166-432). Partitioning salmonids to run based on Monte Carlo modeling, we estimated that Steller sea lions consumed 195 winter steelhead (2.1% of potential passage), 59 summer steelhead (0.3% of potential passage), 15 unmarked spring Chinook salmon (0.3% of potential passage), and 30 marked spring Chinook salmon (0.2% of potential passage).

Effect of Removals

A total of 185 sea lion "agents" were initialized for the ABM including 119 from previous reporting periods (August 14, 2020 – June 30, 2023) and 66 from the current reporting period (July 1, 2023 – June 30, 2024); 8 SSLs occurred during two seasons thus resulting in a grand total of 193 agents (see Appendix 3). Of the 185 sea lions, 95 were SSLs (94 from Bonneville Dam and 1 from Willamette Falls) and 90 were CSLs (80 from Bonneville Dam and 10 from Willamette Falls).

The predicted (median) number of salmonids required by these sea lions had they not been removed was approximately 41,887 fish (95% confidence interval was approximately 26,875 to 61,384 fish) (Appendix 3, Fig. A5).

While it is important to note that bioenergetic models produce estimates of food requirements and not food consumption, these results were consistent with data from captive animals. In addition to preventing the future loss of fish the removal of habituated sea lions is believed to reduce opportunities for new, naive animals to be recruited into upriver nuisance populations.

TASK FORCE RECOMMENDATIONS

In addition to the Terms and Conditions outlined previously, in the 2020 Authorization NMFS determined that a subset of Task Force recommendations warranted consideration by the Eligible Entities as they will help achieve the goal of reducing/eliminating sea lion predation on at-risk fish species in the Columbia River Basin. NMFS requested that the Eligible Entities, to the maximum extent practicable, implement the following recommendations to minimize sea lion predation on at-risk fish species in the Columbia River Basin and-or to help evaluate the effectiveness of the authorized lethal removals or alternative actions:

1. Consistent with the intent of the Endangered Salmon Predation Prevention Act, NMFS requests that the Eligible Entities develop a long-term management strategy to prevent the future recruitment of sea lions into the 120(f) geographic area.

2. As recommended by the Task Force, NMFS requests that the Eligible Entities continue to pursue non-lethal methods to reduce sea lion predation on at-risk fish stocks.

3. As recommended by the Task Force, NMFS requests that the Eligible Entities conduct necropsies on euthanized sea lions to monitor sea lion age, disease, diet, and health trends in sea lion populations.

4. As recommended by the Task Force, NMFS requests that the Eligible Entities explore opportunities to displace and-or minimize the use of manmade haul outs by sea lions in the Columbia River.

5. As recommended by the Task Force, NMFS requests that the Eligible Entities look at the rate of sea lion recruits after habituated animals are removed to understand the effectiveness of the lethal removal program.

6. As recommended by the Task Force, NMFS requests that the Eligible Entities, in coordination with the Alaska Fisheries Science Center, monitor Steller sea lion rookeries in northern California (Saint George Reef and Sugarloaf Island), Oregon (Three Arch Rocks, Orford Reef and Rogue Reef), and Washington (Carroll Island and Sea Lion Rock) to assess the population status of Steller sea lions at these rookeries.

7. As recommended by the Task Force, NMFS requests that the Eligible Entities consider creating a way to collect public input and observations on the problem interactions in areas identified as Categories 2 and Category 3.

8. As recommended by the Task Force, NMFS requests that the Eligible Entities consider setting up a program, in coordination with NMFS, which would support or help secure the funds needed for monitoring to evaluate success of the lethal removal program.

9. As recommended by the Task Force, NMFS requests that the Eligible Entities conduct a management strategy evaluation on the performance of the bioenergetics model used to estimate the expected benefits of the MMPA section 120 program.

The Eligible Entities provided a report on December 1, 2023 to NMFS on the implementation status of each of these recommendations (see Clark et al. 2023 for details).

TABLES AND FIGURES

Table 1. Description and relevant data for lethally removed sea lions between July 1, 2023, and June 30, 2024, under MMPA §120(f) authority. Bonneville Dam Coordinates = 45.6392º, −121.9521º. Willamette Falls Coordinates = 45.3511º, −121.6193º

Removal Date	Location	Species	Animal ID	Date Branded	Weight (lbs)	Length (cm)
Fall 2023 Season						
9/12/2023	Bonneville Dam	SSL	EB051	N/A	926	276
9/12/2023	Bonneville Dam	SSL	EB052	N/A	1358	284
9/13/2023	Bonneville Dam	SSL	EB053	N/A	1733	305
10/11/2023	Bonneville Dam	SSL	EB054	N/A	1382	295
10/11/2023	Bonneville Dam	SSL	EB055	N/A	832	261
10/12/2023	Bonneville Dam	SSL	EB056	N/A	1145	294
10/12/2023	Bonneville Dam	SSL	EB057	N/A	838	257
10/12/2023	Bonneville Dam	SSL	EB058	N/A	774	269
10/18/2023	Bonneville Dam	SSL	EB059	N/A	1381	287
10/24/2023	Bonneville Dam	SSL	EB060	N/A	1427	282
10/26/2023	Bonneville Dam	SSL	EB061	N/A	1390	292
10/31/2023	Bonneville Dam	SSL	EB062	N/A	1284	280
11/1/2023	Bonneville Dam	SSL	EB063	N/A	1127	279
11/1/2023	Bonneville Dam	SSL	O50	5/18/2017	1547	299
11/14/2023	Bonneville Dam	SSL	EB064	N/A	1381	269
11/14/2023	Bonneville Dam	SSL	EB065	N/A	1065	271
11/30/2023	Bonneville Dam	SSL	EB065	N/A	581	229
11/30/2023	Bonneville Dam	SSL	EB066	N/A	729	253
11/30/2023	Bonneville Dam	SSL	EB067	N/A	851	267

Removal Date	Location	Species	Animal ID	Date Branded	Weight (lbs)	Length (cm)
Spring 2024 Season						
4/2/2024	Bonneville Dam	SSL	EB069	N/A	1218	285
4/2/2024	Bonneville Dam	SSL	EB070	N/A	988	264
4/4/2024	Bonneville Dam	CSL	ZB049	N/A	674	219
4/4/2024	Bonneville Dam	CSL	ZB050	N/A	657	235
4/9/2024	Bonneville Dam	SSL	EB071	N/A	1271	271
4/9/2024	Bonneville Dam	SSL	EB072	N/A	896	264
4/9/2024	Bonneville Dam	SSL	EB073	N/A	1499	284
4/10/2024	Bonneville Dam	SSL	EB074	N/A	1325	282
4/10/2024	Bonneville Dam	SSL	EB075	N/A	890	269
4/10/2024	Bonneville Dam	SSL	EB076	N/A	1066	275
4/11/2024	Bonneville Dam	SSL	EB077	N/A	1125	276
4/11/2024	Bonneville Dam	SSL	EB078	N/A	685	247
4/11/2024	Bonneville Dam	CSL	ZB051	N/A	521	223
4/16/2024	Bonneville Dam	CSL	ZB052	N/A	461	260
4/16/2024	Bonneville Dam	SSL	EB079	N/A	1150	282
4/16/2024	Bonneville Dam	SSL	EB080	N/A	1428	280
4/17/2024	Bonneville Dam	SSL	EB081	N/A	1050	275
4/17/2024	Bonneville Dam	SSL	EB082	N/A	1486	287
4/23/2024	Bonneville Dam	CSL	ZB053	N/A	410	220
4/23/2024	Bonneville Dam	CSL	ZB054	N/A	535	225
4/23/2024	Bonneville Dam	CSL	ZB055	N/A	447	212
4/23/2024	Bonneville Dam	CSL	ZB056	N/A	406	219
4/23/2024	Bonneville Dam	CSL	ZB057	N/A	341	206
4/23/2024	Bonneville Dam	CSL	ZB058	N/A	240	186

Removal Date	Location	Species	Animal ID	Date Branded	Weight (lbs)	Length (cm)
Spring 2024 Season						
4/23/2024	Bonneville Dam	CSL	ZB059	N/A	598	232
4/24/2024	Bonneville Dam	CSL	ZB060	N/A	227	180
4/24/2024	Bonneville Dam	CSL	ZB061	N/A	346	206
4/24/2024	Bonneville Dam	CSL	ZB062	N/A	332	195
4/24/2024	Bonneville Dam	CSL	ZB063	N/A	346	203
4/24/2024	Bonneville Dam	CSL	ZB064	N/A	186	174
4/24/2024	Bonneville Dam	CSL	ZB065	N/A	413	205
4/25/2024	Bonneville Dam	SSL	EB083	N/A	1072	274
4/25/2024	Bonneville Dam	CSL	2-65	5/7/2019	833	232
4/25/2024	Bonneville Dam	CSL	ZB066	N/A	565	223
4/25/2024	Bonneville Dam	CSL	ZB067	N/A	711	250
5/2/2024	Bonneville Dam	CSL	ZB068	N/A	617	224
5/7/2024	Bonneville Dam	CSL	ZB069	N/A	553	220
5/7/2024	Bonneville Dam	CSL	ZB070	N/A	356	199
5/7/2024	Bonneville Dam	CSL	ZB071	N/A	743	241
5/7/2024	Bonneville Dam	SSL	EB084	N/A	1349	285
5/7/2024	Bonneville Dam	SSL	EB085	N/A	891	270
5/8/2024	Bonneville Dam	CSL	ZB072	N/A	746	240
5/8/2024	Bonneville Dam	CSL	ZB073	N/A	596	230
5/8/2024	Bonneville Dam	CSL	ZB074	N/A	691	217
5/8/2024	Willamette Falls	CSL	ZW008	N/A	913	233
5/8/2024	Willamette Falls	CSL	ZW009	N/A	771	225
5/14/2024	Willamette Falls	CSL	ZW010	N/A	925	236

N/A=Unbranded animal

Table 2. Raw data from USACE sea lion predation monitoring during Fall 2023 and Spring 2024 (statistically expanded estimates for unsampled times and locations will be included in the final report). Only Steller sea lions were present at Bonneville Dam in fall, whereas both California and Steller sea lions were present in spring. Number of observed predation events for each sea lion species are presented, broken down by prey species where possible. Statistically expanded estimates for unsampled times and locations will be included in the final USACE report.

Fish predation by pinnipeds at Bonneville Dam between 27 August 2023 and 13 May 2024			
Fish Species	Observed Number of Fish Killed	Adjusted Number of Fish Killed (95% CI)	Percent Run Consumed During Observation Period
Fall Chinook Salmon	21	192 (74 – 294)	0.1%
Spring Chinook Salmon	252	2218 (1858 – 2546)	2.8%
Steelhead – Aug. – Sep. 2023	4	36 (6 – 60)	0.2%
Steelhead – March – May 2024	4	39 (0 – 76)	3.8%
Coho Salmon	6	55 (6 – 93)	0.1%
White Sturgeon – March – May 2024	2	19 (0 – 38)	N/A
White Sturgeon – Aug. – Sep. 2023	2	17 (0 – 33)	N/A

Season	Dates Observed	Location Observed	Total Daylight Hours Available	Daylight Hours Observed	Sample Rate (%)
Fall 2023	27 August - 9 September	PH2	186	24	12.94
Spring 2024	24 March - 13 May	SPW, PH2	1425	157	11.02

Table 3. Minimum number of individual prey recovered from gastro-intestinal tracts (stomach and large intestines) collected from 19 euthanized Steller sea lion (SSL) captured at Bonneville Dam between July 1, 2023, and June 30, 2024, under Columbia River Basin (CRB) MMPA §120(f) (valid 8/14/2020–8/14/2025). Spring 2024 GI tracts are being processed and will be reported later.

Date	Removal Location	Sea lion species	Animal ID	Unidentified salmon		Pacific Lamprey	Cyprinidae	American Shad	Sturgeon	Catfish
				Adult	Juvenile					
Fall 2023 Removals										
2023-09-12	Bonneville Dam	SSL	EB051	2		1				
2023-09-12	Bonneville Dam	SSL	EB052	2		33				
2023-09-13	Bonneville Dam	SSL	EB053	4						
2023-10-11	Bonneville Dam	SSL	EB054							2
2023-10-11	Bonneville Dam	SSL	EB055			11			1	
2023-10-12	Bonneville Dam	SSL	EB056	4					2	
2023-10-12	Bonneville Dam	SSL	EB057	1					1	
2023-10-12	Bonneville Dam	SSL	EB058	1					1	
2023-10-18	Bonneville Dam	SSL	EB059				2		1	
2023-10-24	Bonneville Dam	SSL	EB060	3					1	
2023-10-26	Bonneville Dam	SSL	EB061	2					3	
2023-10-31	Bonneville Dam	SSL	EB062	8						
2023-11-01	Bonneville Dam	SSL	EB063	10						
2023-11-01	Bonneville Dam	SSL	O50	8						1
2023-11-14	Bonneville Dam	SSL	EB064	4					1	
2023-11-14	Bonneville Dam	SSL	EB065	4		1			1	
2023-11-30	Bonneville Dam	SSL	EB066	1						
2023-11-30	Bonneville Dam	SSL	EB067							
2023-11-30	Bonneville Dam	SSL	EB068	1				1	1	
Spring 2024 Removals										
N/A	Bonneville Dam/WF	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fall 2023 Total				55	0	46	2	1	13	3

