State of Washington DEPARTMENT OF FISH AND WILDLIFE
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Jennifer Quan 12/1/2023
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, 2022, through June 30, 2023, and the 3-Year Comprehensive Report on Work Conducted Under This Permit to Date.

Dear Ms. Quan:

The following information comprises the 2023 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, as well as the required 3-year comprehensive report on work conducted under this permit to date. 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

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, 2022, through June 30, 2023. 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)

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

1) Authorization

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) Permit Duration

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

3) Eligible Entities

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) Delegation of Authority

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) Disposition

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) Monitoring and Reporting.

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.

[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. Authorization

All animals were removed within the designated boundaries of the management area as described above. Specifically, removals conducted between July 1, 2022, and June 30,

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

2023, occurred at Bonneville Dam. In total, 22 CSLs and 6 SSLs were removed during this period (Table 2).

2. Permit Duration

This contains two reports. First is an annual report that covers management activities between July 1, 2022, and June 30, 2023. Second is a 3-year comprehensive report on work conducted between August 14, 2020, and June 30, 2023. 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. Eligible Entities

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 22 adult male CSLs and 6 adult male SSLs at Bonneville Dam.

b) No removals occurred during this reporting period in the Willamette River and other tributaries of the Columbia River within the state of Oregon below Bonneville Dam.

4. Delegation of Authority

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. Limit on Removals

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, 2023), a cumulative total of 60 CSLs and 59 SSLs have been removed under this authorization.

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

6. Manner of Removals

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 September 7, 2023. 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, 2024, to determine any needed modifications.

i) NMFS reviewed and approved the IACUC Animal Care and Use Protocols finalized on September 7, 2023, prior to their enactment for management. These methodologies will again be presented to NMFS for annual approval prior to December 1, 2024.

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) No tribes that are party to this permit requested parts from sea lion carcasses killed pursuant to this permit for educational and cultural purposes during this reporting period.

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 period of management beginning July 1, 2022, until June 30, 2023, as well as the requirement to submit a 3-year comprehensive report on or before December 1, 2023. 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 and 3-year comprehensive reports.

    ii. The specific locations where the Eligible Entities captured individual sea lions is detailed in Table A2 of the annual report and Table B1 of the 3-year comprehensive report.

    iii. The number of sea lions killed or transferred by species is detailed in Table A2 of the annual report and Table B1 of the 3-year comprehensive 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 A3 of the annual report, as well as in the Results and Discussion Section of the 3-year comprehensive report.

    vi. Estimates of predation impacts of removed animals are presented in the Results and Discussion sections of both the annual and 3-year comprehensive reports, and in Appendices 3 and 4.

    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 2022 – 2023 represents our annual monitoring report to NMFS. The Eligible Entities are currently planning to conduct similar work in 2023 – 2024 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, Brown et al. 2022, Wright et al. 2023). This same information for the current MMPA §120(f) permit is included in this report.

i. In the 3-year comprehensive report contained in this document and in Appendix 4, the Eligible Entities present 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. This report contains 3-year comprehensive reporting to NMFS by the Eligible Entities on the above mentioned-requirements, 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:
2023 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, 2023

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 ~40 – 200 individuals and associated predation estimates of 1,000 – 8,000 salmonids per year (Tidwell et al. 2023). 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 (Tidwell et al. 2023). 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 more salmonids than CSLs did in 2006 when authority to lethally remove CSLs at Bonneville Dam was initially requested (Tidwell et al. 2023). 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, 2022, and June 30, 2023, 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 2022 and 2023. 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 2023 are outlined below. Non-lethal hazing is not a requirement of lethal management at Willamette Falls, and no non-lethal deterrence measures were conducted at this location 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 Tidwell et al. 2023 for methods).

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. (2023) and Brown et al. (2022) 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.

Boat-based deterrent activities

Boat-based hazers from CRITFC 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.

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 Tidwell et al. 2023 for methods). At Willamette Falls, ODFW has estimated sea lion predation since 2014; see Wright et al. (2023) 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 2024; 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 2022 monitoring efforts began on July 27, 2022, and concluded on December 31, 2022, consisting of 101 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 2022 was 32 animals and occurred on November 11, 2022. Average SSL abundance during the entire Fall 2022 monitoring period was 8 ± 6 individuals.

Both CSLs and SSLs were present at Bonneville Dam during the Spring 2023 monitoring period, which began on January 1, 2023, and extended until June 2, 2023, consisting of a total of 103 separate counts. Whereas SSLs were present at the dam for much of Spring 2023 (January 3 – May 18), CSLs were not observed until March 27 and were last seen on May 25. Peak SSL abundance during Spring 2023 was 54 animals and occurred on May 1, 2023. Average Spring 2023 SSL abundance was 6 ± 11 individuals. Peak CSL abundance during this same period was 50 individuals, which were recorded on April 7, 2023. The average CSL abundance in Spring 2023 was 4 ± 8 animals; however, if only the period beginning with the first CSL observation is considered, the average was 9 ± 9 individuals per count.

Mainstem Columbia River

Weekly boat river surveys between the Bonneville Dam tailrace and the I-205 crossing in Portland, Oregon, peaked with 266 sea lions counted on April 5 and maintained an average of 111.6 sea lions per week (range: 5 – 266) throughout the spring survey season (Figure A1). Between April 4 and May 15, 2023, a total of 781 sea lions and 9 harbor seals were enumerated in 113 observations. Of those, 4 observations included smelt predation events. The boat survey on April 24 included two observations near the mouth of the Sandy River that were estimated to be 70+ and 120+ mixed species sea lions that were too numerous to count while maintaining boat speed and are reported as unknown sea lions in Figure A1. Relative to recent survey years, 2023 marked a major increase in the number of California sea lions.

[3] When completed, the 2022-2023 USACE annual report will be available here: http://pweb.crohms.org/tmt/documents/FPOM/2010/Task%20Groups/Task%20Group%20Pinnipeds/

Willamette River

Pinniped counts based on automated cameras and incidental observations by staff at the Sportcraft haulout area began July 2022 before sea lions migrated into the study area and continued through early June 2023 when all sea lions had migrated out of the study area. Counts based on formal observations at Willamette Falls began in early January 2022 and continued through early June 2023. Boat-based river surveys began September 1, 2022 and continued through mid-May 2023.

California sea lions — There were no known occurrences of California sea lions in the study area during the last half of 2022 (Figure A2). The first California sea lion sighing occurred on March 27, 2023, and was followed by continuous observations of at least 1-6 individuals from April 11-May 23. The maximum number of animals observed on one day was six which occurred on May 12; the last sighting in the study area occurred on May 23. Boat surveys of the Willamette River from the falls to the confluence with the Columbia River showed a similar phenology and relative abundance (Figure A3). Only one individually identifiable California sea lion was documented at Willamette Falls in 2023: X834. Originally marked in Astoria on April 3, 2017, this animal had never been observed at the falls previously and was thus a new recruit. This animal was later found dead in southern Oregon on August 17.

Steller sea lions — There were no known occurrences of Steller sea lions in the study area during the last half of 2022 (Figure A2). The first individual to be sighted at the falls was on January 5, 2023, followed by an intermittent sighting of 1-2 animals throughout January. Steller sea lions were then absent from the falls during February followed again by sightings of 1-2 animals from March 2 through May 2. Boat surveys of the Willamette River from the falls to the confluence with the Columbia River showed substantially greater abundance downriver in late 2022 followed by decreasing abundance throughout the first half of 2023 (Figure A3). Two identifiable Steller sea lions were observed at Willamette Falls this season: one branded animal (O43) and one animal with an identifiable scar, both of which had been observed at the falls in previous years.

Boat-based deterrent activities

The boat based hazing crew from CRITFC hazed sea lions for a total of 5 days between April 11 and May 5, 2023. Hazing resulted in 83 and 129 “takes” of CSLs and SSLs respectively (where "take" refers to a discreet hazing event). A total of 283 cracker shells and 339 seal bombs were used during deterrent activities (Table A1).

Trapping

All animals captured during this reporting period (July 1, 2022, until June 30, 2023) were captured using the trap array within the Boat Restricted Zone at Bonneville Dam, Columbia River Mile 146 (45.6392°, -121.9521, Table A2).

In total, 22 adult male California sea lions and 6 adult male Steller sea lions were humanely euthanized between July 1, 2022, and June 30, 2023 (Table A2). Trapping was attempted throughout Fall 2022, but no successful captures occurred during that period, and 5 of trapping weeks took place in Spring 2023, from April 19 through May 16 (Table A2). No trapping activities occurred at Willamette Falls in the reporting period (Table A2, Figure A2).

The average weight of CSLs humanely euthanized between July 1, 2022, and June 30, 2023, (n = 22) was approximately 244 kg (539 lbs), with a range 106 – 373 kg (234 – 823 lbs). The average length of euthanized CSLs was approximately 214 cm (7.0 ft), with a range of 170 – 238 cm (5.6 – 7.8 ft). For SSLs humanely euthanized between July 1, 2022, and June 30, 2023, (n = 6), the average weight was approximately 309 kg (681 lbs) with a range of 220 – 389 kg (485 – 858 lbs) The average length of euthanized SSLs was approximately 244 cm (8.0 ft), with a range of 224 – 260 cm (7.3 – 8.5 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 2022 and Spring 2023 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 2022 predation monitoring extended from November 21, 2022, through November 28, 2022, and was focused on the tailrace below Powerhouse 2 at Bonneville Dam. Only SSLs were present at the dam during the Fall 2022 predation monitoring period. The raw data based on 11 hours of sampling contained 4 predation events (Table A3), consisting in order of abundance of steelhead (*Oncorhynchus mykiss*) and white sturgeon.

Predation monitoring in Spring 2023 began on April 2 and continued until May 20, when abundance of sea lions at the dam declined. Spring predation sampling occurred at all three tailraces of the dam. Both SSLs and CSLs were present at Bonneville Dam during this period and observers collected 228 hours of predation monitoring data consisting of 241 predation events (Table A3). 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 white sturgeon and steelhead.

Diet — GI tract summary

Twenty-eight gastro-intestinal (GI) tracts were collected from humanely euthanized CSLs and SSLs between July 1, 2022, and June 30, 2023. No sea lions were lethally removed in Fall 2022, so these 28 GI tracts represent only Spring 2023. Twenty-six of these contained undigested prey remains (Table A4). The six SSL GI tracts contained three individual fish of the family Cyprinidae (minnows and carp), two juvenile Chinook salmon, two juvenile steelhead, one sturgeon, and one Pacific lamprey (*Entosphenus tridentatus*), as well as 11 unidentified salmon (10 adults, one juvenile). The 20 CSL GI tracts contained 18 Pacific lamprey, three American shad (*Alosa sapidissima*), one juvenile Chinook salmon, one juvenile steelhead, one individual fish from the family Cyprinidae, and 80 unidentified salmon (54 adult, 26 juvenile).

Willamette Falls

Predation — A total of 138 predation events by California sea lions were documented during the 2023 field season (see Wright et al. 2023 for full report). This includes predation events seen at pre-assigned, probability-based sample units, as well as all anecdotal observations. Salmonids were the most frequently observed prey item (70%), followed by lamprey (26%), and other or unknown prey (4%). Based on the subset of these observations that occurred during probability sampling, we estimated that a total of 403 salmonids were consumed by California sea lions across the sampling frame. Partitioning this total to the entire run based on Monte Carlo modeling, we estimated that California sea lions consumed 18 winter steelhead (0.9% of potential escapement), 10 summer steelhead (0.9% of potential escapement), 138 unmarked spring Chinook salmon (1.9% of potential escapement above falls), and 237 marked spring Chinook salmon (1.4% of potential escapement).

Observers documented 41 predation events by Steller sea lions during the 2023 field season (see Wright et al. 2023 for full report). This includes predation events seen at pre-assigned, probability-based sample units, as well as all anecdotal observations. Salmonids was the most frequently observed prey item (42%), followed by sturgeon (27%), other or unknown prey (24%), and lamprey (7%). Based on the subset of these observations that occurred during probability sampling, we estimated that a total of 119 salmonids were consumed by Steller sea lions across the sampling frame. This estimate was highly uncertain, however, due to the low number of observed events in the frame and we therefore did not further partition the total into run-specific estimates.

Effect of Removals

A total of 119 sea lion "agents" were initialized for the ABM including 91 from previous reporting periods (August 14, 2020 – June 30, 2022) and 28 from the current reporting period (July 1, 2022 – June 30, 2023); seven SSLs occurred during two seasons thus resulting in a grand total of 126 agents (see Appendix 3). Of the 119 sea lions, 59 were SSLs (58 from Bonneville Dam and one from Willamette Falls) and 60 were CSLs (53 from Bonneville Dam and seven from Willamette Falls).

The predicted (median) number of salmonids required by these sea lions had they not been removed was approximately 28,696 fish (95% confidence interval was approximately 16,221 to 44,974 fish) (Appendix 3, Fig. 5).

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.

TABLES AND FIGURES

Table A1. Summary of boat-based hazing activities at Bonneville Dam, 2023.

		Take*		Munitions	
Date	#Events	#CSL	#SSL	Cracker Shells	Seal Bombs
4/11/2023	5	46	10	75	121
4/12/2023	7	4	36	55	87
4/17/2023	5	12	19	40	52
4/21/2023	8	10	34	68	69
5/5/2023	5	11	30	45	10
Grand Total	30	83	129	283	339

*Take refers to numbers of animal-harassment events (note: one animal may be harassed multiple times).

Table A2**.** Description and relevant data for lethally removed sea lions between July 1, 2022, and June 30, 2023, under MMPA §120(f) authority. Bonneville Dam Coordinates = 45.6392º, -121.9521º.

Removal Date	Location	Species	Animal ID	Date Branded	Weight (lbs)	Length (cm)
Spring 2023 Season						
4/20/2023	Bonneville Dam	CSL	ZB027	N/A	726	231
4/20/2023	Bonneville Dam	CSL	ZB028	N/A	611	230
5/2/2023	Bonneville Dam	SSL	EB045	N/A	616	232
5/2/2023	Bonneville Dam	SSL	EB046	N/A	663	241
5/2/2023	Bonneville Dam	CSL	ZB029	N/A	631	215
5/2/2023	Bonneville Dam	CSL	ZB030	N/A	378	210
5/3/2023	Bonneville Dam	SSL	EB047	N/A	858	260
5/3/2023	Bonneville Dam	CSL	ZB031	N/A	540	218
5/3/2023	Bonneville Dam	CSL	ZB032	N/A	823	238
5/4/2023	Bonneville Dam	CSL	ZB033	N/A	494	225
5/4/2023	Bonneville Dam	CSL	ZB034	N/A	234	170
5/4/2023	Bonneville Dam	CSL	ZB035	N/A	647	220
5/4/2023	Bonneville Dam	CSL	ZB036	N/A	439	208
5/9/2023	Bonneville Dam	CSL	ZB037	N/A	753	237
5/9/2023	Bonneville Dam	SSL	EB048	N/A	685	257
5/10/2023	Bonneville Dam	CSL	ZB038	N/A	768	232
5/10/2023	Bonneville Dam	CSL	ZB039	N/A	596	222
5/10/2023	Bonneville Dam	SSL	EB049	N/A	781	249
5/10/2023	Bonneville Dam	CSL	ZB040	N/A	631	230
5/11/2023	Bonneville Dam	SSL	EB050	N/A	485	224
5/11/2023	Bonneville Dam	CSL	ZB041	N/A	249	186

Removal Date	Location	Species	Animal ID	Date Branded	Weight (lbs)	Length (cm)
5/11/2023	Bonneville Dam	CSL	ZB042	N/A	688	235
5/11/2023	Bonneville Dam	CSL	ZB043	N/A	579	217
5/16/2023	Bonneville Dam	CSL	ZB044	N/A	373	189
5/16/2023	Bonneville Dam	CSL	ZB045	N/A	326	192
5/16/2023	Bonneville Dam	CSL	ZB046	N/A	655	219
5/16/2023	Bonneville Dam	CSL	ZB047	N/A	274	175
5/16/2023	Bonneville Dam	CSL	ZB048	N/A	446	206

Table A3. Raw data from USACE sea lion predation monitoring during Fall 2022 and Spring 2023 (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 28 July 2022 and 26 May 2023			
Fish Species	**Observed Number of Fish Killed**	**Adjusted Number of Fish Killed (95% CI)**	**Percent Run Consumed During Observation Period**
Fall Chinook Salmon	0	0 (0 – 0)	0.0%
Spring Chinook Salmon	235	2181 (1740 – 2578)	2.2%
Steelhead – Aug. – Oct. 2022	3	29 (3 – 49)	145.8%
Steelhead – April – May 2023	2	17 (0 – 34)	3.3%
Coho Salmon	0	0 (0 – 0)	0.0%
White Sturgeon – April – May 2023	4	37 (2 – 63)	N/A
White Sturgeon – Aug. – Oct. 2022	1	10 (0 – 16)	N/A

Season	**Dates Observed**	**Location Observed**	**Total Daylight Hours Available**	**Daylight Hours Observed**	**Sample Rate (%)**
Fall 2022	21 November - 28 November	PH2	72	11	15.28
Spring 2023	2 April - 20 May	PH1, SPW, PH2	2009	228	11.35

Table A4. Minimum number of individual prey recovered from gastro-intestinal tracts (stomach and large intestines) collected from 22 euthanized California sea lions (CSL) and 6 Steller sea lion (SSL) captured at Bonneville Dam between July 1, 2022, and June 30, 2023, under Columbia River Basin (CRB) MMPA §120(f) (valid 8/14/2020 - 8/14/2025).