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Figure 1. Yearly estimates of the number of sea lion days spent at Bonneville Dam by California (CSL, blue) and Steller (SSL, red) sea lions from 2017 (when USACE implemented consistent Fall monitoring) through Spring 2024. Top: estimated sea lion days for the Spring monitoring period (January – May); Middle: estimated sea lion days for the Fall monitoring period (August – December); Bottom: year-round estimates of sea lion days. Vertical dashed line represents the beginning of the current removal permit in August 2020. Fall 2024 data are not included in this reporting period, so are omitted in the middle and bottom panels.
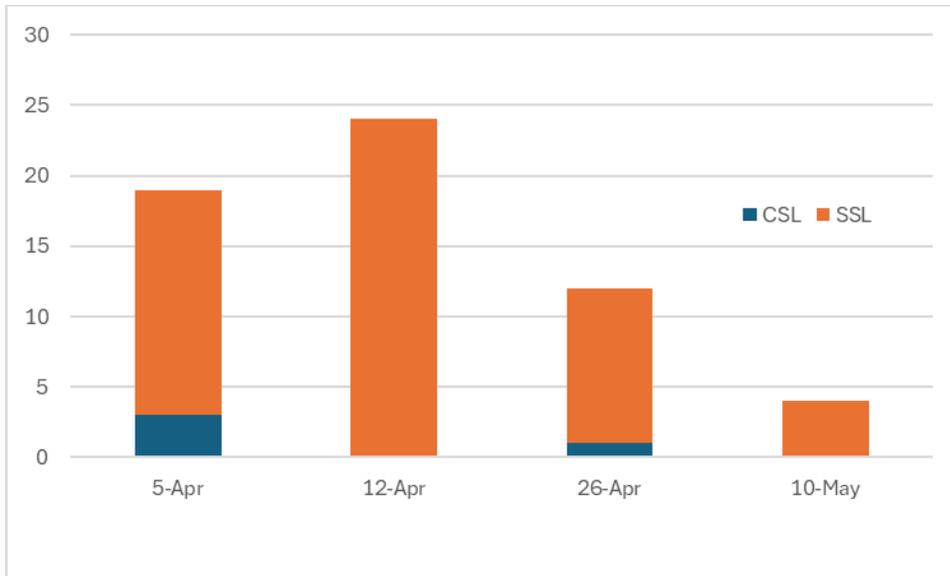
Figure 2. Sea lion counts on the Columbia River in 2024 between the Bonneville Dam tailrace and I-205 in Portland, Oregon.
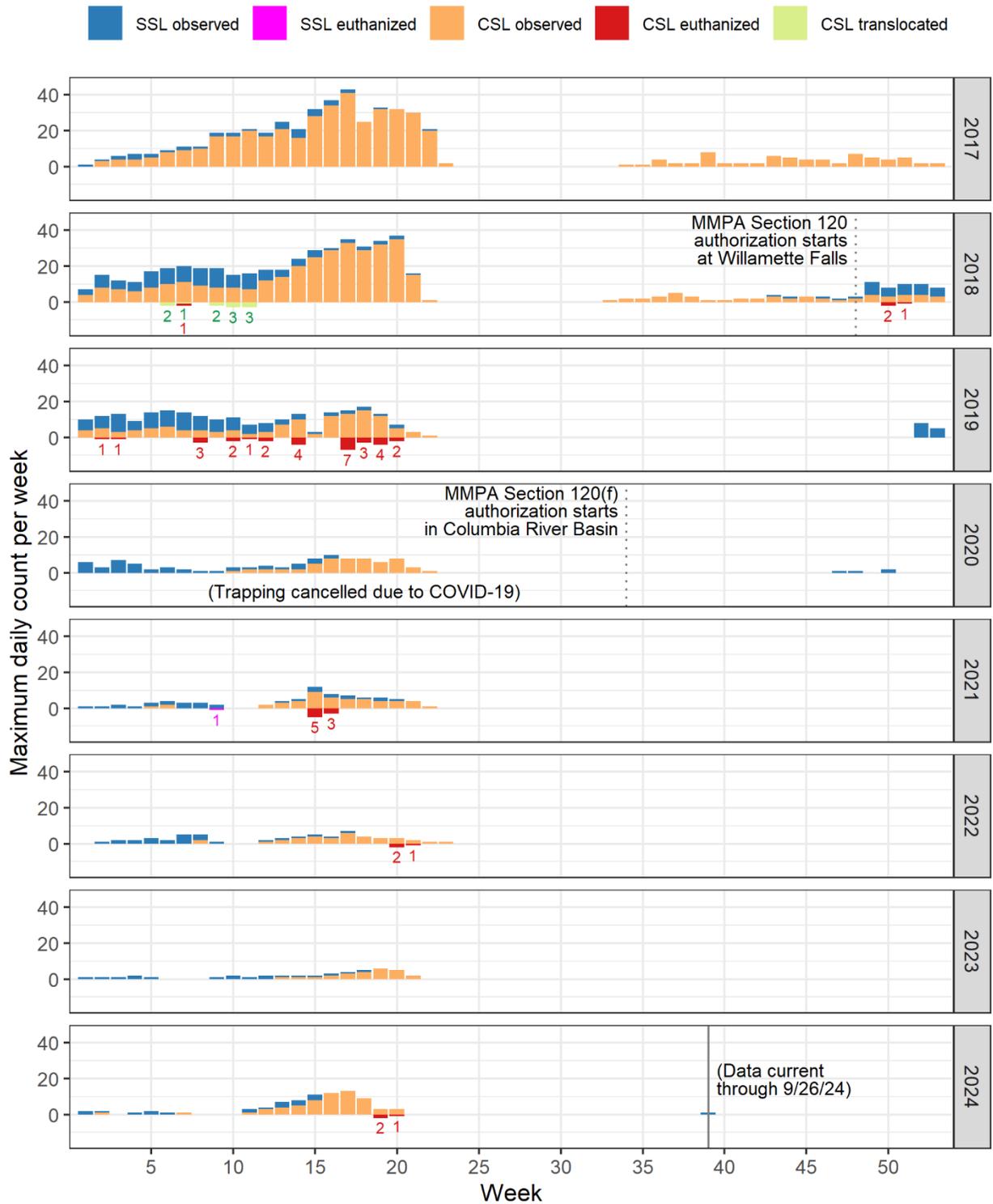
Figure 3. Weekly counts of California sea lions (CSL) and Steller sea lions (SSL) in the Willamette Falls study area, 2017-2024. Numbers translocated or euthanized are summed over the week; numbers observed are the minimum number of unique individuals observed for that week and may include animals translocated or euthanized.

Date	Survey end	CSL	SSL
2023-09-18	Columbia R.		
09-27	Columbia R.		1
10-13	St Johns Br.		1
10-27	Columbia R.		1
11-09	Columbia R.		1
11-17	Columbia R.		1
12-01	Columbia R.		1
2024-01-11	Ross Isl.		1
02-09	Columbia R.		
03-13	Columbia R.	1	1
03-22	Columbia R.	2	4
04-05	St Johns Br.	4	4
05-03	St Johns Br.	8	
05-16	St Johns Br.	3	
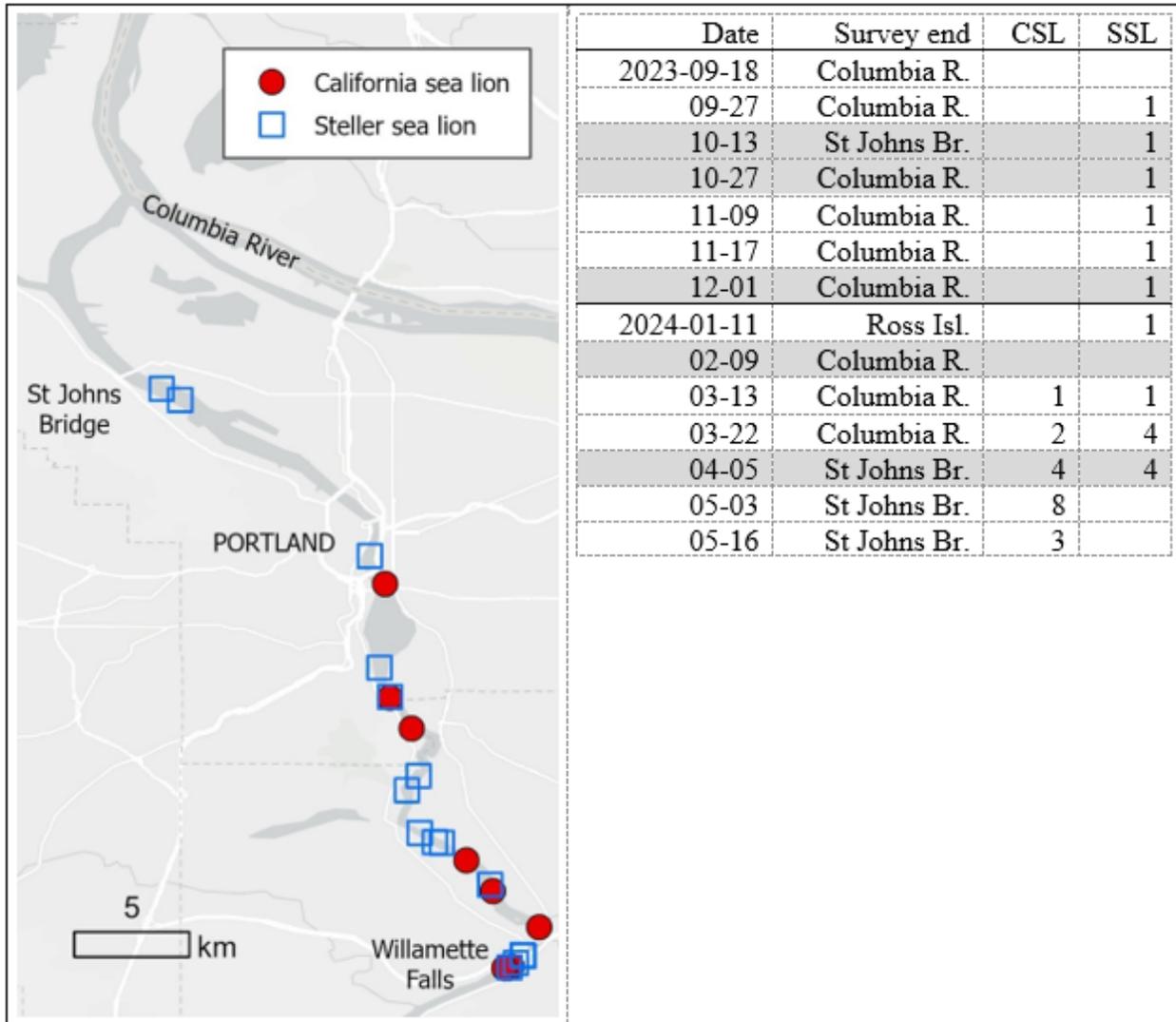
Figure 4. Individual sighting locations (map at left) and total counts (table at right) for California sea lions (CSL) and Steller sea lions (SSL) observed during vessel-based surveys of the Willamette River beginning at Willamette Falls in Oregon City and proceeding downriver to the location noted in table.

Figure 5. Estimated salmon consumption by California (blue) and Steller (red) sea lions at Bonneville Dam. Spring estimates (January – May) from 2002 – 2024 are shown in the bottom panel. Top panel shows fall estimates (August – December) for years with complete fall monitoring data (2017 – 2023). Estimates derived by multiplying sea lion days for each species by daily consumption estimates from the agent-based model (Appendix 3).

ACKNOWLEDGEMENTS

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Appendix 1. IACUC

Assurance of Animal Care and Use Form

IACUC Use Only
IACUC Number:
ODFW/WDFW/CRITFC/IDFG 2024-1

(Circle One)

Date Received: **Initial Review Date:** <u>08 8 2024</u>

<u>08 8 2024</u>   Second review:

                       Third review:

IACUC Training Complete: ☐

IACUC Recommendations: Approved: ☑   Not Approved: ☐

Withhold Approval Pending Modification: ☐

Type of Submission: New ☐   Modification ☐   Renewal ☑

IACUC Chair Signature: *Doug Maita* **Date:** <u>8/14/2024</u>
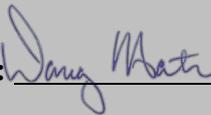
Columbia River Predatory California and Steller Sea Lion Lethal Removal Section 120(f)
Authorization Animal Care and Use Form

A. Administrative Data

Project Title: Columbia River Predatory California and Steller Sea Lion Lethal Removal

Institutions: State of Washington, State of Oregon, State of Idaho, Columbia River Intertribal Fish Commission (representing: Nez Perce Tribe, Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Umatilla), Confederated Tribes of the Grand Ronde Community; Confederated Tribes of the Siletz Indians of Oregon, and the Confederated Tribes of the Warm Springs Reservation of Oregon

Principal Investigators: John Powell (IDFG), Casey Clark (WDFW), Michael Brown (ODFW), Douglas Hatch (CRITFC -- Chair), Robin Brown (Community Member At-Large), Colin Gillin (ODFW – Veterinarian)

Mailing Address:

Telephone: **Fax: Email:**

Initial Submission ☐   **Renewal** ☑   **or Modification** ☐

Project Title: Columbia River Predatory California and Steller Sea Lion Removal

Anticipated Start Date: September 7, 2024 **Anticipated End Date:** Ongoing

Duration of Approved Protocol: September 7, 2024 through August 14, 2025

Study Site(s) Location (or Where Animals Will Be Housed): Bonneville Lock and Dam, Willamette Falls (Willamette River), Columbia River main stem River Miles 112-292, Columbia River Tributaries

Other approved IACUC Animal Care and Use Assurance relating to this project:

Permits: Identify all relevant permits (Federal, State and other) necessary to conduct this project. Provide permit type(s), permit number(s), and expiration date(s). Please indicate if a permit application is pending a decision.

Permit Type	Permit Number	Expiration Date
NMFS Permit & Letter of Authorization		August 14, 2025
Oregon Fish & Wildlife Statutes	OARs	
Washington F&W Statutes	RCWs	

*The NMFS policy intends to comply with the **Animal Welfare Act** (AWA) - Title 7 of U.S. Code §2131 et. seq. and implementing regulations and adhere to the principles of the **U.S. Government Principles** for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training (USGP) and follow the guidelines in the National Research Council **Guide for the Care and Use of Laboratory Animals.***

B. Justifications

This is a request to renew Approved Protocols contained in the Assurance of Animal Care and Use (AAC&U) Form with IACUC Number ODFW, WDFW, CRITFC & IDFG 2021-1 entitled "Columbia River Predatory California and Steller sea lion Removal" dated 31 August 2021.

In accordance with USGP #2, "Procedures involving animals should be designed and performed with due consideration of their relevance to human or animal health, the advancement of knowledge, or the good of society."

1. Research Goals:

a. What are the scientific issues addressed by the research? Specifically, how will this research improve human or animal health or advance knowledge?

Predatory California and Steller sea lions foraging for salmonids, sturgeon, lamprey and other species in the Columbia River below Bonneville Dam are having a significant negative impact on the recovery of populations of threatened and endangered (T&E) fish populations. This action, as permitted by 2020 Amendments to the Marine Mammal Protection Act, will reduce predator-associated mortality of fish stocks from depleted or ESA-listed populations. In particular, salmonids attempting to pass fishways to reach upriver spawning areas are subjected to bottleneck effects as they stage below upriver obstacles or attempt to pass through fish ladders. The objective of this work is to remove a number of upriver, habituated individual California and Steller sea lions from a large, robust, and healthy populations to protect T&E salmonids, lamprey and sturgeon, many from very small and highly at-risk populations. This management tool was provided to the states by the U.S. Congress in Section 120 of the MMPA, as originally amended in 1994. This current management authorization was granted the states by the Dept of Commerce, NOAA-NMFS under a Permit and Letter of Authorization (LOA) dated August 14, 2020, providing authorization for a duration of five years until August 14, 2025.

b. What are the specific goals of the animal studies described in this protocol?

The goal of this work is to reduce pinniped predation on T&E salmonids, and populations of lamprey, sturgeon and other at-risk stocks in the lower Columbia River (River Mile 112 to River Mile 292) and its tributaries to aid in the recovery of these fish populations. This will be accomplished by lethally removing California and Steller sea lions in these areas. After pinnipeds are captured and euthanized, numerous biological samples (e.g., GI

tracts, blood, tissues, organs, teeth) will be collected for a variety of scientific study purposes including food habits analyses, histology, and studies of pathogens and disease as per Task Force recommendation (See Letter of Authorization, 14 Aug 2020).

2. Explain why animal studies are preferred to non-animal alternatives in achieving these research goals.

The permanent removal of these predatory sea lions is required to achieve the objective of protecting fish stocks in the Columbia River and its tributaries. Multiple years of capture and transport, capture and holding, and all other non-lethal tools currently available have been shown to be statistically and biologically ineffective in reducing pinniped predation in these areas.

In accordance with the Animal Welfare Act – "…the principal investigator has provided written assurance that the activities do not unnecessarily duplicate previous experiments."

3. Does this research duplicate previous experiments?　　☐ YES　■ NO

If YES, please explain why this duplication is necessary. N/A

4. Do the animal procedures planned for this research involve only simple field observation with no impact on either the animals or their environment? (e.g. aerial surveys, brand or tag resighting, focal "animal" follow, vessel surveys)

　　☐ YES　■ NO

If YES, it is not necessary to complete the informational sections of this protocol form. Instead, answer the following:

a. **Use Appendix A to describe the study activities. Include all precautions to ensure no adverse impact on the study animals and their environment.**
b. **Include copies of any required permits.**
c. **Sign this form under Section H**

If NO, the remainder of this form must be completed. Complete Appendix A for observational studies and then proceed to the next section.

In accordance with the USGP #3, "The animal selected for a procedure should be of an appropriate species and quality and the minimum number required to obtain valid results."

5. List the research species (and stock) and describe why is the most appropriate species to use in these studies:

California sea lions (*Zalophus californianus*), U.S. Stock; Steller sea lions (*Eumetopias jubatus*). The relatively small number of adult and sub-adult male sea lions present within the management zone of the Columbia River are responsible for significant mortalities of adult salmonids, sturgeon and lamprey below Bonneville Dam, Willamette Falls and other sites along the lower Columbia River and its tributaries (Tidwell et al. 2019, Rub et al. 2019, Falcy 2017). Removal of predatory sea lions in this area will permit more salmonids to reach upriver spawning areas contributing to the recovery of these T&E fish populations, prevent predation on other fish stocks, and reduce the numbers of animals annually recruiting to bottleneck sites where fish are especially vulnerable.

6. How many animals do you plan to use for the protocol? Please provide a justification for the numbers of animals used (e.g., statistical power, survey, etc).

The NMFS Bonneville Pinniped-Fishery Interaction Task Force set the maximum lethal removal number for this project to be 540 California sea lions and 176 Steller sea lions over the 5-year period of the permit. These management actions will not exceed 10% of the potential biological removal (PBR) levels for either species.