Date	Removal Location	Sea lion species	Animal ID	Unidentified salmon		Juvenile Chinook	Juvenile Steelhead	Pacific Lamprey	Cyprinidae	Shad	Sturgeon
				Adult	Juvenile						
Fall 2022 Removals											
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spring 2023 Removals											
2023-04-19	Bonneville Dam	CSL	ZB027	1	20	1		1	1		
2023-04-19	Bonneville Dam	CSL	ZB028	3							
2023-05-02	Bonneville Dam	CSL	ZB029	1							
2023-05-02	Bonneville Dam	CSL	ZB030	1							
2023-05-03	Bonneville Dam	CSL	ZB031	1							
2023-05-03	Bonneville Dam	CSL	ZB032	5							
2023-05-04	Bonneville Dam	CSL	ZB033	1							
2023-05-04	Bonneville Dam	CSL	ZB034								
2023-05-04	Bonneville Dam	CSL	ZB035	1	6		1				
2023-05-04	Bonneville Dam	CSL	ZB036	5							
2023-05-09	Bonneville Dam	CSL	ZB037	2							
2023-05-10	Bonneville Dam	CSL	ZB038	4							
2023-05-10	Bonneville Dam	CSL	ZB039	4				1			
2023-05-10	Bonneville Dam	CSL	ZB040	3				2			
2023-05-11	Bonneville Dam	CSL	ZB041								
2023-05-11	Bonneville Dam	CSL	ZB042	3				3			
2023-05-11	Bonneville Dam	CSL	ZB043	2							
2023-05-16	Bonneville Dam	CSL	ZB044	2							

2023-05-16	Bonneville Dam	CSL	ZB045	1							
2023-05-16	Bonneville Dam	CSL	ZB046	6				3			
2023-05-16	Bonneville Dam	CSL	ZB047					7		2	
2023-05-16	Bonneville Dam	CSL	ZB048	8				1		1	
2023-05-02	Bonneville Dam	SSL	EB045	1	1						
2023-05-02	Bonneville Dam	SSL	EB046						1		
2023-05-03	Bonneville Dam	SSL	EB047			2					1
2023-05-09	Bonneville Dam	SSL	EB048	4							
2023-05-10	Bonneville Dam	SSL	EB049	4							
2023-05-11	Bonneville Dam	SSL	EB050	1			2	1	2		
Fall 2022 Total				0	0	0	0	0	0	0	0
Spring 2023 Total				64	27	3	3	19	4	3	1
Cumulative Total				**64**	**27**	**3**	**3**	**19**	**4**	**3**	**1**

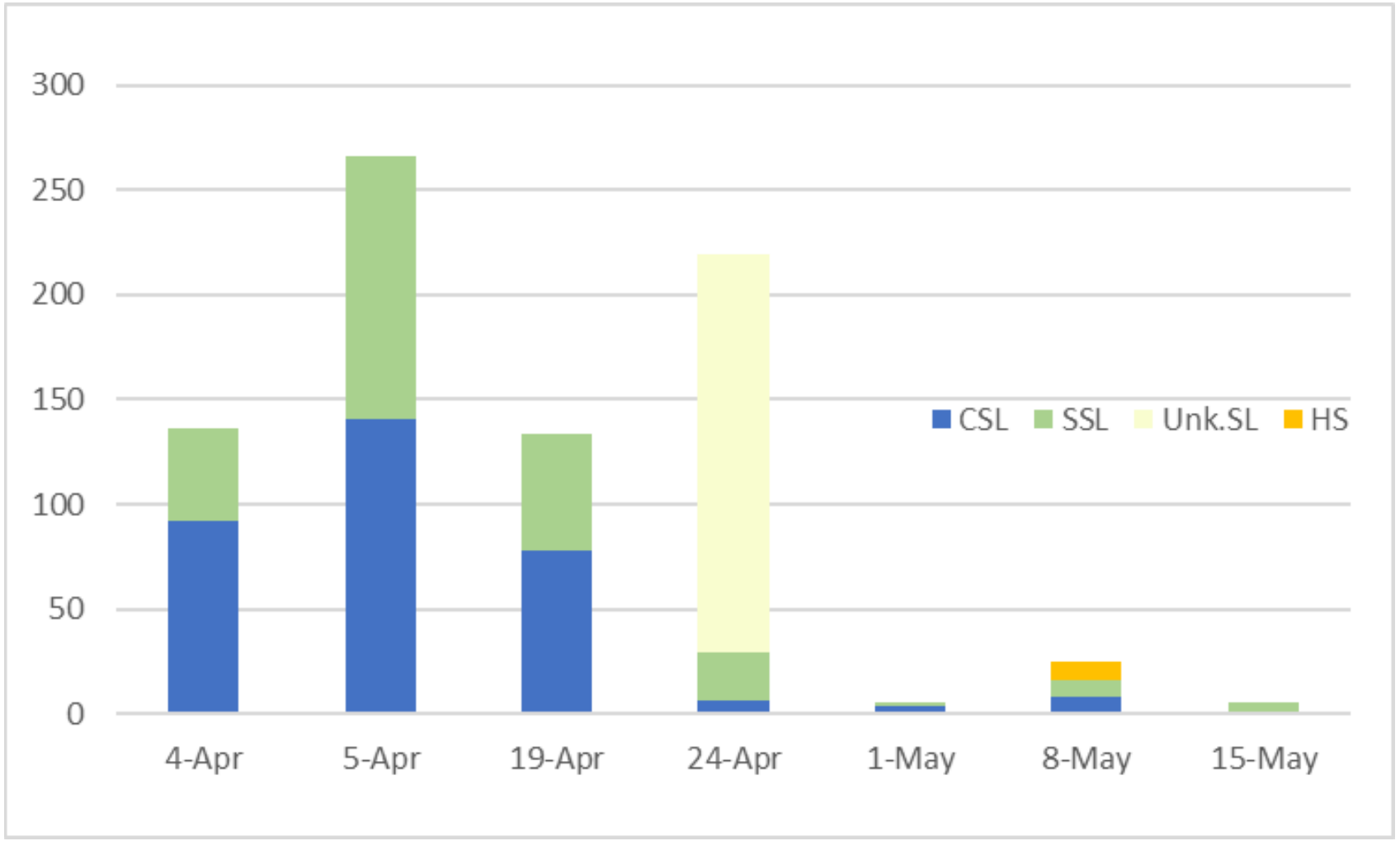


Figure A1. Sea lion counts on the Columbia River in 2023 between the Bonneville Dam tailrace and I-205 in Portland, Oregon. April 24 includes an estimated number of mixed species sea lions that were reported as 190+ individuals that were too numerous to count while maintaining speed.