Complete the following table below to define the numbers(s) of animal(s) to be used in each category and type procedure(s). Use the following animal welfare categories:

Category (adapted from AWAR):

> **B: Applies only to animals held captive in non-research status (display, rehabilitation, brood stock, holding).**
>
> **C: Applies to little or momentary pain or discomfort**
>
> **D: Applies to potential discomfort or pain which is relieved by the appropriate anesthetic or analgesic**
>
> **E: Applies to discomfort or pain which is not relieved thus requires written justification and full IACUC (must consider the 3 R's)**

Species (Common Name)	Age/Sex	Category C (List Procedure)	Category D (List Procedure)	Category E (List Procedure)
California sea lion (*Zalophus californianus*)	Adult males, subadult males	A maximum of 540 during the study period, minor pain or discomfort during trapping and transport to work facility, or trapping and release at site of capture	A maximum of 540 individuals during the study period, chemically anesthetized and euthanized	N/A
Steller sea lion (*Eumetopias jubatus*)	Adult males, subadult males	A maximum of 176 during the study period, minor pain or discomfort during trapping and transport to work facility, or trapping and release at site of capture.	A maximum of 176 individuals during the study period, chemically anesthetized and euthanized.	N/A

In accordance with the AWA: "The principal investigator has considered alternative to procedures that may cause more than momentary or slight pain or distress to the animals, and has provided a written narrative description of the methods and sources (e.g. the Animal Welfare Information Center) used to determine that alternative were not available…."

7. If you have placed any animal numbers in categories D and E, you must complete the following (use Appendix B if additional space is necessary)

a. Explain why the pain or discomfort cannot be relieved and what procedure will be used to minimize discomfort.

SECTION I: CAPTURE VIA TRAPS AND SUBSEQUENT EUTHANASIA

Capture and handling of pinnipeds by use of floating traps, transfer cages, and squeeze cages result in no pain and very little physical discomfort to pinnipeds included in this work. California and Steller sea lions that are to be euthanized are given appropriate primary (e.g. Telazol) and/or secondary (e.g., Telazol, Midazolam, Xylazine, or Medetomidine) doses of anesthetic (e.g., Telazol, Xylazine) via direct injection (syringe or jabstick) to be administered to the animal in the squeeze cage or transfer cage. Animals are to be in late Stage 3 anesthesia as defined by the AVMA (i.e., surgical or deep anesthesia characterized by loss of blink reflexes, shallow breathing) prior to euthanasia and verification of death. A secondary means of euthanasia may be required if death cannot be verified, and is given via approved chemical or physical means (e.g., sodium pentobarbital (Euthasol), potassium chloride or overdose of an anesthetic, or captive bolt). The licensed veterinarian on site shall use discretion to choose the AVMA- approved euthanasia method most appropriate to the circumstances (with the exception of gunshot, which is prohibited for this work). Monitoring devices and physical exam findings should be used to confirm cessation of respiratory and cardiac function, thus verifying death.

Method	Tools
Secondary euthanasia method*	Pentobarbital IV
	IC/ IV potassium chloride
	Captive Bolt
	Exsanguination
Monitoring devices	Doppler unit
	EKG

*All of these secondary methods of euthanasia should only be performed when then animal is completely unconscious and unresponsive.

SECTION II: IMMOBILIZATION AND REMOVAL VIA DARTING

Darting will be used when appropriate as a method for immobilizing and capturing pinnipeds under the Marine Mammal Protection Act Section 120(f) authorization, and subsequent NMFS authorization (14 Aug 2020). The following methodologies for darting, immobilization, handling, and subsequent humane euthanasia are designed with an emphasis on maximizing human and animal safety. Protocols will reflect best scientific methodologies for darting, handling, and immobilizing pinnipeds, as well as safety considerations for other wildlife, people, or pets that may encounter the carcass of a darted animal or a partially injected dart. Darting is to be method of lethal removal secondary to trapping efforts and would be used in situations where trapping is not a practical or effective means of capture, and darting is deemed appropriate by all Eligible Entities (See Section 120(f) Letter of Authorization, 14 Aug 2020).

Darting of animals under MMPA Section 120(f) authority is to be utilized specifically for permanent removal efforts related to sea lion management in relation to conservation of fisheries species in the Columbia River Basin management area. Darting methods in this protocol do not include animals handled under state MMPA Section 109(h) authorization. Darts with tracking capabilities (e.g., acoustic, VHF) may be used, within consideration for the ultimate outcome of darting, including best effort to retrieval of the dart and/or the darted animal

The specific methods proposed for darting activities are as follows:

Pre-Darting Monitoring and Assessment
1. Animals residing in removal areas may be evaluated remotely or in person to determine patterns of behavior to increase the probability of success. This could include situational assessment, remote monitoring by camera, UAV, or in-person resights to confirm predictability of behavior and hauling out at the site of management.

Dart Application
1. During darting, at least two boats and five staff will be present. One person not operating each vessel will be designated to visually track the animal. If beneficial, one or more additional staff members may be present on shore to monitor the animal from land.

2. Each darting attempt will include at least one veterinarian on staff, and a designated veterinarian or another qualified, experienced darter may conduct the darting attempt. All staff handling drugs, darts, or applying remote delivery of anesthetics will be trained, certified, and approved under their agency capture and immobilization training and policy. Primary preference is to first dart the animal while it is hauled out. Animals will be darted using an appropriate dart delivery system depending on individual scenarios.
3. Animals will be darted with an appropriate dose using a combination of Midazolam-Butorphanol-Medetomidine (Frankfurter et al. 2016, Haulena 2007).

Post-Darting Monitoring
4. After an animal is darted, it will be observed for anesthetic effect leading to induction, and tracked at an appropriate distance for safe and rapid retrieval to secure and transport the animal for subsequent euthanasia.

Handling and Euthanasia
5. Nets, donut poles (a pole with a round section of PVC attached), noose poles, Shepherd's hooks or other similar tools may be used to secure the animal or retain the animal in the direct management area.
6. Once the animal displays signs of full induction on land or water (i.e., non-responsiveness to direct stimuli, bubble blowing, and/or aimless swimming or treading water), it will be approached and secured in a manner that allows for controlled administration of euthanasia as per existing IACUC protocols for sea lion management.
7. After the animal has been secured, it may be euthanized in the field by the attending veterinarian[1], or transported to a secure facility for euthanasia, necropsy, and disposal.

Documentation and Reporting
8. Documentation will be collected of all darting attempts, including (but not limited to): managing parties initiating the darting activity; veterinary staffing; gun and dart type; drug combinations; animal reaction to anesthesia and ultimate results; means of physical immobilization, handling, and euthanasia; and a recap of efforts with notes for improvement or debriefing before future attempts. A report regarding the removal effort will be filed to NMFS within 72 hours as per MMPA Section 120(f) requirement.

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[1] Mortality can be confirmed via several methods including the following: (1) lack of vital signs (heartbeat, respiration measured manually); (2) lack of retinal responsiveness; (3) lack of intraocular Doppler signal; (4) lack of cardiac activity via EKG monitor, or other (5) AVMA-approved methodologies.

b. What informational methods and resources did you use to determine that (no-animal or non-painful) alternative were not appropriate for this research?

 i. **Include the databases that were searched (include keywords used).**
 ii. **Include literature citations**
 iii. **Include meetings with knowledgeable individuals (name, date)**
 iv. **Include other methods/resources**

Beginning in the early 2000s, the number of California, and subsequently Steller sea lions observed foraging for salmonids below Bonneville Dam has increased annually (along with the number of salmonids, lamprey and sturgeon killed by these predators).

Beginning in 2005, through 2008, the States of Oregon and Washington used all available non-lethal tools, at increasing levels of intensity, in efforts to non-lethally deter California sea lions from foraging at this location. Over that period and to this date, non-lethal hazing has proven to be ineffective at deterring CSL and reducing their predation rates on salmonids at this site (Brown et al. 2008, Annual Report on Field Activities at Bonneville Dam, Willamette Falls Task Force Meeting 2018). Known individual California sea lions observed killing salmonids below Bonneville Dam exposed to significant hazing efforts continue to kill salmonids and return to this area to forage year after year, despite ongoing hazing efforts by USACE. As a result of the failure of effective non-lethal tools to reduce predation, and at the recommendation of the NMFS Pinniped-Fishery Interaction Task Force, NMFS has issued a Permit & Letter of Authorization to the states and tribes for lethal removal of California and Steller sea lions between River Mile 112 and 292 in the Columbia River and Columbia River Tributaries, under certain outlined criteria and methodologies.

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7. Tidwell KS, Van der Leeuw BK, Magill LN, Carrother BA, Wetheimer RH, Bayley KN. Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace: 2017. *US Army Corps of Engineers, Bonneville Lock and Dam*; 2019 Jan 24.
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C. Experimental Procedures

1. General Procedures. *(Detail research procedures in Appendix A)*

In accordance with the AWA, "Procedures that may cause more than momentary or slight pain or distress to the animals will a) be performed with appropriate sedatives, analgesics, or anesthetics unless withholding such agents is justified for scientific reasons in writing by the principal investigator and will continue for only the necessary period of time; b) involve in their planning, consultation with the attending veterinarian…, c) not include the use of paralytics without anesthesia…"

Capture, Samples and methods of collection

Sample Type	Collection method	Sample size	Number of animals
None	Trap, barge, and euthanize	Up to 540 CSL, 176 SSL during study period	Up to 540 CSL, 176 SSL during study period
Entire carcass	Trap, barge, and euthanize identified and authorized animal	Up to 540 CSL, 176 SSL	Up to 540 CSL, 176 SSL
Blood from deceased animals	Syringe	As needed	Up to 540 CSL, 176 SSL
Tissues, organs, skeletal remains	Necropsy and pathological/ histological preparation	Samples of tissues from major organs and tissue types; Multiple samples from up to 540 CSL, 176 SSL	Up to 540 CSL, 176 SSL
Hide, organs, muscle, skeletal remains	As needed for subsistence use by qualifying recipient tribe	As needed	Up to 540 CSL, 176 SSL

2. Animal Restraint

a. Physical (*Describe method, duration, equipment used*)

CAPTURE VIA FLOATING TRAPS

For full darting methodologies, please see section above

Sea lions are captured on a floating trap used by animals for a resting area. Traps are locked open (unarmed) when staff are not present or weather conditions (excessive heat, cold or precipitation) prohibit a safe working environment to prevent accidental or unintended trapping which could result in injuries or mortality to animals. Trap doors are closed by a magnetized remote release system (TrapSmart™, SkyHawk™, or similar mechanized system) by team members within line of sight of traps and animals. Tarps are lowered around the seven-foot chain-link walls of the trap to calm animals and reduce visual stimuli. Animals may be moved between traps via an enclosed chain-link tunnel system and either retained or released. Animals that are to be transported and removed are herded or allowed to move freely from the trap into a transfer cage that is tall enough for the animals to walk into on a handling barge. In rare cases sea lions that are not possible to move either due to size (i.e. over 1500lbs) or behavior may be chemically immobilized in the trap, removed mechanically by crane or wench, and placed in a transfer cage and moved by vehicle to the designated work area for processing. Animals are transported via barge and transfer cage, then subsequently into a transfer cage on the back of a vehicle to the work area for processing. Chemical immobilization will take place by use of a jab pole or blow dart – whichever can be most safely administered- to deploy a dose of immobilizing drugs (i.e. Telazol-see chemical restraint table). At the work site, live sea lions are restrained in a squeeze cage at the work area where injectable or gas anesthesia or sedation and euthanasia are administered (see chemical restraint table). A variety of biological samples are collected from each euthanized animal prior to disposal or transfer of the carcass to tribal co-managers.

b. Chemical

Anesthetics and Analgesics:

If anesthetics or analgesics are to be used, please provide the following information: procedure, anesthetic, recommended starting dose and method of administration

Procedure	Anesthetic*	Recommended Starting Dose (to effect) & Method of Administration	Intervention
Anesthesia	Telazol, or generic	IM injection 1-4 mg/kg	N/A
Anesthesia	Telazol Ketamine	1-4 mg/kg IM 0.5-1.0 mg/kg IM	N/A

	Xylazine, or generic	0.5-1.0 mg/kg IM	
Anesthesia	Telazol Xylazine, or generic	1-4 mg/kg IM 1-2 mg/kg IM	N/A
Anesthesia	Isoflurane gas	Cone / mask induction and maintenance at 3-5% saturation.	N/A
Anesthesia	Medetomidine Ketamine, or Xylazine	140 µg/kg IM 0.5-1.0 mg/kg IM 0.5-1.0 mg/kg IM	N/A
Anesthesia	Midazolam-Butorphanol-Medetomidine combination	0.2-0.26 mg/kg Midazolam 0.2-0.4 mg/kg Butorphanol 10-13 µg/kg Medetomidine IM	N/A
Sedation	Diazepam	0.1-0.2 mg/kg IM	N/A
Sedation	Midazolam	0.15-0.2 mg/ kg IM	N/A

*Those drugs that pose the lowest risk to human safety will be considered first for this work, at the discretion of the veterinarian on site.

3. **Marking and Instrumentation** *(Describe mark or tag type, or instrument type to be used. Provide mass of attachment device, range of body mass of study animal, device mass a proportion of body mass and the recommended device mass as a percent of body mass)*

Tag or Instrument	Size (dimensions & mass)	% of body mass	Attachment Method
Duflex flipper tag	2.25x7/8" 5g	(<<1.00%)	Punch
Branded Digits	5" lettering	N/A	Hot Iron Brand

In accordance with AWA: "Activities that involve surgery include appropriate provision for pre-operative and post-operative care of the animal in accordance with established veterinary medical and nursing practices. All survival surgery will be performed using aseptic procedures, including surgical gloves, masks, sterile instruments, and aseptic techniques."

4. Surgical Procedures – Is surgery to be performed? ☐ YES ☑ NO

a. If YES, list surgery location/room:
b. If YES,

    i. is it a terminal procedure? ☐ **YES** ☐ **NO**

    ii. is it a survival procedure? ☐ **YES** ☐ **NO**

c. If YES, then describe the surgical procedure to be performed in Appendix A. Be sure to include the protocol to be followed to ensure asepsis.

d. If aseptic procedures are not to be performed, use this space below to justify why not and describe the procedure of choice.
e. Describe the post-operative care (both immediate and long-term).

5. Injury to animals – Accidental injuries which might occur to animals during handling (Describe the most likely injuries which might occur to research animals, how frequent injuries are expected and planned procedures to treat injuries.)

Possible injuries to SSL and CSL that will be euthanized, held, or released include minor scrapes, abrasions, and bites during the trapping and marking operations (Appendix A). This type of superficial injury may occur in up to 10% of animals handled during any trapping and/or marking operation. Traps are locked (disarmed) open when not in use to prevent accidental or unintended trapping which could result in injury or mortality. When traps are open, at least three staff will be available and in the area in case emergency response is needed. Animals being held or transported are monitored for physiological distress and continually cooled with pumped water to prevent overheating in warm conditions.

6. Euthanasia – All methods of euthanasia must follow the American Veterinary Medical Association Guidelines for the Euthanasia of Animals: 2013 Edition. (2013, 102 pp). Any deviations must be scenically justified. Even if you do not intend to euthanize animals as part of the project, a method of euthanasia must be listed in case of emergency. (Describe agent, dose and route of administration).

-Will the animals be terminated if severely injured during handling?

 ▣ YES ☐ NO

-Will animals be terminated as part of handling protocol

 ▣ YES ☐ NO

If YES, provide the method of euthanasia and disposal of animal upon completion.
If NO, provide method of euthanasia in case of emergency.

Method	Recommended Starting Dose (to effect) and Method of Administration	Disposal
Pentobarbital sodium	IV 60-120 mg /kg or 1ml/4.5 kg (10-20 lbs) BW to effect	Incineration or burial*
Potassium Chloride	IV, IC 75 -150 mg/kg [34.1 to 68.2 mg/lb] BW	Rendering facility, incineration or burial*
Overdose of anesthetic	Recommended starting dosages on previous page, Table of Anesthetics	Rendering facility, incineration or burial*
Captive Bolt	Administered to cranium	Rendering facility, Incineration or burial*

Disposal method selected based on method of euthanasia, agreement with facility and/or federal guidelines. Tribal co-managers may request use of the carcass or parts of the carcass for traditional use purposes. This will occur on a case-by-case basis, and a database will be maintained regarding the disposition of samples used for research and traditional use.