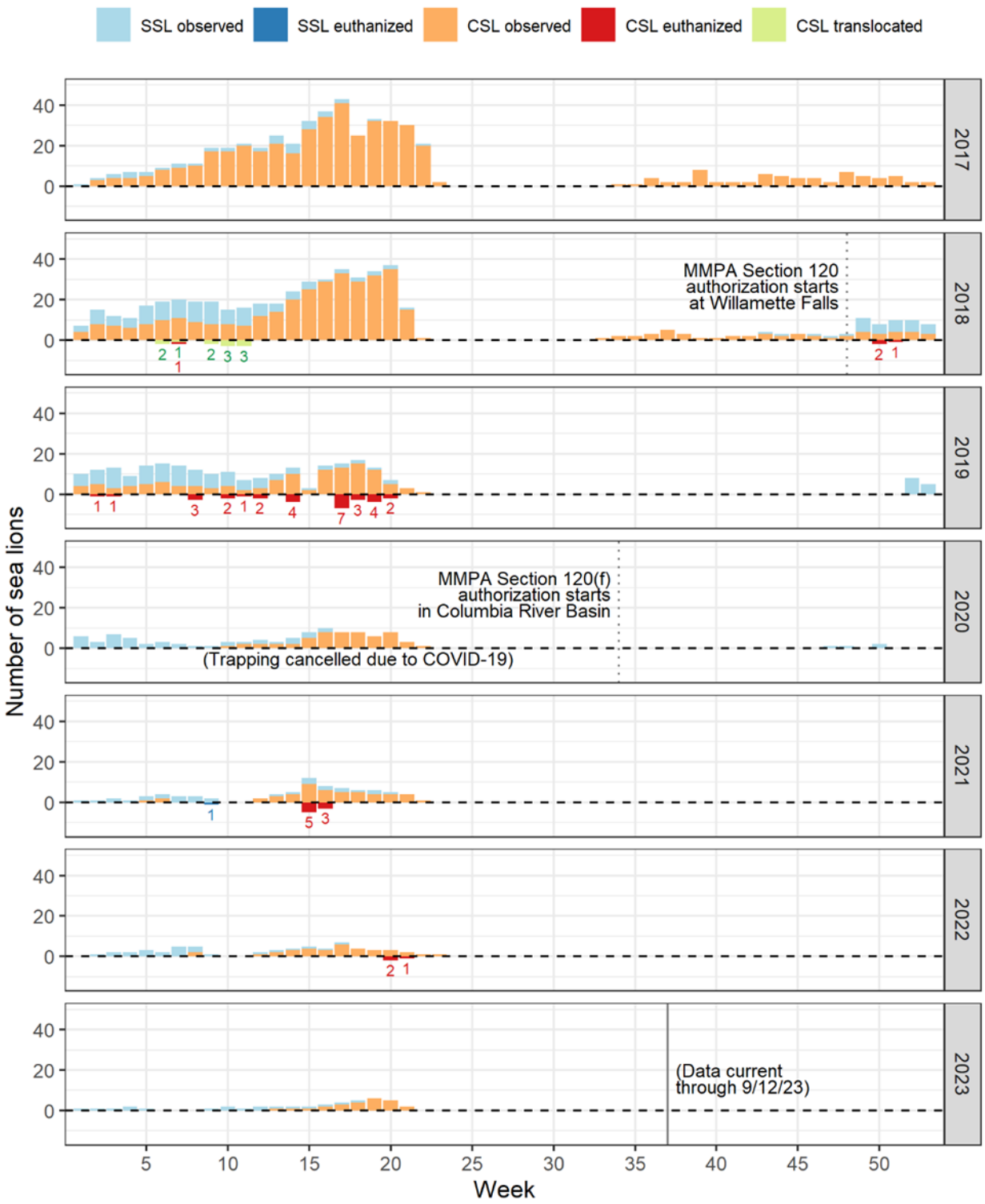
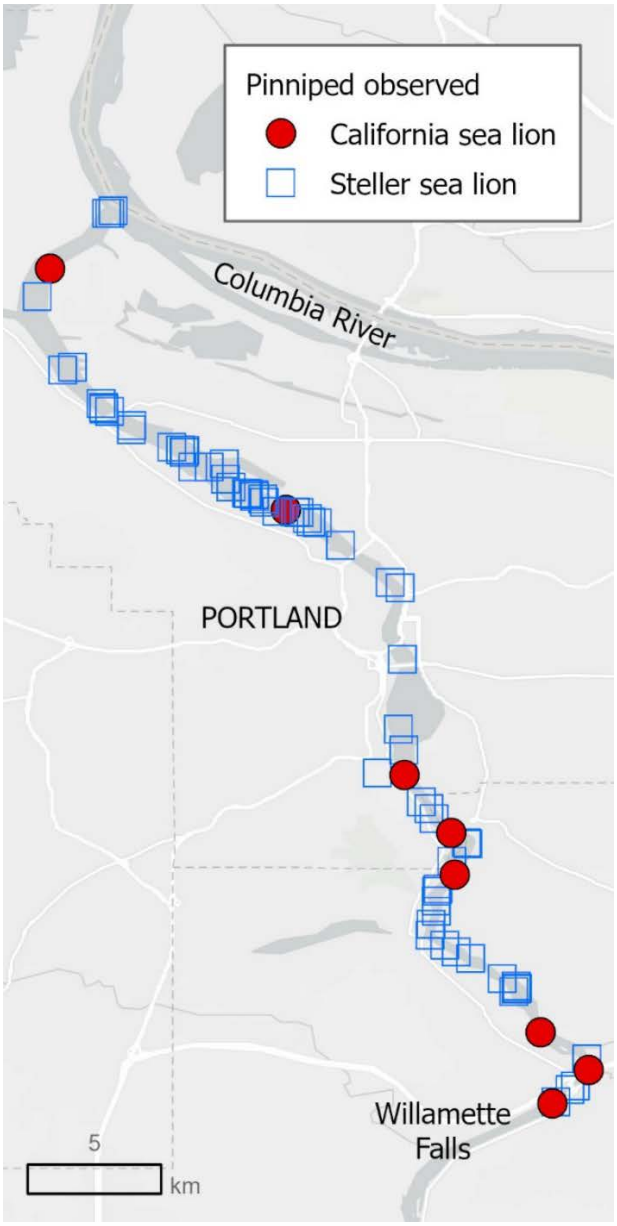


Figure A2. Weekly counts of California sea lions (CSL) and Steller sea lions (SSL) in the Willamette Falls study area, 2017-2023. Numbers translocated or euthanized are summed over the week; numbers observed are the minimum number of unique individuals observed for that week and may include animals translocated or euthanized.



Date	Survey end	CSL	SSL
2022-09-01	Columbia R		
09-20	Ross Island		
10-07	Columbia R		
10-21	Columbia R		3
11-04	Columbia R		
11-18	Columbia R		3
11-22	Multnomah Ch		2
11-10	Columbia R		
12-02	Columbia R		2
12-09	Columbia R		4
12-16	Columbia R		4
12-21	Columbia R		16
2023-01-17	Columbia R		7
01-24	Columbia R		7
01-30	Columbia R		3
02-07	Columbia R		
02-13	Columbia R		
02-21	Columbia R		
02-28	Columbia R	1	1
03-09	Columbia R		4
03-15	Columbia R		3
03-22	Columbia R		3
03-31	Columbia R		1
04-07	Columbia R	1	3
04-12	Columbia R	1	3
04-21	Columbia R		1
04-28	Columbia R	3	1
05-05	Columbia R	5	3
05-12	Ross Island	7	
05-18	St Johns Bridge	3	

Figure A3. 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.

COMPREHENSIVE REPORT ON WORK CONDUCTED 2020 – 2023

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December 1, 2023

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

As a component of the reporting requirements of the current MMPA §120(f) permit to conduct management of California and Steller sea lions in the Columbia River basin, the Eligible Entities are required to submit a 3-year comprehensive report on activities conducted in the action area on or before December 1, 2023. In this 3-year comprehensive report, which makes up this section of the present document, the specific requirements outlined by the Task Force are as follows:

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. 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.

As such, the 3-year comprehensive report presented here contains a population viability analysis (PVA) for several populations of upper Columbia River spring Chinook that are subject to predation by sea lions at Bonneville Dam. In addition to the PVA, this comprehensive report summarizes the results of the first three years of management activities conducted under the MMPA §120(f) permit, presents several new metrics for tracking sea lion presence at Bonneville Dam, and discusses progress made towards the goals of the permitted work thus far.

METHODS

This 3-year comprehensive report summarizes activities conducted under the MMPA §120(f) Columbia River sea lion management permit between August 14, 2020, and June 30, 2023. The majority of the methods for this work are identical to those outlined in the annual report included in this document. Any additions to or deviations from those methods are outlined here.

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 Tidwell et al. 2023 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.

Effect of removals

In compliance with the reporting requirements of the current permit, this 3-year report also includes a population viability analysis (PVA) for spring Chinook populations that pass over Bonneville Dam. This PVA examines the quasi-extinction risk for these upper Columbia River populations under three predation scenarios: peak predation prior to the current permit (6% of each run), currently observed predation given removals conducted thus far (3% of each run), and an optimistic future scenario with no predation occurring at Bonneville Dam (0% of each run). Methods, results, and discussion for this analysis are included at the end of this report in Appendix 4.

RESULTS AND DISCUSSION

Estimation of sea lion abundance in the action area

Over the first three years of the permitted activities, the beginning of fall monitoring efforts ranged from July 27 to August 3, consisting of an average of 98 ± 2 (mean ± 1 standard deviation) separate counts. Peak SSL abundance during the first three years of the permitted activities was 68 animals and occurred on September 28, 2020, with the next highest peak of 51 individuals occurring on September 13, 2021. Average SSL abundance during the Fall 2020 – 2022 monitoring periods was 18 ± 14 individuals.

Over the first three years of the permit, the first observations of the Spring monitoring effort ranged from January 3 to January 5 and the ending ranged from May 20 to June 2, with CSLs first observed from March 23 to March 27 and last seen on May 20 to May 26. Peak SSL abundance during the Spring 2021 – 2023 monitoring periods was 62 individuals on April 30, 2021. Average spring SSL abundance across the three years was 9 ± 15 individuals. Peak CSL abundance during the Spring 2021 – 2023 monitoring periods was 50 individuals on April 7, 2023. Average spring CSL abundance across the three years was 3 ± 5 individuals; however, if only the periods beginning with the first CSL observations are considered, the average CSL abundance during the spring 2021 – 2023 monitoring periods was 6 ± 7 individuals per count.

This report includes new metrics for examining patterns of sea lion presence at Bonneville Dam and the effects of permanent removals on these patterns. The newly introduced metric of “sea lion days” closely tracks the mean number of sea lions present at the dam since 2017 in spring, fall, and annually (Figures B1 and B2). The peak number of sea lions at the dam did not track the other two metrics as closely (Figure B3) and is likely less useful as an indicator of sea lion impacts on salmonids at Bonneville Dam due to its sensitivity to fleeting increases in abundance. Both the estimates of sea lion days and mean counts of sea lions indicate that during the period

from 2017 – Spring 2023, SSLs greatly outnumbered CSLs. For both metrics, this is driven by a combination of a greater abundance and a longer duration of presence by SSLs than CSLs at Bonneville Dam. Both metrics also indicate the presence of, and therefore likely impact on salmonids by, SSLs is substantially greater during the fall than the spring, accounting for the majority of the annual totals for these two metrics.

The patterns observed in sea lion days, mean sea lion counts, and peak sea lion counts since the initiation of the current permit in August 2020, reducing the requirements for a sea lion to be eligible for removal and allowing removals of SSLs, indicate the removals are successfully reducing the presence and abundance of 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. In Fall 2021 we estimated 2,742.2 Steller sea lion days, an average of 18 ± 11 SSLs, and a peak of 51 SSLs. Most recently in Fall 2022, despite no removals that fall, we estimated 1,214.0 Steller sea lion days, an average of 8 ± 6 SSLs, and a peak of 32 SSLs. This represents a 73% decrease in sea lion days, a 72% decrease in mean counts, and a 53% 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 948 Steller sea lion days, an average count of 6 ± 11 SSLs, and a peak count of 32 SSLs in Spring 2023. This represents a decline of 42%, 45%, and 48% 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 (Figures B1 – B3). Examining the longer time series of spring sea lion monitoring data from USACE shows that these numbers have decreased substantially since the permanent removal of CSLs at Bonneville Dam was authorized in 2008, but are subject to large fluctuations anecdotally associated with changes in ocean conditions and prey abundance (Figure B4). 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.

Trapping

All animals captured during this reporting period (August 14, 2020, until June 30, 2023) 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 (45.3511º, -121.6193º) (Table B1).

During the first three years of this permit, a total of 60 California sea lions and 59 Steller sea lions (all adult males) were humanely euthanized (Table B1). Trapping activities at Bonneville occurred over an average of approximately 4.6 weeks during fall management seasons and 6.7

weeks in the spring, while trapping activities in the Willamette occurred only in the spring for an average of 4.3 weeks. On average, 10 SSLs (range 6-24) were humanely euthanized during the 2020, 2021, and 2022 fall management periods. During the spring 2021, 2022, and 2023 management periods an average of 20 CSLs (range 15 – 23) and 10 SSLs (range 6 – 14) were humanely euthanized (Table B1). Sea lion trapping was conducted under the MMPA §120(f) Columbia River Basin permit; however, CSLs previously added to the list of animals authorized for removal under the previous MMPA §120 Bonneville Dam and MMPA §120 Willamette Falls authorizations were removed under those permits, thus information about those animals was included in the final reports for those permits, submitted to NMFS on November 1, 2021, and November 1, 2023, respectively (Clark et al. 2021b, Brown et al. 2022, Wright et al. 2023).

Over the first three years of management under the current permit, the average weight of humanely euthanized CSLs (n = 60) was approximately 242 kg (534 lbs), with a range of 106 – 552 kg (234 – 1217 lbs). The average length of these CSLs was approximately 220 cm (7.2 ft), with a range of 170 – 267 cm (5.6 – 8.8 ft). The average weight of humanely euthanized SSLs (n =59) was approximately 467 kg (1030 lbs), with a range of 220 – 873 kg (485 – 1925 lbs). The average length of these SSLs was approximately 263 cm (8.6 ft), with a range of 224 – 315 cm (7.3 – 10.3 ft). Age data based on sectioned teeth are available for removals conducted between August 14, 2020, and May 17, 2022. During this period, the average age of CSLs (n = 29) lethally removed under this permit was estimated to be 6.6 ± 2.0 years (range: 3 – 10), and the average age of SSLs (n = 48) was estimated at 5.8 ± 3.0 years (range: 2 – 15).

Estimation of predation rates

A total of 676 predation events (approximately 169 per year, with a range of 138 – 205) by California sea lions were documented in the Willamette Falls study area during the 3-year reporting period. This includes predation events seen at pre-assigned, probability-based sample units, as well as all anecdotal observations. Over the first 3 years of this permit salmonids were the most frequently observed prey item (78% with a range from 70 – 85%), followed by lamprey (19% with a range from 13 – 26%), and other or unknown prey (3% with a range from 2 – 4%). Based on the subset of these observations that occurred during probability sampling, we estimated that a total of 2,929 salmonids (732 per year with a range from 403-1227) were consumed by California sea lions across the sampling frame. Partitioning this total to the entire run based on Monte Carlo modeling, we estimated that California sea lions consumed 115 winter steelhead (29 per year, 1.1% of potential escapement), 197 summer steelhead (49 per year, 1.6% of potential escapement), 565 unmarked spring Chinook salmon (141 per year, 2.3% of potential escapement above falls), and 2051 marked spring Chinook salmon (513 per year, 2.1% of potential escapement).

Observers documented 230 predation events (approximately 58 per year, with a range of 41 – 68) by Steller sea lions in the Willamette Falls study area during the 3-year reporting period. This includes predation events seen at pre-assigned, probability-based sample units, as well as all anecdotal observations. Sturgeon were the most frequently observed prey item (42% with a range of 27 – 65%), followed by salmonids (32% with a range of 16 – 43%), other or unknown prey (18% with a range from 12 – 24%), and lamprey (8% with a range of 0 – 16%). Based on the

subset of these observations that occurred during probability sampling, we estimated that a total of 375 salmonids (94 per year with a range from 45 – 136) were consumed by Steller sea lions across the sampling frame. This estimate was highly uncertain, however, due to the low number of observed events in the frame and we therefore did not further partition the total into run-specific estimates.

Effect of removals

A total of 119 sea lion "agents" were initialized for the ABM from August 14, 2020 – June 30, 2023); seven SSLs occurred during two seasons thus resulting in a grand total of 126 agents (see Appendix 3). Of the 119 sea lions, 59 were SSLs (58 from Bonneville Dam and one from Willamette Falls) and 60 were CSLs (53 from Bonneville Dam and seven from Willamette Falls).

The predicted (median) number of salmonids required by these sea lions had they not been removed was approximately 28,696 fish (95% confidence interval was approximately 16,221 to 44,974 fish) (Appendix 3, Fig. 5).

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.

See Appendix 4 for results and discussion of the PVA for upper Columbia River spring Chinook. In short, reducing pinniped predation on spring Chinook salmon passing Bonneville Dam from the maximum observed rate of 6% to an average of 3% reduced the average probability that a population reaches quasi-extinction by 1.5% from an estimated 32.9% to 31.4% (a relative decrease of 5.6%). Because this estimate only includes predation below Bonneville Dam, and removals at the dam undoubtedly also reduce predation elsewhere in the Columbia River and sea lion recruitment to Bonneville Dam, the predicted reduction in extinction risk is likely a conservative estimate of the project's impacts on listed spring Chinook salmon populations in the Columbia River basin.

Conclusions

The results of this 3-year comprehensive report provide an opportunity to examine progress made by the Eligible Entities towards the goals of the permitted work. For the first time in the program's history, Columbia River sea lion management has been able to operate with relatively few interruptions and to follow a streamlined process to permanently remove both California and Steller sea lions habituated to salmon predation at Bonneville Dam and Willamette Falls. The outcome of this work is most clearly visible at Willamette Falls, where the smaller scale of the issue and quick action taken have effectively removed most predatory sea lions, resulting in substantially decreased salmonid predation, measurable benefits to salmonid runs, and minimal sea lion presence in the action area such that lethal removals have not occurred at this site in

more than a year. The results at Bonneville Dam, though perhaps not as immediately visible as at Willamette Falls due to the larger scale of both the space and the sea lion predation issue, also clearly indicate progress towards reduction of predation impacts by sea lions on salmonids. Substantial declines have been seen in all three of the new metrics of sea lion presence presented in this 3-year comprehensive report since the work under the MMPA §120(f) permit began in Fall 2020. This reduction is particularly apparent for predation occurring in the fall by SSLs, which stands out as the largest source of salmonid predation both in the metrics of sea lion presence and in the estimates of salmon "saved" as a result of removal efforts by the ABM presented in Appendix 3.