Please consult NMFS Research Protocol Guidelines (TBD) for acceptable practices. (AVMA Guidelines, AAZV Guidelines, etc.)

In accordance with the AWA, "Personnel conducting procedures on the species being maintained or studied will be appropriately qualified and trained in those procedures."

7. Training

Please describe below the training and qualifications of yourself and other individuals who are included in this protocol. In particular, please be very specific about the hands-on training of those individuals performing procedures which may produce animal discomfort (i.e., restraint, injections, blood collection, surgery, tagging, biopsy, tooth extraction, urine, fecal, gastric, milk, semen, sample collection, euthanasia, etc.). Use Appendix B to further describe training and experience.

The state program leaders and veterinary staff directing this work have at more than 20 years combined experience in capturing, handling and marking pinnipeds from California to Alaska (Appendix B). This experience includes a wide variety of methods and equipment for accomplishing this work. All euthanasia procedures will be conducted and overseen by licensed agency veterinarians. Program leaders have extensive experience performing necropsies and collecting biological samples of all types. All ODFW and WDFW project support staff have multiple years of direct experience in pinniped capture, handling, marking, necropsies, and biological sample collection. Several support staff and veterinarians have worked on this project since its inception providing extensive experience related to procedures and methodologies described herein. All support staff were trained directly by the state program leaders and several have had additional experience with similar programs conducted in other areas.

Each year, staff involved in handling or managing animals in the field are required to complete an in-person (or virtual) training by their Program Leaders that includes considerations for animal handling safety, euthanasia, and psychological effects staff may experience in relation to euthanasia of wildlife. They also are required to read a material packet regarding the ethical use and treatment of animals and wildlife in research.

D. Husbandry Practices (In Laboratory and Field)

Temporary holding (period greater than 1 hour and less than 24 hours)
Long term holding (periods greater than 24 hours)
(Describe holding facilities or equipment, i.e. pens, cages, nets ,shade, water, etc.)

1. Will the research require holding the animals in captivity? ☒ YES ☐ NO

2. If YES, describe the husbandry practices that will be used.

Sea lions to be lethally removed or permanently placed under human care in a NMFS-approved facility may be held in transfer cages or a specially built trailer for up to 48 hours. In the case of permanent placement, the purpose for holding is to perform a veterinary health assessment and transfer the animal alive to an approved placeholder facility for quarantine. In the case of lethal removal, animals may be held overnight prior to euthanasia. In both cases, animals are held in a secure area and monitored with access permitted only to authorized staff. The holding area is temperature-controlled and with light adjusted as appropriate. Requests for animals for permanent holding are facilitated by federal partners, the interim holding facility (local aquarium or zoo), and the approved permanent holding facility (aquarium or zoo).

3. If YES, describe procedures for disposition of dead animals, including whether or not a necropsy will be performed.

Necropsies and biological sample collection are performed on all sea lions that are euthanized. Multiple biological samples are archived, cataloged and can be made available to external collaborators or researchers for study and analyses as appropriate, via proper permitting and sample use agreements completed by the requesting party.
Carcasses (minus biological samples, GI tracts, and skulls) will be transported to a rendering plant for disposal, transferred to tribal co-managers, incinerated or buried via landfill.

4. Will the animals be removed from the facility? ☒ YES ☐ NO

a. If YES, for how long?

For the life of the animal.

b. If YES, to where?

Occasionally live California or Steller sea lions may be made available to permanent holding facilities in the U.S. at the request of the facility and with the approval of NMFS.

c. If YES, will they be returned to the facility? ☐ YES ☒ NO

d. If NO, why not?

California and Steller sea lions approved for removal will either be euthanized at the project work facility or will be transferred to a permanent holding facility and will not be returned to the project or released into the wild.

E.   Environmental Safety

1. Are infectious agents to be used and is there potential for exposure?

☐ YES ☒ NO

If YES, the agent(s) is…
If YES, is the agent infectious to humans?

2. Are chemical hazards to be used?

☐ YES ☒ NO

If YES, the chemical hazard is…

3. Are radioisotopes to be used?   ☐ YES ☒ NO
If YES, the radioisotope is…

4.   Are there other biohazards of concern like exposure to zoonotic agents?

☒ YES ☐ NO

IF YES, the biohazard(s) is…

A range of diseases that naturally occur in the CSL population, including bacterial and viral agents. Some of these are potentially zoonotic:

- *Leptospira* spp., found primarily in urine samples
- *Brucella pinniipedialis, B. ceti,* Brucellosis
- *Bisgaardia hudsonensis*, seal finger
- *Mycoplasma phocacerebrale, M. phocarhinis, M. phocidae,* mycoplasmosis
- *Calicivirus,* San Miguel sea lion virus, seal finger
- *Parapoxvirus,* seal finger
- *Mycobacteriia marinum, M. pinnipedii,* Mycobacteriosis
- *Erysipelothrix insidiosa,* Erysipeloid
- *Coxiella burnetti*
- *Toxoplasma gondii*, Toxoplasmosis
- *Ajellomyces dermatiditis,* Blastomycosis
- *Lacazia lobio,* Blastomycosis
- Influenza A

Note – If any of the above questions are answered YES, all procedures must comply with NMFS Environmental Safety requirements (TBD).

F. Use of Controlled and/or Prescription Substances (*Source, arrangements for use, ordering, record keeping, storage and precautions taken to avoid unauthorized access)*

Drugs for animal sedation and euthanasia are administered by licensed state veterinarians for this project. They acquire the drugs and maintain a record of purchase, storage, use and disposal of all drugs used.

G. Occupational Health and Safety

Awareness of potential stress disorders in project staff resulting from participation in lethal sea lion removal work under MMPA Section 120 authorizations.

Employees involved with the repeated euthanasia of apparently healthy, live animals can suffer from work-related stress. Studies of these phenomena have shown the negative effects on employee mental health can include compassion fatigue, burnout, traumatic or chronic stress, subconscious fears or anxieties, the general hardening of emotions, depression, and the development of unhealthy coping mechanisms (e.g. substance abuse) (See Literature Cited 1-9, Below).

We aim to be aware of potential issues that may arise related to the experiences of our employees.

Prior to the initiation of work each season, our project leaders and veterinary staff will discuss with all management staff the importance of demonstrating respect and ethical treatment of the animals that we capture, handle and ultimately may euthanize as part of project operations. These cautions and sensitivities will be repeated through the season as appropriate and needed.

An annual in-person or virtual training for all project personnel that discusses animal welfare and the concept of euthanasia. The training describes the effects of handling and anesthesia on wildlife and prioritizing the animal's state of wellbeing in all stages of capture, handling, and euthanasia. Another section of this training discusses PITS (perpetuation-induced traumatic stress), compassion fatigue or burnout, and state and agency employee assistance resource programs available to staff.

Conversations will be conducted before, during and after the season to address the need for all staff to be aware of any possible negative feelings or responses that might result

from this work, particularly as a result of the acts of euthanizing and processing (performing necropsy and disposing of) the animals.

Additionally, we will encourage staff to feel comfortable discussing concerns with supervisors. Staff, supervisors or crew leads are not to diagnose themselves or others, but are encouraged to seek professional medical or counseling assistance if they feel they (or staff working on the project) are affected by PITS (perpetuation-induced traumatic stress), compassion fatigue or burnout related to project activities.

State agency Human Resources and Safety Programs for information on exposure of staff to PTSD is also available as a resource to staff.

Concerns or other discussions by staff related to work performance and production, and employee attitude toward the work and sense of overall wellbeing should be directed to managers or crew leads. Staff will be provided appropriate options for addressing any concerns or health needs as a result of field operations, including reminders of how to access specific health resources including the Oregon and Washington Employee Assistance Programs (EAPs).

Resources:
Oregon
https://www.oregon.gov/dcbs/RightStart/Pages/EAP.aspx
https://inside.dfw.state.or.us/safety/wellness.asp

Washington
https://des.wa.gov/services/hr-finance/washington-state-employee-assistance-program-eap
http://inside.dfw.wa.gov/employees/wellness/stress.html

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G. Training on Animal Care and Use

Have you and all of the personnel listed in the table below as investigators completed Training Module 1 of the AFSC/NWFSC Animal Care and Use Training Program?

☒ YES ☐ NO

If **NO**, you must complete this Training Module before the IACUC will consider this Animal Care and Use Assurance Form.

Animal Welfare Act IACUC Training Module 1

List all the names and telephone numbers of personnel associated with this project and identified in this protocol who will work with animals or animal tissue. Check the appropriate box to indicate whether or not each individual has completed the NMFS Animal Care and Use Training Program.

IACUC Training	Name	Affiliation	Phone	Email
☒Y ☐N	Casey Clark	WDFW	206-503-4244	casey.clark@dfw.wa.gov
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☒Y ☐N	John Powell	IDFG	208-287-2789	john.powell@idfg.idaho.gov
☒Y ☐N	Alex Stacy	IDFG/PSMFC	916-834-0146	alex.stacy@idfg.idaho.gov

I. Assurance

I attest to the accuracy and completeness of the information provided. As a permitted managing party, I promise to ensure this work with animals is conducted in accordance with the outlined protocols as approved by the Columbia River California sea lion lethal removal IACUC under the NMFS Animal Care and Use Policy. I will not make any substantive changes in the above protocol without first obtaining the approval of the NMFS IACUC, and I will not use any procedures not included in this form.

Principal Investigators/Applicants:

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Signed: 08/8/2024

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<u>Appendix A</u>

Experimental Procedures Description(s)

Describe the animal procedures that are to be performed and the necessity in fulfilling the goals and objectives of the project. Be sure to be specific about any procedures which may impact the health and comfort of the study animals (e.g., frequency of performance of any procedures, methods of restraint, blood sample volumes, etc.). Please provide a justification for the animal numbers used.

Additional procedures continued from above:

- Blocking panels between traps are used to prevent animals from hauling out in-between traps where they potentially could become injured or entangled. Each panel is made of 3/8" thick x 48" wide commercial grade rubber belting material. Belting is 54" high and hangs from top of trap corner posts with ½" Blue Steel line with no gap at the bottom decking. Note: bottom of the panel can be secured to the corner posts with short lines if needed.

Appendix B

Training and Experience description(s)

The program leaders directing this work (ODFW Brown, Gillin, WDFW Clark, CRITFC Hatch, IDFG Powell, External R. Brown) have at least a combined 20 years of experience in capturing, handling and marking pinnipeds from California to Alaska. This experience includes a wide variety of methods and equipment for accomplishing this work. All euthanasia procedures will be conducted and overseen by licensed agency veterinarians. Program leaders have extensive experience performing necropsies and collecting biological samples of all types. All ODFW and WDFW project support staff have multiple years of direct experience in pinniped capture, handling, marking, necropsies, and biological sample collection. Several support staff and veterinarians have worked on this project since its inception providing extensive experience related to procedures and methodologies described herein. All support staff were trained directly by the program leaders and several have had additional experience with similar programs conducted in other areas.

Appendix 2. Tissue samples collected from euthanized animals.

SEA LION SAMPLING/RESEARCH LIST – 2023-2024			
PRIMARY SAMPLING - ALL ANIMALS			
Recipient	**Tissue**	**Purpose**	**Collection Method, Quantity, and Preservation**
OSU	Blood serum	Immune Assays	Collect up to 6 mL of blood into Red Top glass vials. Spin down and aliquot serum into 3 cryovials
UCLA	Blood serum	Leptospirosis Study	Collect up to 6 mL of blood into Red Top glass vials. Spin down and aliquot serum into 4 cryovials
WDFW/ODFW/EPMOHC	Blood serum	Disease surveillance, HPAI	Collect up to 6 mL of blood into one Red Top glass vial. Spin down and aliquot serum into 1 cryovial
ODFW	Whole Blood	Archive	Collect up to 6 mL of blood into one Purple Top vial. Transfer 1-2 mL into cryovial, discard excess
OSU	Whole Blood	Total and methylmercury	2 Royal Blue Top 6 mL vials (only 3-4 mL each) invert 5 times. Transfer to OSU for processing
OSU	Blubber	PBDE Analysis; PCBs, DDTs, Organochlorines	Collect 1 baseball-sized blubber sample and put into 250 mL amber glass jars. Do not use foil. Collect blubber in the same place where the blubber depth is measured
OSU	Fur	Heavy metals	Collect 1-inch^2 fur from the same location for each animal using stainless steel scissors or sheers. Put into envelope

ODFW	Gastro-Intestinal Tract	Food Habits	Collect stomach and large intestine. Use Ziptie to seal each. Put all bags into one contractor bag with ID label
UCLA	Kidney	Leptospirosis Study	Collect 1 cm thick wedge (1/4 circle) that includes renal pelvis. Place into Whirlpack. Freeze at -20 or -80
ODFW	Lip	Contaminants	Collect section of lip with at least 2 whiskers/ bank
OSU	Liver	Toxicology	1-2cm cube or biopsy in Whirlpak. Freeze at -20 or -80
WDFW/ODFW/EPMOHC	Lung	Disease surveillance, HPAI	Collect one 5 cm^2 section of lung tissue. Place into Whirlpack. Freeze at -20 or -80
ODFW	Lymph Node	Urogenital Cancer/OHV	Collect one sublumbar lymph node. Remove 1 cm^2 tissue sample and store in formalin
ODFW	Muscle	Archive	Use a scalpel to collect 1 muscle sample (5-10 g) into a 50 mL Falcon tube
ODFW/WDFW/ EPMOHC	Nasal Swab	Disease surveillance, HPAI	Swab nostrils well with 2 swabs, store in preservation medium
ODFW	Penis	Urogenital Cancer/OHV	1 x 2-3cm section of junction of lesion/ normal tissue; if no visible lesion still take section- formalin; 1 cm^2 section frozen; pictures for archiving
ODFW/WDFW	Skin	Genetics	Take two small pieces of skin and place in a labeled cryovials filled with 95% EtOH
Yakama	Stomach Fluid	Food Habits	Collect 10 mL of stomach fluid via needle through stomach wall. Place in 50 mL Falcon Tube filled with 20 mL 95% EtOH. Freeze at -20 or -80
WDFW	Teeth	Aging	Collect flensed snout posterior to upper canine teeth. Freeze for later post-canine and canine extraction
UCLA	Urine	Leptospirosis study	Fill 4 2ml cryovials. Freeze at -20 or -80

Recipient	Tissue	Purpose	Collection Method, Quantity, and Preservation
OSU/ODFW	Whiskers	Stable isotopes, total mercury, archive	Collect 6 whiskers, approximately the same length (~10 cm), and put into 2 labeled envelopes
SUBSAMPLING - AS POSSIBLE			
Recipient	**Tissue**	**Purpose**	**Collection Method, Quantity, and Preservation**
WDFW/ODFW	Skull	Morphometrics	Collect entire skull, flense as much tissue away as possible. Freeze for later cleaning and measurement

OSU=Oregon State University; UCLA=University of California, Los Angeles; EPMOHC=Eastern Pacific Marine One Health
Coalition; WDFW=Washington Department of Fish and Wildlife; ODFW=Oregon Department of Fish and Wildlife;
Yakama=Yakama Nation Fisheries

Appendix 3. Agent-based model for predicting post-removal prey requirements of sea lions removed under §120(f) of the Marine Mammal Protection Act.

1. Introduction

Under section 120 of the Marine Mammal Protection Act (MMPA), NOAA Fisheries has authorized the lethal removal of sea lions in the Columbia River basin to reduce predation on salmon and steelhead listed under the Endangered Species Act as well as other species of conservation concern (NMFS 2022). As part of the terms and conditions of that authorization, permit holders are required to report annually on the expected benefits of the takings such as the actual or predicted predation impacts on prey species of concern.

Direct observation of prey consumption by marine mammals is usually not possible except for unique situations such as surface feeding on large or difficult to consume prey (adult salmonids, sturgeon, and lamprey) from elevated observation substrates such as at Bonneville Dam and Willamette Falls (e.g., Braun et al. 2024, Wright et al. 2024). Even in these exceptional situations, however, estimates are typically conservative (i.e., underestimates) since they include only an unknown fraction of an individual animal's daily foraging activity in both space and time. Furthermore, it is usually not possible to attribute predation events to individual sea lions due to unknown inclusion and detection probabilities which are typically less than one. Lastly, consumption estimates based on direct observation only address past events and not predation that was hypothetically prevented in the future due to the removal program.