Though the greatest benefits to salmon at Bonneville Dam resulting from this work appear to have occurred as a result of reductions in the presence of SSLs in the fall, permanent removals of both SSLs and CSLs have had quantifiable benefits for spring Chinook as well. The PVA presented in Appendix 4 indicates a relative reduction in the quasi-extinction probability of a suite of upper Columbia River basin spring Chinook of 5.6% (an absolute reduction of 1.5%) as a result of permanent removals conducted thus far, with nearly double the potential benefit if sea lion predation at this location were eliminated altogether. For several reasons discussed in Appendix 4, this estimate is likely conservative, as removals conducted at Bonneville Dam result in an unquantified reduction in predation elsewhere in the river system and reduce recruitment of sea lions to Bonneville Dam as newly habituated salmon predators.

COMPLIANCE WITH 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.**

   The Eligible Entities have developed and begun to implement a long-term management strategy to prevent future recruitment of sea lions into the 120(f) geographic area. This strategy relies on the permanent removal of habituated sea lions at key impoundments such as Bonneville Dam and Willamette Falls as a first step towards reducing salmon predation and recruitment rates of new sea lions to the 120(f) geographic area. As this work proceeds, non-lethal deterrents will be phased in and tested, with an end goal of developing an assortment of non-lethal deterrent technologies and techniques that will further reduce recruitment and predation rates. These deterrents may include (but will not be limited to) haulout deterrents, acoustic deterrents, and hazing with pyrotechnics and/or projectiles. Deterrents will be tested and accompanied by monitoring to understand their effectiveness and ensure no unintended consequences of their deployment. Once habituated animals have been removed from Bonneville Dam and Willamette Falls, management will rely primarily on non-lethal deterrents and sporadic removals of animals that do recruit as habituated salmon predators. At this time, focus will shift towards other key predation hot spots within the 120(f) geographic area, following the same sequencing of removal of habituated salmon predators and transitioning ultimately to primarily non-lethal techniques, though non-lethal deterrents will likely be applied sooner in these locations using methods developed at Bonneville Dam and Willamette Falls.

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.**

   The Eligible Entities have continued to pursue non-lethal methods to reduce sea lion predation on at-risk fish stocks in the Columbia River. This has included continued use of boat-based hazing downstream from Bonneville Dam, as well as the testing of commercially available haulout deterrents and the development of custom solutions (e.g., motion-activated sprinkler systems) to non-lethally deter sea lions from haulouts. As a proof of concept, these sprinkler systems have been tested at Tower

Island, adjacent to the Bonneville Dam trap array, and Phoca Rock, several miles downstream of Bonneville Dam, as a means of moving sea lions from terrestrial haulout habitat to floating traps. These efforts have been largely successful barring the occasional equipment malfunction. Future plans include implementation of these tools across a broader geographic area, continued testing and development of other deterrents, and engagement with groups developing new technologies and techniques for non-lethally deterring pinnipeds.

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.**

   The Eligible Entities conduct a full necropsy on every euthanized sea lion, collecting samples and data to monitor sea lion age, disease, diet, and health trends in sea lion populations. These samples and data contribute to both internal investigations conducted by the Eligible Entities and to several studies led by collaborating groups.

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.**

   The Eligible Entities have explored and plan to continue exploring opportunities to displace and/or minimize the use of manmade haulouts by sea lions in the Columbia River. Commercially available and custom-designed solutions have been tested thus far that have shown promise for keeping sea lions off manmade haulouts. These tests included a deployment of SealStop™ and a motion-activated sprinkler system on the docks in the East Mooring Basin in Astoria, Oregon, to pilot their effectiveness as non-lethal deterrents. Once the appropriate tools have been identified, any large-scale deployment of non-lethal haulout deterrents will be accompanied by monitoring to determine the effectiveness of this deterrence and detect any unintended consequences of moving sea lions away from manmade haulouts.

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.**

   The Eligible Entities are currently in the process of removing habituated animals. Concurrently, monitoring of sea lion abundance and branded sea lions is occurring at both Willamette Falls and Bonneville Dam. At Willamette Falls where the majority of the habituated sea lions have been removed, few animals have observed in the action area indicating that recruitment of new predatory sea lions has remained low and lethal removals have not occurred for more than a year. This monitoring will continue

at both locations and may be used to estimate the rate of sea lion recruits after the removal of habituated animals.

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.**

   The Eligible Entities, in coordination with the Alaska Fisheries Science Center, have been monitoring Steller sea lion rookeries. This work has included participation by ODFW and WDFW in a range-wide stock assessment survey in 2021 (which will be repeated in 2024), as well as yearly aerial surveys of Carroll Island and Sea Lion Rock by WDFW staff during pupping season. These counts are incorporated into the Alaska Fisheries Science Center's assessments of the status of the Steller sea lion Eastern Distinct Population Segment. In addition, ODFW, in cooperation with NMFS, conducted numerous shore, vessel, and uncrewed aerial surveys of Steller sea lion haulout sites as part of long-term survival monitoring.

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.**

   Per recommendation 7 from the Task Force, ODFW has developed a Columbia River basin-wide online tool for reporting observations of pinnipeds and pinniped predation of salmon by the public. This tool is freely available and the Eligible Entities have worked to guide the public towards this tool so all reports of problem interactions can be collected and consolidated into one location. This reporting tool can be found here: (https://www.dfw.state.or.us/MRP/mammals/docs/Seal%20and%20Sea%20Lion%20Reporter%20User%20Guide%20v%202021-01-22.pdf)

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.**

   Both separately and in collaboration, the Eligible Entities have pursued funding for monitoring to evaluate the success of the lethal removal program. Since 2021, the State of Washington has provided funds to WDFW for sea lion management and monitoring activities in the Columbia River. Further, the Eligible Entities worked with the office of Representative Jaime Herrera Beutler to obtain Community Project Funding to purchase the equipment needed for sea lion management and monitoring

in the Columbia River. These funds were routed through NMFS to WDFW and are being used to support this work. The Eligible Entities are continuing to pursue additional Federal funding to support the management and monitoring efforts in the region with the goal of continuing to evaluate the 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 §120(f) program.**

   The Eligible Entities have developed and employed an agent-based modeling (ABM) approach to estimate the benefits of the Columbia River sea lion management program. This modeling framework uses daily bioenergetic requirements of California and Steller sea lions, along with numerous other factors such as growth, survival, and residency information, to estimate "salmon saved" as a result of the permanent removals. Criteria were developed to evaluate the performance and usefulness of the ABM by comparing model outputs to values in the published literature and consistency with observed empirical data. Detailed descriptions of those evaluation criteria and this model's performance against them are included Appendix 3, Section 4 of this report.

TABLES AND FIGURES

Table B1**.** Description and relevant data for lethally removed sea lions between August 14, 2020, and June 30, 2023, 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 2020 Season						
10/14/2020	Bonneville Dam	SSL	EB001	N/A	888	263
10/15/2020	Bonneville Dam	SSL	EB002	N/A	710	249
10/22/2020	Bonneville Dam	SSL	O53	5/9/2018	747	250
11/3/2020	Bonneville Dam	SSL	EB003	N/A	776	235
11/4/2020	Bonneville Dam	SSL	O44	5/16/2017	951	271
11/5/2020	Bonneville Dam	SSL	EB004	N/A	902	255
Spring 2021 Season						
3/2/2021	Willamette Falls	SSL	EW001	N/A	1400*	†
4/6/2021	Bonneville Dam	SSL	EB005	N/A	802	253
4/13/2021	Willamette Falls	CSL	ZW001	N/A	560*	†
4/13/2021	Willamette Falls	CSL	ZW002	N/A	600*	†
4/13/2021	Willamette Falls	CSL	ZW003	N/A	650*	†
4/14/2021	Bonneville Dam	CSL	ZB001	N/A	1251	285
4/14/2021	Bonneville Dam	SSL	EB006	N/A	533	212
4/15/2021	Bonneville Dam	CSL	ZB002	N/A	859	263
4/15/2021	Bonneville Dam	SSL	EB007	N/A	808	255
4/15/2021	Bonneville Dam	SSL	EB008	N/A	746	235
4/15/2021	Willamette Falls	CSL	ZW004	N/A	600*	228
4/20/2021	Bonneville Dam	SSL	O41	5/10/2017	1403	261
4/20/2021	Willamette Falls	CSL	ZW005	N/A	580*	245
4/20/2021	Willamette Falls	CSL	ZW006	N/A	600*	225

Removal Date	Location	Species	Animal ID	Date Branded	Weight (lbs)	Length (cm)
4/21/2021	Bonneville Dam	SSL	EB009	N/A	876	249
4/22/2021	Bonneville Dam	SSL	EB010	N/A	997	274
4/28/2021	Bonneville Dam	SSL	EB011	N/A	753	240
4/28/2021	Bonneville Dam	SSL	EB012	N/A	840	252
4/28/2021	Bonneville Dam	CSL	ZB003	N/A	551	233
4/29/2021	Bonneville Dam	CSL	ZB004	N/A	691	235
4/29/2021	Bonneville Dam	CSL	06-3	9/18/2017	622	222
4/29/2021	Bonneville Dam	SSL	EB013	N/A	1115	243
5/4/2021	Bonneville Dam	CSL	ZB005	N/A	461	218
5/4/2021	Bonneville Dam	CSL	ZB006	N/A	634	225
5/4/2021	Bonneville Dam	CSL	ZB007	N/A	600	207
5/4/2021	Bonneville Dam	CSL	ZB008	N/A	581	214
5/4/2021	Bonneville Dam	CSL	X693	2/8/2017	540	214
5/5/2021	Bonneville Dam	SSL	EB014	N/A	738	247
5/5/2021	Bonneville Dam	CSL	ZB009	N/A	748	230
5/5/2021	Bonneville Dam	CSL	ZB010	N/A	572	223
5/5/2021	Bonneville Dam	CSL	ZB011	N/A	578	231
5/6/2021	Bonneville Dam	SSL	EB015	N/A	783	255
5/6/2021	Bonneville Dam	CSL	ZB012	N/A	492	214
5/11/2021	Bonneville Dam	CSL	ZB013	N/A	538	213
5/11/2021	Bonneville Dam	CSL	ZB014	N/A	493	218
5/11/2021	Bonneville Dam	CSL	ZB015	N/A	1217	267
5/12/2021	Bonneville Dam	SSL	EB016	N/A	1590	275
Fall 2021 Season						
9/14/2021	Bonneville Dam	SSL	EB017	N/A	776	249

Removal Date	Location	Species	Animal ID	Date Branded	Weight (lbs)	Length (cm)
9/15/2021	Bonneville Dam	SSL	EB018	N/A	958	270
9/15/2021	Bonneville Dam	SSL	EB019	N/A	570	236
9/16/2021	Bonneville Dam	SSL	EB020	N/A	796	247
9/21/2021	Bonneville Dam	SSL	O49	5/17/2017	1111	266
9/22/2021	Bonneville Dam	SSL	EB021	N/A	1085	273
9/23/2021	Bonneville Dam	SSL	EB022	N/A	1397	309
9/28/2021	Bonneville Dam	SSL	EB023	N/A	860	253
9/29/2021	Bonneville Dam	SSL	EB024	N/A	1563	304
9/30/2021	Bonneville Dam	SSL	EB025	N/A	644	232
10/6/2021	Bonneville Dam	SSL	EB026	N/A	1484	288
10/6/2021	Bonneville Dam	SSL	EB027	N/A	1379	277
10/7/2021	Bonneville Dam	SSL	O48	5/17/2017	1344	276
10/14/2021	Bonneville Dam	SSL	O42	5/11/2017	1192	273
11/2/2021	Bonneville Dam	SSL	EB028	N/A	1008	254
11/3/2021	Bonneville Dam	SSL	EB029	N/A	991	261
11/3/2021	Bonneville Dam	SSL	O47	5/16/2017	1477	272
11/9/2021	Bonneville Dam	SSL	EB030	N/A	832	261
11/9/2021	Bonneville Dam	SSL	EB031	N/A	1167	282
11/10/2021	Bonneville Dam	SSL	EB032	N/A	990	275
11/16/2021	Bonneville Dam	SSL	EB033	N/A	1261	266
11/16/2021	Bonneville Dam	SSL	EB034	N/A	1728	295
11/17/2021	Bonneville Dam	SSL	EB035	N/A	1597	302
11/17/2021	Bonneville Dam	SSL	EB036	N/A	1532	315
Spring 2022 Season						
4/19/2022	Bonneville Dam	SSL	EB037	N/A	1186	276

Removal Date	Location	Species	Animal ID	Date Branded	Weight (lbs)	Length (cm)
4/20/2022	Bonneville Dam	SSL	EB038	N/A	1444	289
4/20/2022	Bonneville Dam	SSL	EB039	N/A	1663	275
4/20/2022	Bonneville Dam	CSL	ZB016	N/A	429	210
4/21/2022	Bonneville Dam	SSL	O37	4/30/2013	1925	295
4/26/2022	Bonneville Dam	CSL	ZB017	N/A	726	226
4/26/2022	Bonneville Dam	CSL	ZB018	N/A	699	223
4/26/2022	Bonneville Dam	CSL	X842	4/3/2017	506	220
4/27/2022	Bonneville Dam	SSL	EB040	N/A	973	254
4/28/2022	Bonneville Dam	CSL	ZB019	N/A	798	234
4/28/2022	Bonneville Dam	SSL	EB041	N/A	1637	290
5/3/2022	Bonneville Dam	SSL	EB042	N/A	827	249
5/3/2022	Bonneville Dam	CSL	ZB020	N/A	493	217
5/3/2022	Bonneville Dam	CSL	ZB021	N/A	443	203
5/3/2022	Bonneville Dam	CSL	C-096	4/22/2015	833	220
5/3/2022	Bonneville Dam	CSL	ZB022	N/A	466	207
5/4/2022	Bonneville Dam	CSL	2n61	5/16/2018	696	219
5/5/2022	Bonneville Dam	CSL	ZB023	N/A	819	235
5/10/2022	Bonneville Dam	CSL	ZB024	N/A	656	226
5/10/2022	Bonneville Dam	SSL	EB043	N/A	871	252
5/10/2022	Bonneville Dam	SSL	EB044	N/A	727	243
5/11/2022	Bonneville Dam	CSL	ZB025	N/A	593	215
5/11/2022	Bonneville Dam	CSL	ZB026	N/A	599	217
5/17/2022	Willamette Falls	CSL	ZW007	N/A	685	225
Spring 2023 Season						
4/20/2023	Bonneville Dam	CSL	ZB027	N/A	726	231

Removal Date	Location	Species	Animal ID	Date Branded	Weight (lbs)	Length (cm)
4/20/2023	Bonneville Dam	CSL	ZB028	N/A	611	230
5/2/2023	Bonneville Dam	SSL	EB045	N/A	616	232
5/2/2023	Bonneville Dam	SSL	EB046	N/A	663	241
5/2/2023	Bonneville Dam	CSL	ZB029	N/A	631	215
5/2/2023	Bonneville Dam	CSL	ZB030	N/A	378	210
5/3/2023	Bonneville Dam	SSL	EB047	N/A	858	260
5/3/2023	Bonneville Dam	CSL	ZB031	N/A	540	218
5/3/2023	Bonneville Dam	CSL	ZB032	N/A	823	238
5/4/2023	Bonneville Dam	CSL	ZB033	N/A	494	225
5/4/2023	Bonneville Dam	CSL	ZB034	N/A	234	170
5/4/2023	Bonneville Dam	CSL	ZB035	N/A	647	220
5/4/2023	Bonneville Dam	CSL	ZB036	N/A	439	208
5/9/2023	Bonneville Dam	CSL	ZB037	N/A	753	237
5/9/2023	Bonneville Dam	SSL	EB048	N/A	685	257
5/10/2023	Bonneville Dam	CSL	ZB038	N/A	768	232
5/10/2023	Bonneville Dam	CSL	ZB039	N/A	596	222
5/10/2023	Bonneville Dam	SSL	EB049	N/A	781	249
5/10/2023	Bonneville Dam	CSL	ZB040	N/A	631	230
5/11/2023	Bonneville Dam	SSL	EB050	N/A	485	224
5/11/2023	Bonneville Dam	CSL	ZB041	N/A	249	186
5/11/2023	Bonneville Dam	CSL	ZB042	N/A	688	235
5/11/2023	Bonneville Dam	CSL	ZB043	N/A	579	217
5/16/2023	Bonneville Dam	CSL	ZB044	N/A	373	189
5/16/2023	Bonneville Dam	CSL	ZB045	N/A	326	192
5/16/2023	Bonneville Dam	CSL	ZB046	N/A	655	219

Removal Date	Location	Species	Animal ID	Date Branded	Weight (lbs)	Length (cm)
5/16/2023	Bonneville Dam	CSL	ZB047	N/A	274	175
5/16/2023	Bonneville Dam	CSL	ZB048	N/A	446	206

† = Data not collected, *Weight is estimated.