One method that overcomes some of these limitations is bioenergetics modeling. In this approach, the daily energy requirement of an animal is estimated and then translated into prey-specific biomass requirements which in turn can be translated into numbers of individual prey. Furthermore, the bioenergetics model can be nested in a series of models that describe other processes affecting total post-removal biomass requirements such as survival, growth, site fidelity, residency, and diet composition. Since such a complex series of models quickly becomes intractable using standard analytical approaches, one possible approach to analyzing such a system is to use agent- or individual-based models (ABMs/IBMs) (An et al. 2021, Grimm et al. 2020, Macal 2016, Sibley et al. 2013).

The objective of this exercise was to develop a sea lion management ABM to predict the cumulative, post-removal prey requirements of sea lions removed under MMPA §120(f). Note that this model is still under active development and will be updated as new data become available.

2. Methods

This draft model description follows the Overview, Design concepts, and Details (ODD) protocol for describing individual- and agent-based models (Grimm et al. 2006), as updated by Grimm et al. (2020). Additional detail will be added in future reports. The model was developed and implemented in R 4.4.1 (R Core Team 2024).

2.1. Overview: Purpose and pattern

The primary purpose of the sea lion management ABM is to predict the cumulative number of prey (particularly salmonids) required over the projected post-removal lifetime of California sea lions and/or Steller sea lions authorized for removal under MMPA §120(f) (Table A1).

We define three patterns as the criteria for model usefulness: 1) estimates of per capita biomass consumption that are consistent with the published literature; 2) estimates of per capita biomass consumption as a percent of body mass that are consistent with the published literature; and 3) estimates of numbers of prey consumed that are consistent with observation data.

2.2. Overview: Entities, state variables, and scales

Entities in the model are individual sea lions that were removed under MMPA §120(f).

Each sea lion has a unique ID and the following variables: age in years; whether or not they survived the annual time step; growth in body mass per annual time step; whether or not they returned (site fidelity) to an upriver site per seasonal time step; and the residency duration in days per seasonal time step. Within a seasonal time-step, additional variables included biomass requirements for up to three prey items including salmonids, sturgeon, lamprey, and "other". Species (CSL, SSL), sex (male), location (Bonneville Dam, Willamette Falls), season (fall = July-December; spring = January-June), and diet composition were fixed and did not vary by annual, seasonal, or daily time steps.

The model is currently non-spatial, so the environment is not represented, and sea lions only have one location per season (Bonneville Dam or Willamette Falls). The model runs at three different time scales: annual (survival, growth), seasonal (fidelity, residency, diet), and daily (bioenergetics).

2.3. Overview: Process overview and scheduling

Processes: The model was developed to cover the life cycle of nuisance sea lions as it pertains to their time at terminal upriver feeding sites in the Columbia River Basin. It is structured in a combination of several deterministic and stochastic processes (Figure A1).

Schedule: The simulation starts after the removal for each sea lion and varies depending on whether the animal was removed in the fall or spring.

For fall-season removals, a daily loop starts based on residency duration, which is estimated independently for each sea lion based on a single sample from a Poisson distribution where the parameter is based on empirical data from marked animals from Bonneville Dam and Willamette Falls. To account for the within-season removal process, the residency is multiplied by a draw from a Uniform(0,1) distribution. For each day in the residency loop, location and season specific biomass requirements are estimated based on a bioenergetics model for up to three prey types. Currently the biomass requirement is converted to number of fish at the end of the

simulation based on mean prey weights but future updates to the model may convert biomass to fish numbers at the daily level (e.g., using a multinomial distribution to select prey types).

After the fall residency loop ends, the probability of returning in the spring to an upriver location is determined independently for each sea lion based on a Bernoulli trial, where site fidelity (return probability) is based on empirical data from marked animals from Bonneville Dam and Willamette Falls (stochasticity in return location may be added at a later date). If an animal returns, residency duration is estimated as above but without any reduction due to the removal process; for spring-season removals the residency is multiplied by a draw from a Uniform(0,1) distribution.

At the end of the spring residency loop, each animal's probability of surviving to the next fall is determined by a species-, sex- (male), and age-specific survival probability as defined by a Bernoulli trial where the probability of success (survival) is based on the published literature. If an animal survives, then its age is incremented and body mass increases by an age-specific factor based on the published literature (stochasticity in growth may be added at a later date).

2.4. Design: Design concepts

The 11 design concepts (basic principles, emergence, adaptation, objectives, learning, prediction, sensing, interaction, stochasticity, collectives, and observation,) will be described at a later date.

2.5. Details: Initialization

Individual state variables (age, mass, fidelity, residency) were initialized based on either individual-specific empirical data or population averages estimated from such data (Table A2). The one exception was Steller sea lions of unknown age. Due to a relatively low sample size of tooth-aged Steller sea lions, coupled with a suspected negative bias in tooth-based aging, we instead used the median age of California sea lions (i.e., 8) for unknown-age Steller sea lions. See below for additional details on estimated initialization parameters.

2.6. Details: Input data

Three input files (besides agent data) are imported into the model: survival data, growth data, and diet composition data. These are defined in separate model scripts and are based on published literature and/or observed data.

2.7. Details: Sub-models

There are six sub-models in the ABM; two of these operate at the annual time scale (survival, growth), three at the seasonal time scale (fidelity, residency, diet), and one at the daily time scale (bioenergetics). Each agent (sea lion) only occurs at one location based on where it was removed (Bonneville Dam or Willamette Falls) but may occur in more than one season if it's resight history included more than one season (which by definition would only apply to identifiable animals). Future versions of the ABM may allow for multiple locations per year (but not within season) and inclusion of individually un-identifiable sea lions.

2.7.1. Survival sub-model (annual)

The probability of an animal surviving each annual time step was based on a species-, sex-, and age-specific survival rate (Table A3, Figure A2). Each individual at each time step lives or dies based on the outcome of a Bernoulli trial where the probability of success (survival) equals the species-, sex-, and age-specific survival rate. If the animal survives, then it advances to the growth sub-model after which its age is increased by one year regardless of whether it was removed in the spring (before its birthday) or the fall (after its birthday); future versions of the model may explicitly account for the timing of the birthday with respect to removal season.

For animals removed in the spring, the probability of surviving from spring of year i to spring of year $i + 1$ closely matches the assumptions of the survival estimates since parturition is during the summer (assumed July 1 for modeling purposes). For fall removals of animals, the meaning of annual survival becomes more ambiguous and may be refined in subsequent models. If the animal dies, then that particular run in the overall simulation is complete for that animal. Model runs that result in no biomass requirements due to mortality and/or not returning to the upriver sites are temporarily retained, however, in order to accurately estimate summary statistics. The model is run for 18 years to ensure mortality for every individual.

2.7.2. Growth sub-model (annual)

The amount of food an animal requires per day is a function of many factors but the most important is an animal's metabolic rate which in turn is a function of its body mass as stated in Kleiber's equation (adults; from Winship et al. 2002):

$$\text{Basal metabolism (BM in kJ d}^{-1}\text{)} = 292.88 \times M^{0.75}$$

where M is body mass (kg). The growth sub-model is still under development but is currently based on relative rates of change from the mass-at-age models of Winship et al. (2006) (Figure A3). Asymptotes of 1000 lbs (454 kgs) and 2000 lbs (907 kgs) were used to cap growth for CSLs and SSLs, respectively. In the ABM, the growth process is currently deterministic but future versions of the model may add stochasticity.

2.7.3. Site fidelity sub-model (seasonal)

The site fidelity sub-model estimates the probability of an animal returning to an upriver location in a given season, given that it's known to be alive. For example, CSL "2n11" was branded at Bonneville Dam in 2016 but not detected there again until 2018; his estimated fidelity rate or probability of returning was therefore one year (2018) out of two (2017, 2018) or 0.5. If that same animal had also been seen on the coast in 2020 his estimated fidelity would have been one year (2018) out of four (2017-2020) or 0.25. Removal animals that were unmarked or marked but only seen one year (e.g., removed same year as marking) were given the average fidelity rate for that species-, location-, and season combination (Table A4). The probability of an animal returning is based on the outcome of a Bernoulli trial where the probability of success (returning) equals the fidelity parameter for that animal.

It is important to note that the estimated fidelity rates are likely biased low due to imperfect detectability of marked animals since 1) in any given year a marked animal may occur but not be detected and 2) prior to marking they are undetectable by definition even though they may have occurred there for multiple years. In addition, as with other datasets, there is a time lag between data collection and data entry so new resights are continually being added and therefore fidelity estimates will likely be revised in future model runs. In addition, future versions of the ABM may include a step where the probability of returning is drawn from a multinomial distribution with three outcomes possible outcomes: not return, return to Bonneville Dam, return to Willamette Falls.

2.7.4. Residency sub-model (seasonal)

The residency sub-model estimates the number of days an animal stays at a given location in a given season, given that it has returned. Residency rates were calculated based on the elapsed days between the first and last date a marked animal was observed but only after first removing seasons in which they were marked and/or removed in order to avoid negatively biasing rates by including artificially left- or right-censored seasons. Removal animals with unknown residency histories were assigned the average residency rate for that species-, location-, and season combination (Table A4, Figure A4).

As with the site fidelity sub-model, imperfect detectability of marked animals likely led to conservative estimates of residency (i.e., too low). On the other hand, residency may have been overestimated in some cases if animals made temporary within-season trips to and from an upriver site rather than staying there the entire time between first and last detection. This latter behavior was observed in the early years of research at Bonneville Dam but it is unknown to what extent it currently occurs. In addition, apparent residency rates for CSLs at both Bonneville Dam and Willamette Falls have declined over time. Future versions of this ABM could incorporate the apparent decline in residency rather than including the mean value, although the point of this exercise is to predict what might have happened had there been no intervention and in that case the residency rates would most likely have remained high or have even increased.

2.7.5. Diet sub-model (seasonal)

The current version of the diet sub-model consists of three prey (Table A5). The precent biomass contribution of each prey type is based on a synthesis of results from scat and gastro-intestinal tract analyses as well as direct observations of surface feeding events at and below Bonneville Dam and Willamette Falls. Currently the diet composition is fixed but future versions of the ABM may include stochasticity by drawing from a multinomial distribution of prey types. Energetic densities (kJ g-1) of prey are treated as fixed except for the "other" category which draws from a uniform distribution.

Total biomass requirements are converted to numbers of fish based on average prey weights. Currently only salmonid numbers are calculated but future versions of the model may include sturgeon, lamprey, and possibly other species. Prey size currently enters the modeling process after the ABM run is complete and total prey-specific biomass estimates have been calculated.

Future versions of the ABM may treat prey size as a separate sub-model and also include stochasticity by randomly drawing prey sizes from a distribution of values rather than treating it as fixed.

2.7.6. Bioenergetics sub-model (daily)

The final component of the ABM is the bioenergetics sub-model which was modified from Winship et al. (2002). This sub-model estimates the daily biomass requirement for prey category i and predator j based on the following formula

$$BR_{ij}[kg\ d^{-1}] = \frac{GER[kJ\ d^{-1}] \times prey_i}{ED_i[kJ\ g^{-1}]} \div 1000$$

where GER is the gross energy requirement

$$\frac{P + (A_j \times BM_j)}{E_{HIF} \times E_{f+u}}$$

and A is the energetic cost of activity

$$A_j = water_j * A_{water} + (1 - water_j) * A_{land}$$

Additional parameter definitions and values are described in Table A6. (Note that the update to the denominator of GER found in Winship and Trites (2003) was not used since it is not applicable to high energetic densities such as that found in Pacific lamprey.)

In contrast to many other bioenergetic models (e.g., Winship et al. 2002), for this particular application the model was greatly simplified since it is only for one sex (males), one age-class (non-pups), and for relatively short periods of time which meant that production (growth in body mass) could be omitted. Future versions may include production, however, since Steller sea lions have longer annual residency times at Bonneville Dam than California sea lions for which the model was originally intended. On the other hand, biomass requirements for growth in adults have shown to be small relative to requirements such as basal metabolism, activity, and waste (e.g., see Figure 1 in Winship et al. 2002), so omitting it from the model is not likely to negatively bias the results.

2.8. Sensitivity analysis

Sensitivity analysis will be implemented in a future version of this ABM.

2.9 Output

Results are based on 300 repetitions of the ABM, which currently takes approximately 24 hours to run. The method of summary varies depending on whether statistics are at the individual level or the population level. At the population level, estimates are based on percentiles from the 300

repetitions, where point estimates are equal to 50th percentile (median) and interval estimates (95% CIs) are based on the 2.5th and 97.5th percentiles.

For individual-level attributes, results are summarized using a four-step approach. First, annual summaries per location-species-season-agent-run-year are stored (e.g., residency) or calculated (e.g., mean daily biomass requirement), conditional on survival and fidelity where applicable. Removal years are excluded prior to this step since they would negatively bias the results. Second, mean values per location-species-season-agent-run are calculated across years such that the total number of records equals the product of the number of repetitions (300) and agents (193 in 2024). Third, mean values per location-species-season-agent are calculated across runs such that the total number records equal the number of agents. And finally, the mean and range per location-species-season are calculated across agents such that the total number of records equals the number of agents in each location-species-season combination.

3. Results

The predicted post-removal salmonid requirements for the 185 sea lions removed under MMPA §120(f) was 41,887 salmonids (95% CI = 26,875-61,384) (Figure A5). Individual-level summary statistics are summarized in Table A7.

4. Discussion

Section 2.1 defined three patterns as the criteria for model usefulness: 1) estimates of per capita biomass consumption that are consistent with the published literature; 2) estimates of per capita biomass consumption as a percent of body mass that are consistent with the published literature; and 3) estimates of numbers of prey consumed that are consistent with observation data. Regarding the first two criteria, while it's important to note that bioenergetic models produce estimates of food requirements and not food consumption, the ABM results (Table A7) were nonetheless consistent with published data on food consumption by captive animals.

For example, Kastelein et al. (2000) reported that one captive 16-year-old male California sea lion consumed an average 9.5 kg day^{-1} and up to a maximum of 35.5 kg day^{-1}. This is comparable to mean ABM estimates of 12.5 and 15.2 kg day^{-1} at Bonneville Dam and Willamette Falls, respectively. Similarly, Kastelein et al. (1990) reported that one captive 16-year-old male Steller sea lion consumed an average of approximately 20 kg day^{-1} and up to a maximum of 26 kg day^{-1}. This is also comparable to mean ABM estimates ranging from 24.0-29.1 kg day^{-1}. Likewise, when expressed as a percentage of body weight, estimates of daily food consumption by captive male California sea lions and Steller sea lions (i.e., 3-9%; Winship et al. 2006) were similar to ABM estimates (3.2-5.0%).

Regarding the third criteria, while direct comparisons between the ABM results and surface-based predation estimates are challenging for a variety of reasons (e.g., differing predator population sizes, limited fall observation effort), results from the ABM are nonetheless a similar order of magnitude as observation-based estimates. One potentially surprising result, however, is the high level of predation in the fall by Steller sea lions at Bonneville Dam compared to the

spring (Figure A5). This was due to the fact that even though salmonids were assumed to be a smaller proportion of their diet (Table A5), higher rates of both fidelity and residency (Table A4) translated into higher rates of predation than in the spring. And while both observed fall Chinook salmon and coho salmon take by Steller sea lions at Bonneville Dam are estimated to be in the hundreds (Braun et al. 2024), it is suspected that most salmonid predation is on chum salmon further downriver of the dam.

In conclusion, agent-based modeling has proven to be a useful and effective framework for the ongoing analysis of the benefits of sea lion management in the Columbia River Basin. Future work on the model may include a restructuring of how daily prey requirements are calculated as well as incorporating additional stochasticity into one or more of the sub-models (e.g., diet).

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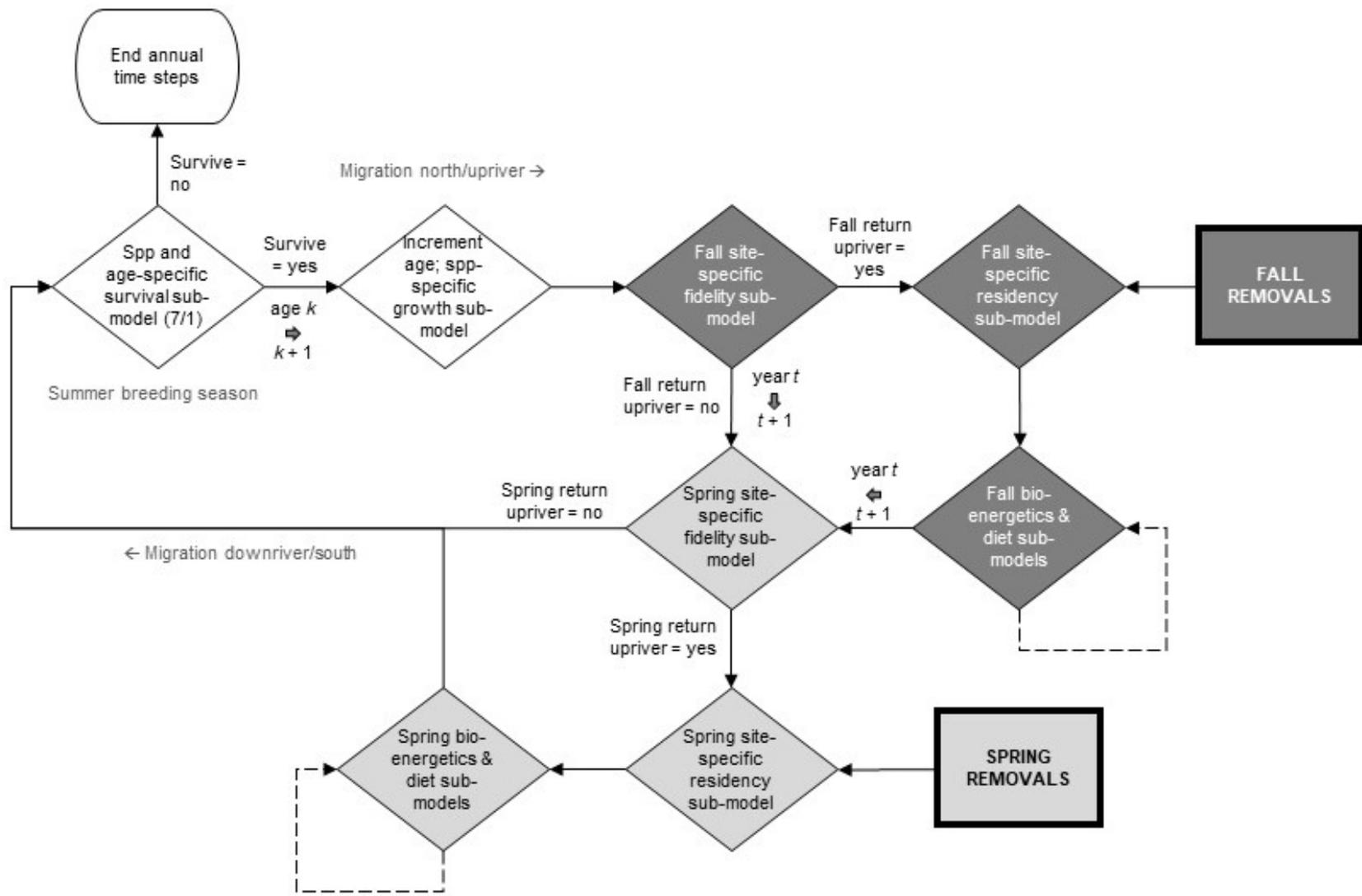
Figure A1. Flowchart of sea lion management agent-based model.
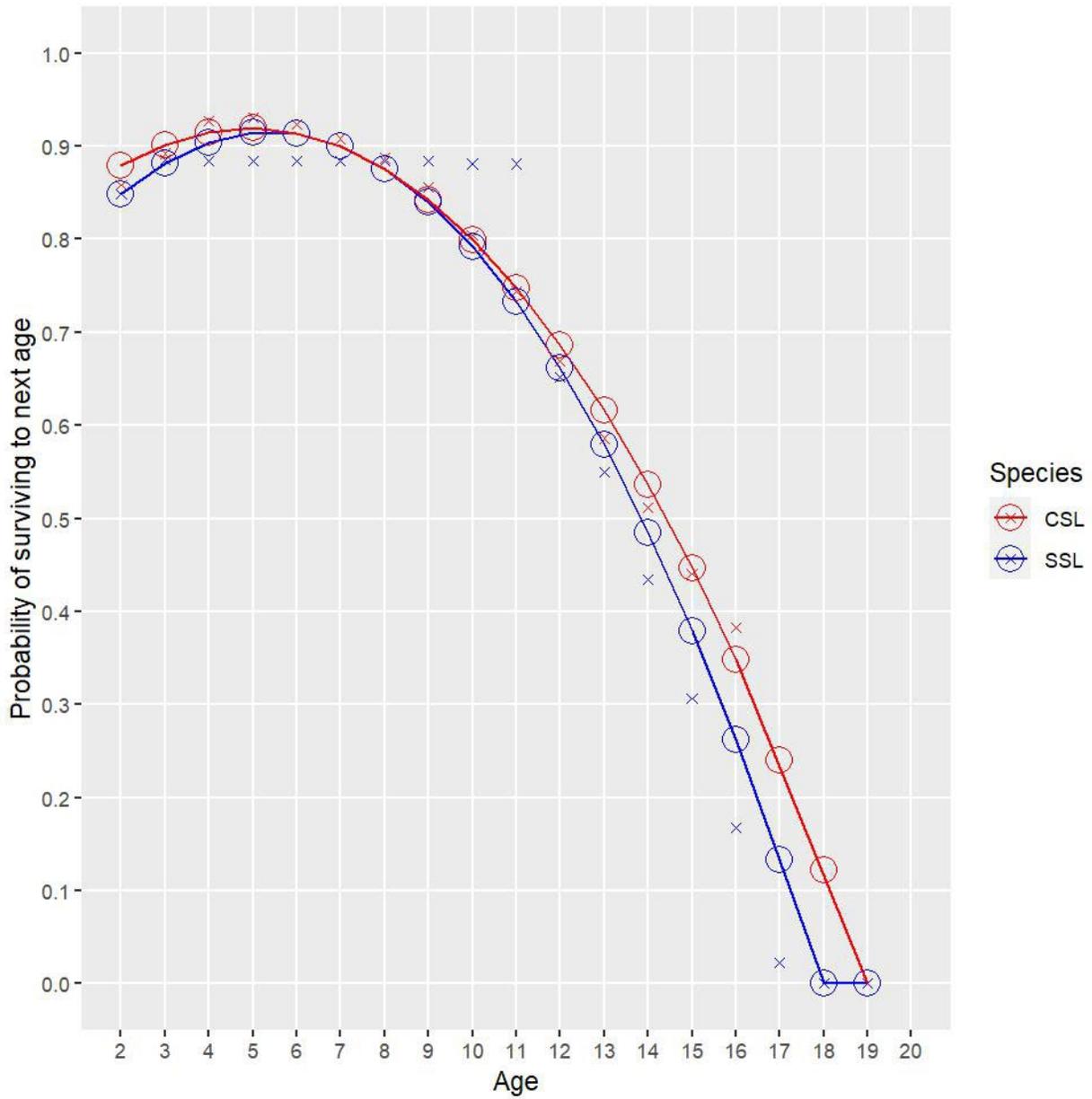
Figure A2. Survival sub-model. California sea lion (CSL) data from DeLong et al. (2017); Steller sea lion (SSL) data from Wright et al. (2017; ages 0-11) and Maniscalco et al. (2015; ages >11); lines indicate second order polynomial fits to data. See Table 3 for additional details.
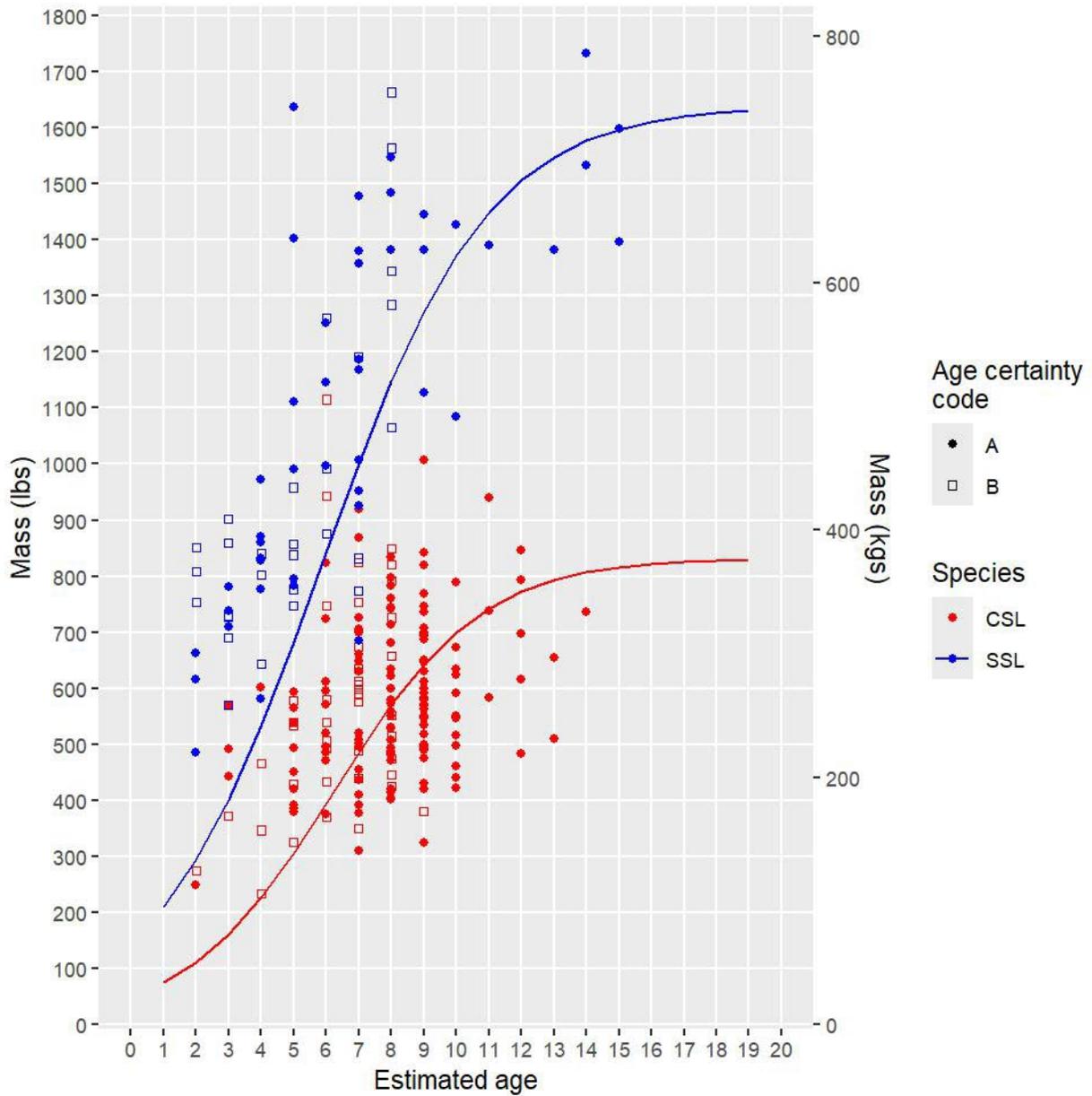
Figure A3. Growth sub-model. Lines represent mass-at-age growth curves for male California sea lions (CSL) and Steller sea lions (SSL) (Winship et al. 2006); points represent empirical age and weight data from sea lions removed at Bonneville Dam and Willamette Falls. Age certainty code is a reliability index provided by Matson's Laboratory, where "A" is the highest reliability rating.
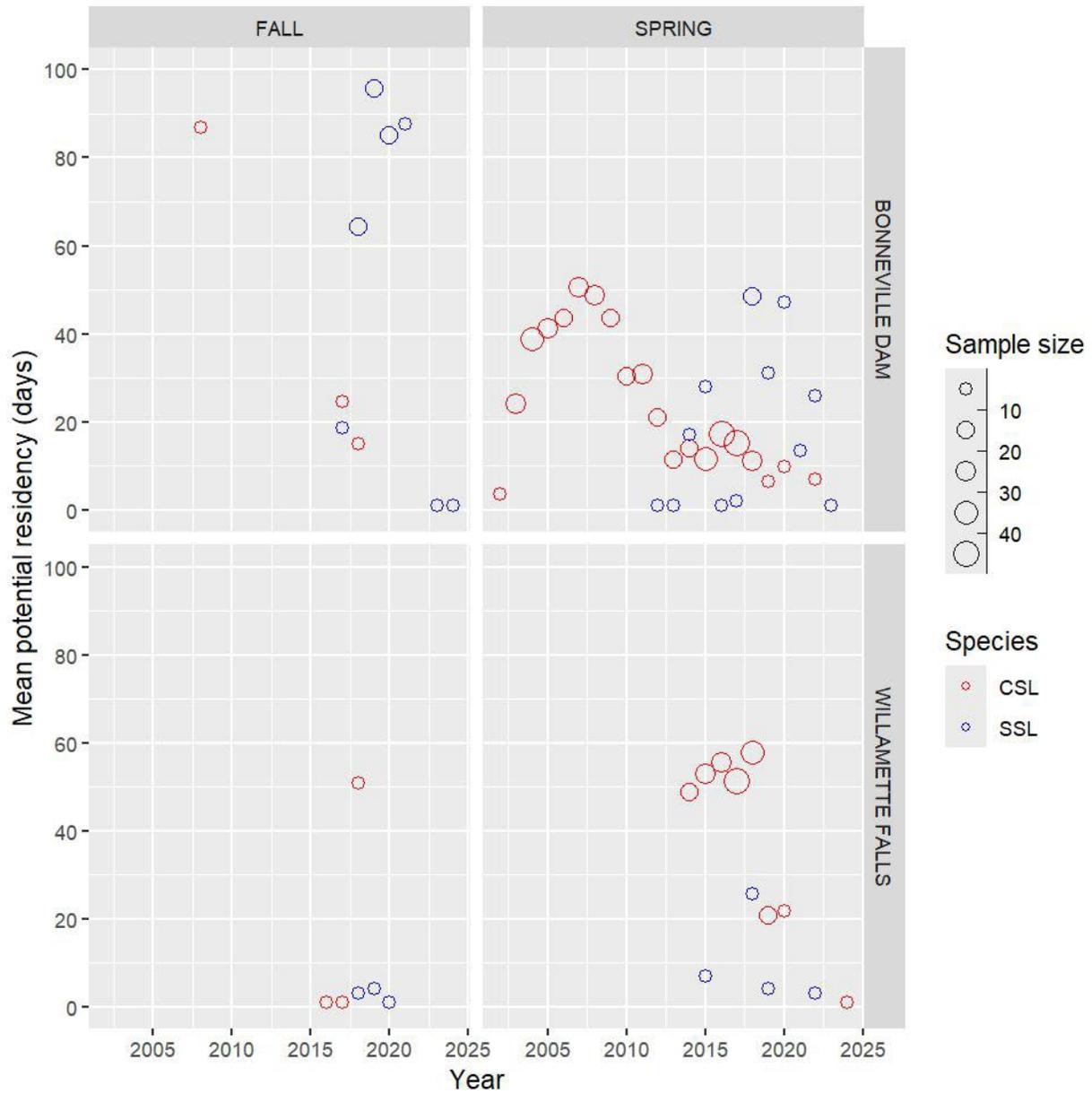
Figure A4. Residency sub-model. Annual average potential residency by year, season, location and species (based on all identifiable upriver animals, not just removals).
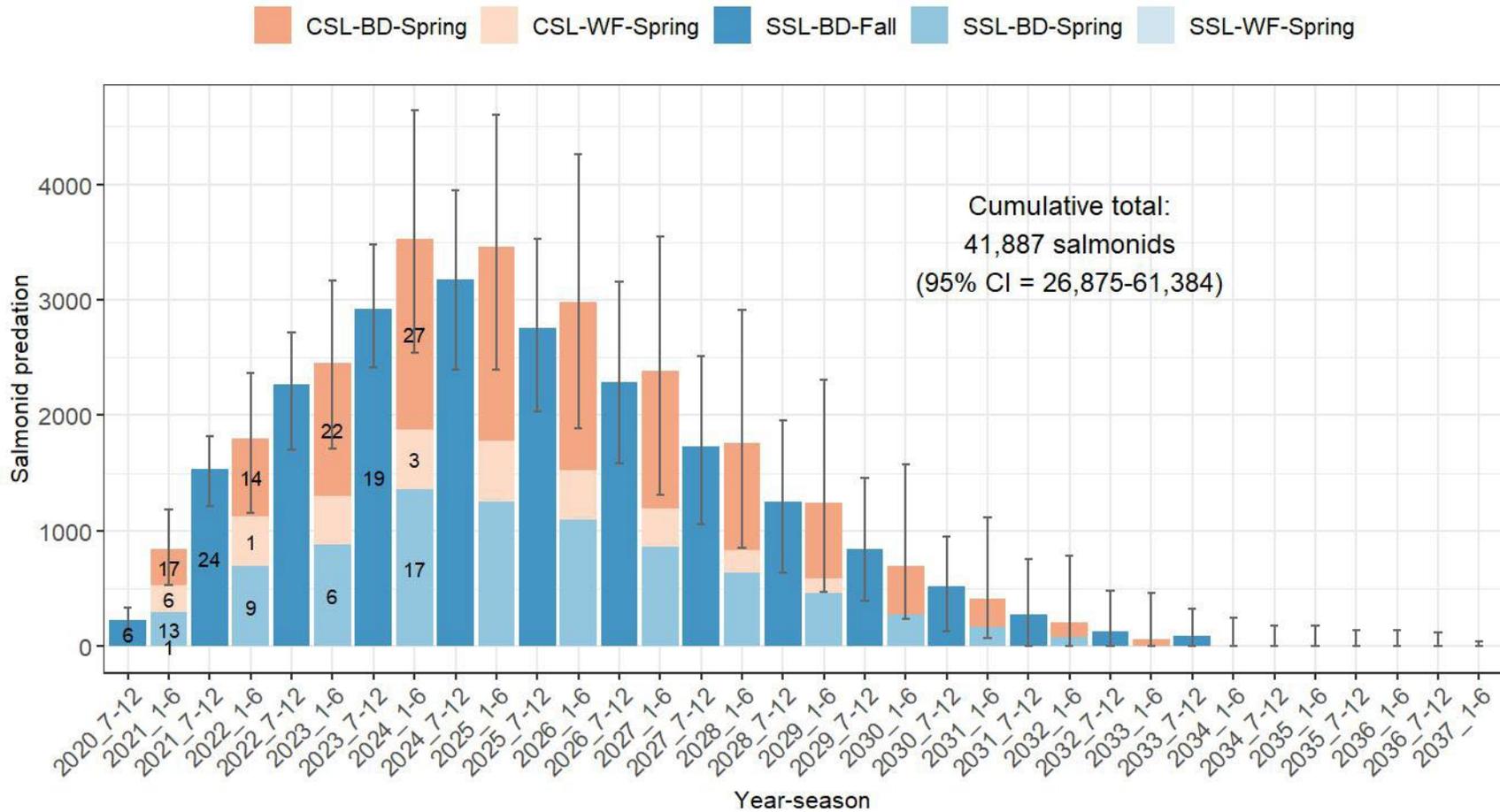
Figure A5. Predicted post-removal salmonid requirements for 90 California sea lions (CSLs) and 95 Steller sea lions (SSLs; includes one suspected hybrid) removed at Bonneville Dam (BD) and Willamette Falls (WF) from fall 2020 to spring 2024 under MMPA §120(f). Predictions based on 2.5th, 50th, and 97.5th percentiles from 300 ABM simulations; numbers overlaid on bars indicate number of animals removed for the species-location-season combination indicated in the legend.

Table A1. California sea lions (CSLs) and Steller sea lions (SSLs) removed at Bonneville Dam (BD) and Willamette Falls (WF) from fall 2020 to spring 2024 under MMPA §120(f). Animals removed under separate but overlapping MMPA §120 authority were not included.

Location	Species	Season	2020	2021	2022	2023	2024	Total removals
BD	CSL	Spring	NA	17	14	22	27	80
	SSL	Spring	NA	13	9	6	17	45
		Fall	6	24	0	19	NA	49
WF	CSL	Spring	NA	6	1	0	3	10
	SSL	Spring	NA	1	0	0	0	1
Total			6	61	24	47	47	185

Table A2. Dataset used to initiate the ABM, sorted by date of capture. The variable 'Type' indicates whether individual-level (I) or population-level (P) data were used to parameterize the preceding variable to its left. Note that O37 was a suspected hybrid SSL-CSL but was modeled as a SSL.

Agent	Individual	Spp	ID	Location	Season	Date	Age	Type	Mass_kgs	Type	Fidelity_p	Type	Residency_d	Type
1	1	Ej	EB001	BD	Fall	20201014	8	P	403	I	0.84	P	54	P
2	2	Ej	EB002	BD	Fall	20201015	3	I	322	I	0.84	P	54	P
3	3	Ej	O53	BD	Fall	20201022	5	I	339	I	1.00	I	123	I
4		Ej	O53	BD	Spring	20201022	5	I	339	I	1.00	I	25	P
5	4	Ej	EB003	BD	Fall	20201103	4	I	352	I	0.84	P	54	P
6	5	Ej	O44	BD	Fall	20201104	7	I	431	I	1.00	I	48	I
7		Ej	O44	BD	Spring	20201104	7	I	431	I	0.67	I	1	I
8	6	Ej	EB004	BD	Fall	20201105	3	I	409	I	0.84	P	54	P
9	7	Ej	EW001	WF	Spring	20210302	8	P	455	P	0.10	P	16	P
10	8	Ej	EB005	BD	Spring	20210406	4	I	364	I	0.38	P	25	P
11	9	Zc	ZW001	WF	Spring	20210413	8	P	258	P	0.87	P	39	P
12	10	Zc	ZW002	WF	Spring	20210413	8	P	258	P	0.87	P	39	P
13	11	Zc	ZW003	WF	Spring	20210413	8	P	258	P	0.87	P	39	P
14	12	Ej	EB006	BD	Spring	20210414	6	I	567	I	0.38	P	25	P
15	13	Zc	ZB001	BD	Spring	20210414	5	I	242	I	0.71	P	22	P
16	14	Ej	EB007	BD	Spring	20210415	3	I	390	I	0.38	P	25	P
17	15	Ej	EB008	BD	Spring	20210415	2	I	367	I	0.38	P	25	P
18	16	Zc	ZB002	BD	Spring	20210415	9	I	338	I	0.71	P	22	P
19	17	Zc	ZW004	WF	Spring	20210415	8	P	258	P	0.87	P	39	P
20	18	Ej	O41	BD	Fall	20210420	5	I	636	I	1.00	I	1	I
21		Ej	O41	BD	Spring	20210420	5	I	636	I	0.75	I	22	I
22	19	Zc	ZW005	WF	Spring	20210420	8	P	258	P	0.87	P	39	P
23	20	Zc	ZW006	WF	Spring	20210420	8	P	258	P	0.87	P	39	P
24	21	Ej	EB009	BD	Spring	20210421	6	I	397	I	0.38	P	25	P
25	22	Ej	EB010	BD	Spring	20210422	6	I	452	I	0.38	P	25	P
26	23	Ej	EB011	BD	Spring	20210428	2	I	342	I	0.38	P	25	P
27	24	Ej	EB012	BD	Spring	20210428	4	I	381	I	0.38	P	25	P
28	25	Zc	ZB003	BD	Spring	20210428	10	I	250	I	0.71	P	22	P
29	26	Zc	06n3	BD	Spring	20210429	8	I	282	I	1.00	I	1	I
30	27	Ej	EB013	BD	Spring	20210429	3	I	313	I	0.38	P	25	P
31	28	Zc	ZB004	BD	Spring	20210429	6	I	506	I	0.71	P	22	P

Agent	Individual	Spp	ID	Location	Season	Date	Age	Type	Mass_kgs	Type	Fidelity_p	Type	Residency_d	Type
32	29	Zc	X693	BD	Spring	20210504	10	I	209	I	0.71	P	22	P
33	30	Zc	ZB005	BD	Spring	20210504	8	I	288	I	0.71	P	22	P
34	31	Zc	ZB006	BD	Spring	20210504	9	I	272	I	0.71	P	22	P
35	32	Zc	ZB007	BD	Spring	20210504	6	I	264	I	0.71	P	22	P
36	33	Zc	ZB008	BD	Spring	20210504	5	I	245	I	0.71	P	22	P
37	34	Ej	EB014	BD	Spring	20210505	3	I	335	I	0.38	P	25	P
38	35	Zc	ZB009	BD	Spring	20210505	6	I	339	I	0.71	P	22	P
39	36	Zc	ZB010	BD	Spring	20210505	6	I	259	I	0.71	P	22	P
40	37	Zc	ZB011	BD	Spring	20210505	5	I	262	I	0.71	P	22	P
41	38	Ej	EB015	BD	Spring	20210506	5	I	355	I	0.38	P	25	P
42	39	Zc	ZB012	BD	Spring	20210506	3	I	223	I	0.71	P	22	P
43	40	Zc	ZB013	BD	Spring	20210511	5	I	244	I	0.71	P	22	P
44	41	Zc	ZB014	BD	Spring	20210511	6	I	224	I	0.71	P	22	P
45	42	Zc	ZB015	BD	Spring	20210511	8	P	552	I	0.71	P	22	P
46	43	Ej	EB016	BD	Spring	20210512	8	P	721	I	0.38	P	25	P
47	44	Ej	EB017	BD	Fall	20210914	5	I	352	I	0.84	P	54	P
48	45	Ej	EB018	BD	Fall	20210915	5	I	435	I	0.84	P	54	P
49	46	Ej	EB019	BD	Fall	20210915	3	I	259	I	0.84	P	54	P
50	47	Ej	EB020	BD	Fall	20210916	5	I	361	I	0.84	P	54	P
51	48	Ej	O49	BD	Fall	20210921	5	I	504	I	1.00	I	133	I
52		Ej	O49	BD	Spring	20210921	5	I	504	I	1.00	I	2	I
53	49	Ej	EB021	BD	Fall	20210922	10	I	492	I	0.84	P	54	P
54	50	Ej	EB022	BD	Fall	20210923	15	I	634	I	0.84	P	54	P
55	51	Ej	EB023	BD	Fall	20210928	4	I	390	I	0.84	P	54	P
56	52	Ej	EB024	BD	Fall	20210929	8	I	709	I	0.84	P	54	P
57	53	Ej	EB025	BD	Fall	20210930	4	I	292	I	0.84	P	54	P
58	54	Ej	EB026	BD	Fall	20211006	8	I	673	I	0.84	P	54	P
59	55	Ej	EB027	BD	Fall	20211006	7	I	626	I	0.84	P	54	P
60	56	Ej	O48	BD	Fall	20211007	8	I	610	I	1.00	I	84	I
61		Ej	O48	BD	Spring	20211007	8	I	610	I	1.00	I	89	I
62	57	Ej	O42	BD	Fall	20211014	7	I	541	I	1.00	I	76	I
63		Ej	O42	BD	Spring	20211014	7	I	541	I	1.00	I	33	I
64	58	Ej	EB028	BD	Fall	20211102	7	I	457	I	0.84	P	54	P
65	59	Ej	EB029	BD	Fall	20211103	6	I	450	I	0.84	P	54	P

Agent	Individual	Spp	ID	Location	Season	Date	Age	Type	Mass_kgs	Type	Fidelity_p	Type	Residency_d	Type
66	60	Ej	O47	BD	Fall	20211103	7	I	670	I	1.00	I	83	I
67		Ej	O47	BD	Spring	20211103	7	I	670	I	1.00	I	14	I
68	61	Ej	EB030	BD	Fall	20211109	4	I	377	I	0.84	P	54	P
69	62	Ej	EB031	BD	Fall	20211109	7	I	529	I	0.84	P	54	P
70	63	Ej	EB032	BD	Fall	20211110	5	I	449	I	0.84	P	54	P
71	64	Ej	EB033	BD	Fall	20211116	6	I	572	I	0.84	P	54	P
72	65	Ej	EB034	BD	Fall	20211116	8	P	784	I	0.84	P	54	P
73	66	Ej	EB035	BD	Fall	20211117	15	I	724	I	0.84	P	54	P
74	67	Ej	EB036	BD	Fall	20211117	14	I	695	I	0.84	P	54	P
75	68	Ej	EB037	BD	Spring	20220419	7	I	538	I	0.38	P	25	P
76	69	Ej	EB038	BD	Spring	20220420	9	I	655	I	0.38	P	25	P
77	70	Ej	EB039	BD	Spring	20220420	8	I	754	I	0.38	P	25	P
78	71	Zc	ZB016	BD	Spring	20220420	5	I	195	I	0.71	P	22	P
79	72	Ej	O37	BD	Spring	20220422	8	P	873	I	0.56	I	36	I
80	73	Zc	X842	BD	Spring	20220426	6	I	230	I	0.71	P	22	P
81	74	Zc	ZB017	BD	Spring	20220426	8	I	329	I	0.71	P	22	P
82	75	Zc	ZV018	BD	Spring	20220426	7	I	317	I	0.71	P	22	P
83	76	Ej	EB040	BD	Spring	20220427	4	I	441	I	0.38	P	25	P
84	77	Ej	EB041	BD	Spring	20220428	5	I	743	I	0.38	P	25	P
85	78	Zc	ZB019	BD	Spring	20220428	8	I	362	I	0.71	P	22	P
86	79	Zc	C096	BD	Spring	20220503	8	I	378	I	0.57	I	13	I
87	80	Ej	EB042	BD	Spring	20220503	4	I	375	I	0.38	P	25	P
88	81	Zc	ZB020	BD	Spring	20220503	5	I	224	I	0.71	P	22	P
89	82	Zc	ZB021	BD	Spring	20220503	3	I	201	I	0.71	P	22	P
90	83	Zc	ZB022	BD	Spring	20220503	4	I	211	I	0.71	P	22	P
91	84	Zc	2n61	BD	Spring	20220504	9	I	316	I	0.50	I	1	I
92	85	Zc	ZB023	BD	Spring	20220505	9	I	371	I	0.71	P	22	P
93	86	Ej	EB043	BD	Spring	20220510	4	I	395	I	0.38	P	25	P
94	87	Ej	EB044	BD	Spring	20220510	3	I	330	I	0.38	P	25	P
95	88	Zc	ZB024	BD	Spring	20220510	8	P	298	I	0.71	P	22	P
96	89	Zc	ZB025	BD	Spring	20220511	5	I	269	I	0.71	P	22	P
97	90	Zc	ZB026	BD	Spring	20220511	7	I	272	I	0.71	P	22	P
98	91	Zc	ZW007	WF	Spring	20220516	8	P	311	I	0.87	P	39	P
99	92	Zc	ZB027	BD	Spring	20230420	7	I	329	I	0.71	P	22	P

Agent	Individual	Spp	ID	Location	Season	Date	Age	Type	Mass_kgs	Type	Fidelity_p	Type	Residency_d	Type
100	93	Zc	ZB028	BD	Spring	20230420	6	I	277	I	0.71	P	22	P
101	94	Ej	EB045	BD	Spring	20230502	2	I	279	I	0.38	P	25	P
102	95	Ej	EB046	BD	Spring	20230502	2	I	301	I	0.38	P	25	P
103	96	Zc	ZB029	BD	Spring	20230502	7	I	286	I	0.71	P	22	P
104	97	Zc	ZB030	BD	Spring	20230502	7	I	171	I	0.71	P	22	P
105	98	Ej	EB047	BD	Spring	20230503	5	I	389	I	0.38	P	25	P
106	99	Zc	ZB031	BD	Spring	20230503	6	I	245	I	0.71	P	22	P
107	100	Zc	ZB032	BD	Spring	20230503	6	I	373	I	0.71	P	22	P
108	101	Zc	ZB033	BD	Spring	20230504	8	I	224	I	0.71	P	22	P
109	102	Zc	ZB034	BD	Spring	20230504	4	I	106	I	0.71	P	22	P
110	103	Zc	ZB035	BD	Spring	20230504	9	I	293	I	0.71	P	22	P
111	104	Zc	ZB036	BD	Spring	20230504	7	I	199	I	0.71	P	22	P
112	105	Ej	EB048	BD	Spring	20230509	7	I	311	I	0.38	P	25	P
113	106	Zc	ZB037	BD	Spring	20230509	7	I	342	I	0.71	P	22	P
114	107	Ej	EB049	BD	Spring	20230510	3	I	354	I	0.38	P	25	P
115	108	Zc	ZB038	BD	Spring	20230510	9	I	348	I	0.71	P	22	P
116	109	Zc	ZB039	BD	Spring	20230510	6	I	270	I	0.71	P	22	P
117	110	Zc	ZB040	BD	Spring	20230510	9	I	286	I	0.71	P	22	P
118	111	Ej	EB050	BD	Spring	20230511	2	I	220	I	0.38	P	25	P
119	112	Zc	ZB041	BD	Spring	20230511	2	I	113	I	0.71	P	22	P
120	113	Zc	ZB042	BD	Spring	20230511	9	I	312	I	0.71	P	22	P
121	114	Zc	ZB043	BD	Spring	20230511	8	I	263	I	0.71	P	22	P
122	115	Zc	ZB044	BD	Spring	20230516	3	I	169	I	0.71	P	22	P
123	116	Zc	ZB045	BD	Spring	20230516	5	I	148	I	0.71	P	22	P
124	117	Zc	ZB046	BD	Spring	20230516	13	I	297	I	0.71	P	22	P
125	118	Zc	ZB047	BD	Spring	20230516	2	I	124	I	0.71	P	22	P
126	119	Zc	ZB048	BD	Spring	20230516	8	I	202	I	0.71	P	22	P
127	120	Ej	EB051	BD	Fall	20230912	7	I	420	I	0.84	P	54	P
128	121	Ej	EB052	BD	Fall	20230912	7	I	616	I	0.84	P	54	P
129	122	Ej	EB053	BD	Fall	20230913	14	I	786	I	0.84	P	54	P
130	123	Ej	EB054	BD	Fall	20231011	13	I	627	I	0.84	P	54	P
131	124	Ej	EB055	BD	Fall	20231011	7	I	377	I	0.84	P	54	P
132	125	Ej	EB056	BD	Fall	20231012	6	I	519	I	0.84	P	54	P
133	126	Ej	EB057	BD	Fall	20231012	5	I	380	I	0.84	P	54	P

Agent	Individual	Spp	ID	Location	Season	Date	Age	Type	Mass_kgs	Type	Fidelity_p	Type	Residency_d	Type
134	127	Ej	EB058	BD	Fall	20231012	7	I	351	I	0.84	P	54	P
135	128	Ej	EB059	BD	Fall	20231018	8	I	626	I	0.84	P	54	P
136	129	Ej	EB060	BD	Fall	20231024	10	I	647	I	0.84	P	54	P
137	130	Ej	EB061	BD	Fall	20231026	11	I	630	I	0.84	P	54	P
138	131	Ej	EB062	BD	Fall	20231031	8	I	582	I	0.84	P	54	P
139	132	Ej	EB063	BD	Fall	20231101	9	I	511	I	0.84	P	54	P
140	133	Ej	O50	BD	Fall	20231101	8	I	702	I	0.83	I	115	I
141		Ej	O50	BD	Spring	20231101	8	I	702	I	1.00	I	81	I
142	134	Ej	EB064	BD	Fall	20231114	9	I	626	I	0.84	P	54	P
143	135	Ej	EB065	BD	Fall	20231114	8	I	483	I	0.84	P	54	P
144	136	Ej	EB066	BD	Fall	20231130	4	I	264	I	0.84	P	54	P
145	137	Ej	EB067	BD	Fall	20231130	3	I	331	I	0.84	P	54	P
146	138	Ej	EB068	BD	Fall	20231130	2	I	386	I	0.84	P	54	P
147	139	Ej	EB069	BD	Spring	20240402	8	P	552	I	0.38	P	25	P
148	140	Ej	EB070	BD	Spring	20240402	8	P	448	I	0.38	P	25	P
149	141	Zc	ZB049	BD	Spring	20240404	8	P	306	I	0.71	P	22	P
150	142	Zc	ZB050	BD	Spring	20240404	8	P	298	I	0.71	P	22	P
151	143	Ej	EB071	BD	Spring	20240409	8	P	577	I	0.38	P	25	P
152	144	Ej	EB072	BD	Spring	20240409	8	P	406	I	0.38	P	25	P
153	145	Ej	EB073	BD	Spring	20240409	8	P	680	I	0.38	P	25	P
154	146	Ej	EB074	BD	Spring	20240410	8	P	601	I	0.38	P	25	P
155	147	Ej	EB075	BD	Spring	20240410	8	P	404	I	0.38	P	25	P
156	148	Ej	EB076	BD	Spring	20240410	8	P	484	I	0.38	P	25	P
157	149	Ej	EB077	BD	Spring	20240411	8	P	510	I	0.38	P	25	P
158	150	Ej	EB078	BD	Spring	20240411	8	P	311	I	0.38	P	25	P
159	151	Zc	ZB051	BD	Spring	20240411	8	P	236	I	0.71	P	22	P
160	152	Ej	EB079	BD	Spring	20240416	8	P	522	I	0.38	P	25	P
161	153	Ej	EB080	BD	Spring	20240416	8	P	648	I	0.38	P	25	P
162	154	Zc	ZB052	BD	Spring	20240416	8	P	209	I	0.71	P	22	P
163	155	Ej	EB081	BD	Spring	20240417	8	P	476	I	0.38	P	25	P
164	156	Ej	EB082	BD	Spring	20240417	8	P	674	I	0.38	P	25	P
165	157	Zc	ZB053	BD	Spring	20240423	8	P	186	I	0.71	P	22	P
166	158	Zc	ZB054	BD	Spring	20240423	8	P	243	I	0.71	P	22	P
167	159	Zc	ZB055	BD	Spring	20240423	8	P	203	I	0.71	P	22	P

Agent	Individual	Spp	ID	Location	Season	Date	Age	Type	Mass_kgs	Type	Fidelity_p	Type	Residency_d	Type
168	160	Zc	ZB056	BD	Spring	20240423	8	P	184	I	0.71	P	22	P
169	161	Zc	ZB057	BD	Spring	20240423	8	P	155	I	0.71	P	22	P
170	162	Zc	ZB058	BD	Spring	20240423	8	P	109	I	0.71	P	22	P
171	163	Zc	ZB059	BD	Spring	20240423	8	P	271	I	0.71	P	22	P
172	164	Zc	ZB060	BD	Spring	20240424	8	P	103	I	0.71	P	22	P
173	165	Zc	ZB061	BD	Spring	20240424	8	P	157	I	0.71	P	22	P
174	166	Zc	ZB062	BD	Spring	20240424	8	P	151	I	0.71	P	22	P
175	167	Zc	ZB063	BD	Spring	20240424	8	P	157	I	0.71	P	22	P
176	168	Zc	ZB064	BD	Spring	20240424	8	P	84	I	0.71	P	22	P
177	169	Zc	ZB065	BD	Spring	20240424	8	P	187	I	0.71	P	22	P
178	170	Zc	2n65	BD	Spring	20240425	8	P	378	I	0.60	I	14	I
179	171	Ej	EB083	BD	Spring	20240425	8	P	486	I	0.38	P	25	P
180	172	Zc	ZB066	BD	Spring	20240425	8	P	256	I	0.71	P	22	P
181	173	Zc	ZB067	BD	Spring	20240425	8	P	323	I	0.71	P	22	P
182	174	Zc	ZB068	BD	Spring	20240502	8	P	280	I	0.71	P	22	P
183	175	Ej	EB084	BD	Spring	20240507	8	P	612	I	0.38	P	25	P
184	176	Ej	EB085	BD	Spring	20240507	8	P	404	I	0.38	P	25	P
185	177	Zc	ZB069	BD	Spring	20240507	8	P	251	I	0.71	P	22	P
186	178	Zc	ZB070	BD	Spring	20240507	8	P	161	I	0.71	P	22	P
187	179	Zc	ZB071	BD	Spring	20240507	8	P	337	I	0.71	P	22	P
188	180	Zc	ZB072	BD	Spring	20240508	8	P	338	I	0.71	P	22	P
189	181	Zc	ZB073	BD	Spring	20240508	8	P	270	I	0.71	P	22	P
190	182	Zc	ZB074	BD	Spring	20240508	8	P	313	I	0.71	P	22	P
191	183	Zc	ZW008	WF	Spring	20240508	8	P	414	I	0.87	P	39	P
192	184	Zc	ZW009	WF	Spring	20240508	8	P	350	I	0.87	P	39	P
193	185	Zc	ZW010	WF	Spring	20240514	8	P	420	I	0.87	P	39	P

Table A3. Survival sub-model parameters. Estimate is value from the published literature and indicates probability of surviving to next age (e.g., probability of male CSL surviving from age 2 to age 3 is 0.858). Final indicates predicted value from second order polynomial fit to published estimates (see footnotes).

	Male California sea lion survival probabilities			Male Steller sea lion survival probabilities		
Age	Estimate	Source	Final	Estimate	Source	Final
2[a]	0.858	Table 3, DeLong et al. 2017	0.879	0.848	Averaged 2002-2009 cohorts, Table S2, Wright et al. 2017	0.849
3	0.892	Ibid	0.901	0.885	Ibid	0.882
4	0.927	Ibid	0.915	0.884	Ibid	0.904
5	0.931	Ibid	0.919	0.884	Ibid	0.914
6	0.923	Ibid	0.914	0.884	Ibid	0.913
7	0.908	Ibid	0.899	0.884	Ibid	0.900
8	0.887	Ibid	0.876	0.884	Ibid	0.875
9	0.856	Ibid	0.842	0.884	Ibid	0.839
10	0.804	Ibid	0.800	0.881	Ibid	0.792
11	0.744	Ibid	0.748	0.881	Ibid	0.732
12	0.669	Ibid	0.686	0.652	Table S1/Appendix 1b, Maniscalco et al. 2015	0.661
13	0.586	Ibid	0.616	0.550	Ibid	0.579
14	0.512	Ibid	0.536	0.434	Ibid	0.485
15	0.440	Ibid	0.446	0.306	Ibid	0.379
16	0.383	Ibid	0.348	0.168	Ibid	0.262
17	0.354[b]	Ibid	0.240	0.023	Ibid	0.133
18	0.350[b]	Ibid	0.122	0.001	Ibid	0.001
19	0.366[c]	Ibid	0.000	0.001[c]	Ibid	0.000

[a] No CSLs <2 years of age have been observed in removal population
[b] Set to NA (prior to smoothing) due to small sample size and high uncertainty in estimates
[c] Set to zero since no male CSL in the study was sighted >19 years of age; survival of male SSL >19 was also effectively zero.

Table A4. Fidelity and residency sub-model parameters based on mark-resight data of all upriver animals (not just removals). Note that some individuals may occur in multiple locations and/or seasons.

Location	Species	Season	Fidelity*		Residency (days)**	
			Mean	n	Mean	n
BD	CSL	Spring	0.71	363	21.6	252
	SSL	Spring	0.38	49	24.6	31
		Fall	0.84	21	54.3	25
WF	CSL	Spring	0.87	57	38.7	72
	SSL	Spring	0.10	6	16.1	6

* Base dataset consisted of 16,280 resights of 570 individual sea lions. Excluding cases where an animal was only seen upriver one season and then never again (anywhere) resulted in 14,261 resights of 443 individual sea lions.

**Base dataset consisted of 16,280 resights of 570 animals. Excluding season of initial marking and/or removal resulted in 12,736 resights of 369 animals. Further excluding cases where <20% of the residency was actually resighted resulted in a dataset of 11,793 resights of 342 animals.

Table A5. Diet sub-model parameters based on synthesis of scat, gastro-intestinal tract, and surface feeding data from Bonneville Dam (BD) and Willamette Falls (WF).

| Location | Spp | Season | Diet component #1 | | | | Diet component #2 | | | Diet component #3 | | |
			Prey	%	ED (kJ/g)*	Weight (kg)**	Prey	%	ED (kJ/g)*	Prey	%	ED (kJ/g)*
BD	CSL	Spring	Spring Chinook salmon	90	7.2	5.7	Pacific lamprey	5	25.65	Other	5	$U(3, 7.2)$
	SSL	Spring	Spring Chinook salmon	70	7.2	5.7	White sturgeon	20	4.4	Other	10	$U(3, 7.2)$
		Fall	Salmonid	40	5.9	5.4	White sturgeon	40	4.4	Other	20	$U(3, 7.2)$
WF	CSL	Spring	Salmonid	85	5.9	5.4	Pacific lamprey	10	25.65	Other	5	$U(3, 7.2)$
	SSL	Spring	Salmonid	15	5.9	5.4	White sturgeon	70	4.4	Other	15	$U(3, 7.2)$

*Energetic density (ED) sources: salmonids (O'Neil et al 2014), sturgeon (pers. com. P. Stevens, ODFW), lamprey (Clemens et al. 2019), other (Winship and Trites 2003).

**Mean weight sources: salmonids (predation-weighted mean of salmon and steelhead at Willamette Falls, Jepson et al. 2015); spring Chinook salmon (CRTIFC, 2004-2007).

Table A6. Bioenergetics sub-model parameters as modified from Winship et al. (2002).

Symbol	Description	Value	Units	Source
P	Production (energy invested in growth)	0	kJ d^{-1}	See methods
A_{water}	Water metabolic rate multiplier	~triangle(2.5, 4.0, 5.5)	Unitless	Winship et al. (2002)
A_{land}	Land metabolic rate multiplier	~triangle(1.0, 1.2, 1.4)	Unitless	Winship et al. (2002)
$water_{j = CSL}$	Percent of time spent in the water	~triangle(0.08, 0.78, 1)	%	Unpublished data, ODFW & WDFW
$water_{j = SSL}$	Percent of time spent in the water	~triangle(0, 0.68, 1)	%	Unpublished data, ODFW & WDFW
BM_j	Basal metabolism	$292.88 \times M_j^{0.75}$	kJ d^{-1}	Winship et al. (2002); adults
M_j	Body mass	f_i(mass, age)	kgs	Growth sub-model
E_{f+u}	Fecal and urinary digestive efficiency	~U(0.81, 0.89)	%	Winship et al. (2002)
E_{HIF}	Energy utilization efficiency	~U(0.85, 0.90))	%	Winship et al. (2002); maintenance
$prey_i$	% of total diet biomass comprised of prey i	0-100	%	Diet sub-model
ED_i	Energetic density of prey i	3-25.65	kJ g^{-1}	Diet sub-model

Table A7. Individual-level results summary for sea lion management ABM.

Location	Species	Season	Agents	Mean of agent means (range in agent means)					
				Recurrence, yrs	Residency, days	Daily biomass requirement, kgs	Daily biomass requirement, % body mass	Daily salmonid biomass requirement, kgs	Daily salmonid requirement, # fish
BD	CSL	Spring	80	2.7 (0.8-4.4)	20.9 (1.5-22.1)	12.5 (5.2-18.1)	3.8 (3.3-5.0)	11.4 (4.7-16.4)	2 (0.8-2.9)
	SSL	Spring	52	1.9 (1.1-4.7)	26.2 (1.7-88.4)	24 (15.2-29.5)	3.5 (3.2-4.0)	14.3 (9.0-17.5)	2.5 (1.6-3.1)
		Fall	50	3.2 (0.4-5.0)	58.8 (1.6-132.6)	29.1 (21.7-35.8)	4.3 (4.0-4.7)	9.8 (7.3-12.1)	1.8 (1.4-2.2)
WF	CSL	Spring	10	2.9 (2.8-3.0)	38.8 (38.2-39.1)	15.2 (13.8-18.1)	4.2 (4.0-4.4)	13.8 (12.5-16.4)	2.6 (2.3-3.0)
	SSL	Spring	1	0.3	15.8	27.2	4.9	3.2	0.6