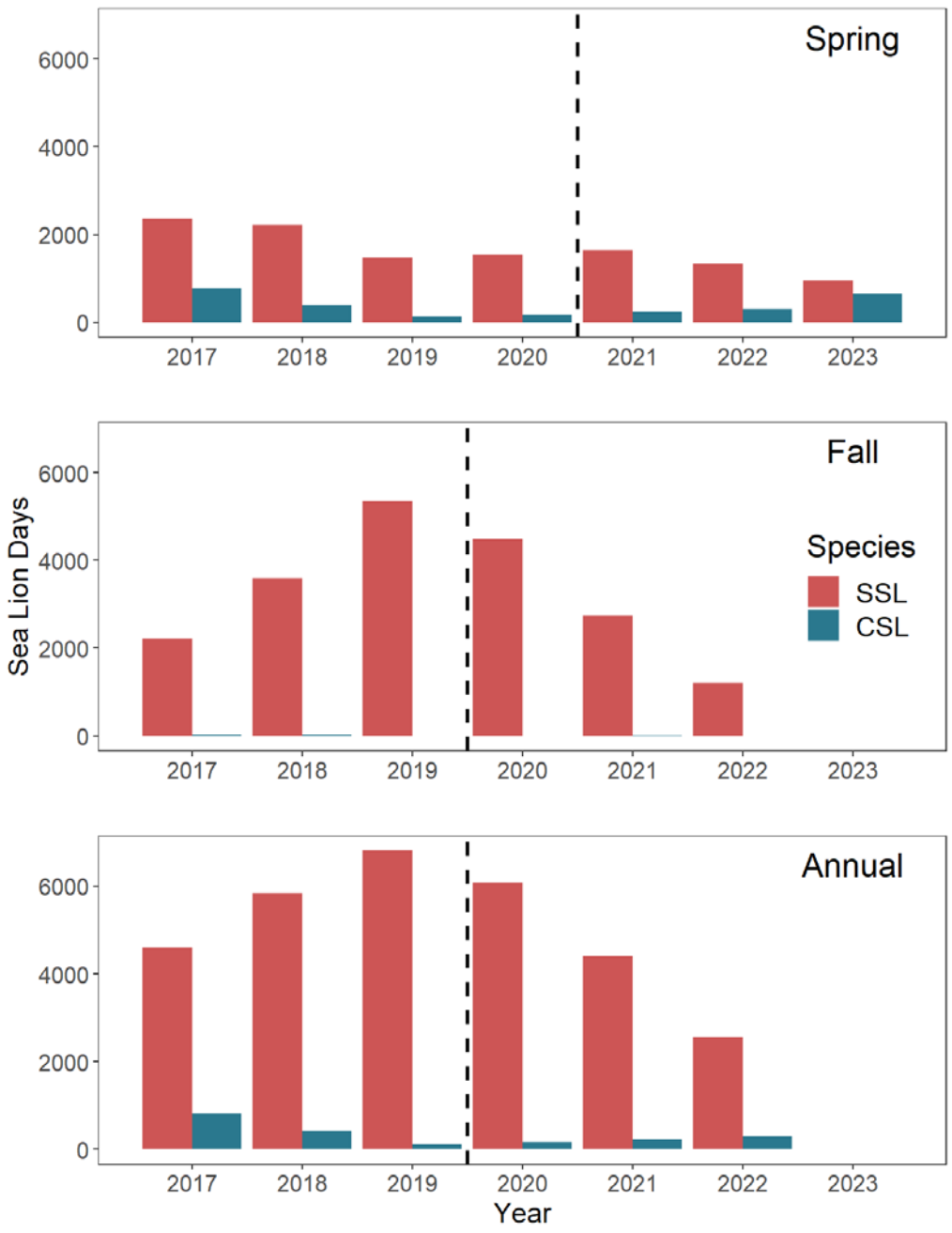

Figure B1. Yearly estimates of the number of sea lion days spent at Bonneville Dam by California (CSL, blue) and Steller (SSL, red) sea lions from 2017 (when USACE implemented consistent Fall monitoring) through Spring 2023. Top: estimated sea lion days for the Spring monitoring period (January – May); 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 2023 data are not included in this reporting period, so are omitted in the middle and bottom panels.

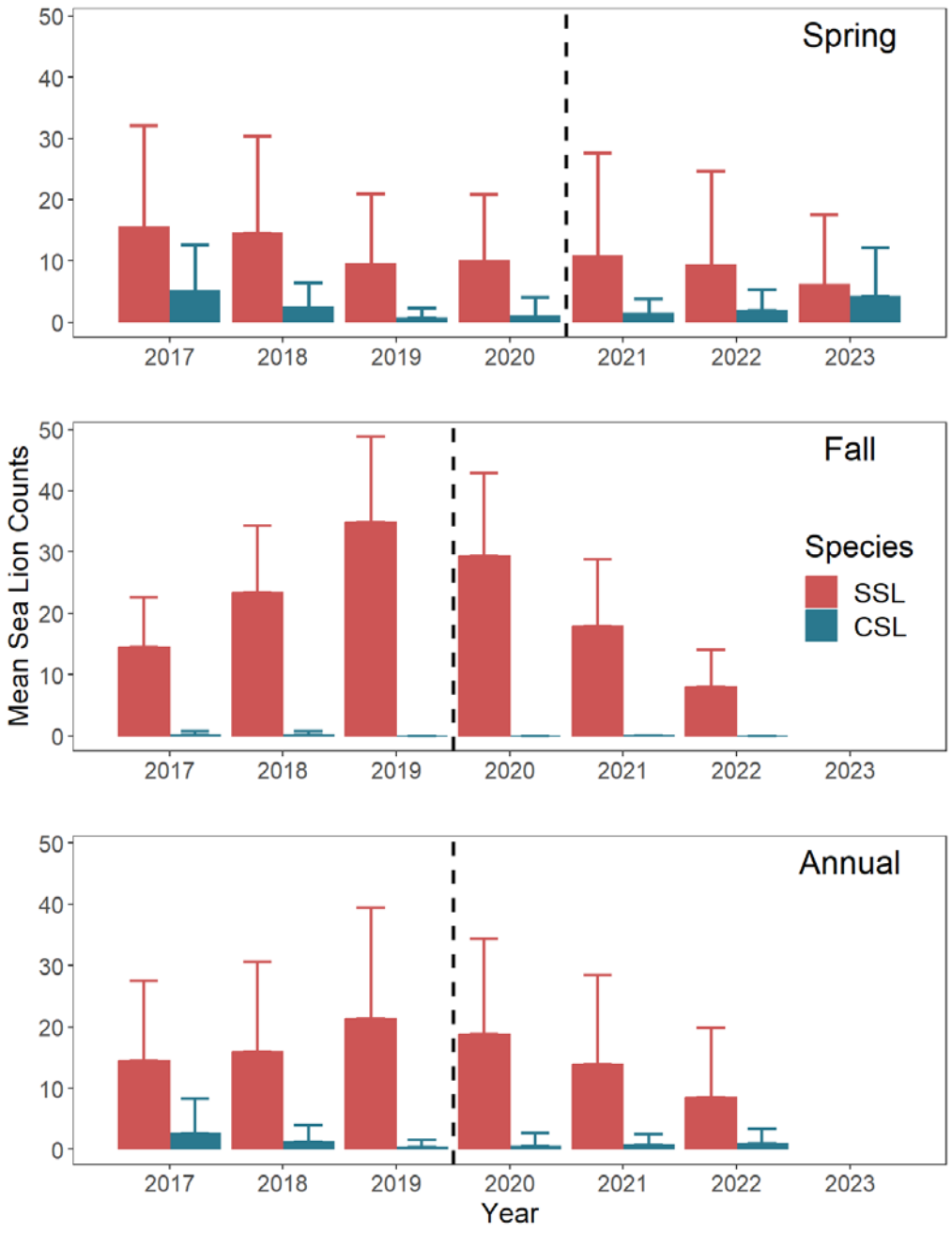

Figure B2. Yearly mean counts of California (CSL, blue) and Steller (SSL, red) sea lions at Bonneville Dam from 2017 (when USACE implemented consistent Fall monitoring) through Spring 2023. Error bars encompass one standard deviation. Top: mean sea lion counts from the Spring monitoring period (January – May); Middle: mean counts for the Fall monitoring period (August – December); Bottom: year-round mean counts. Vertical dashed line represents the beginning of the current removal permit in August 2020. Fall 2023 data are not included in this reporting period, so are omitted in the middle and bottom panels.

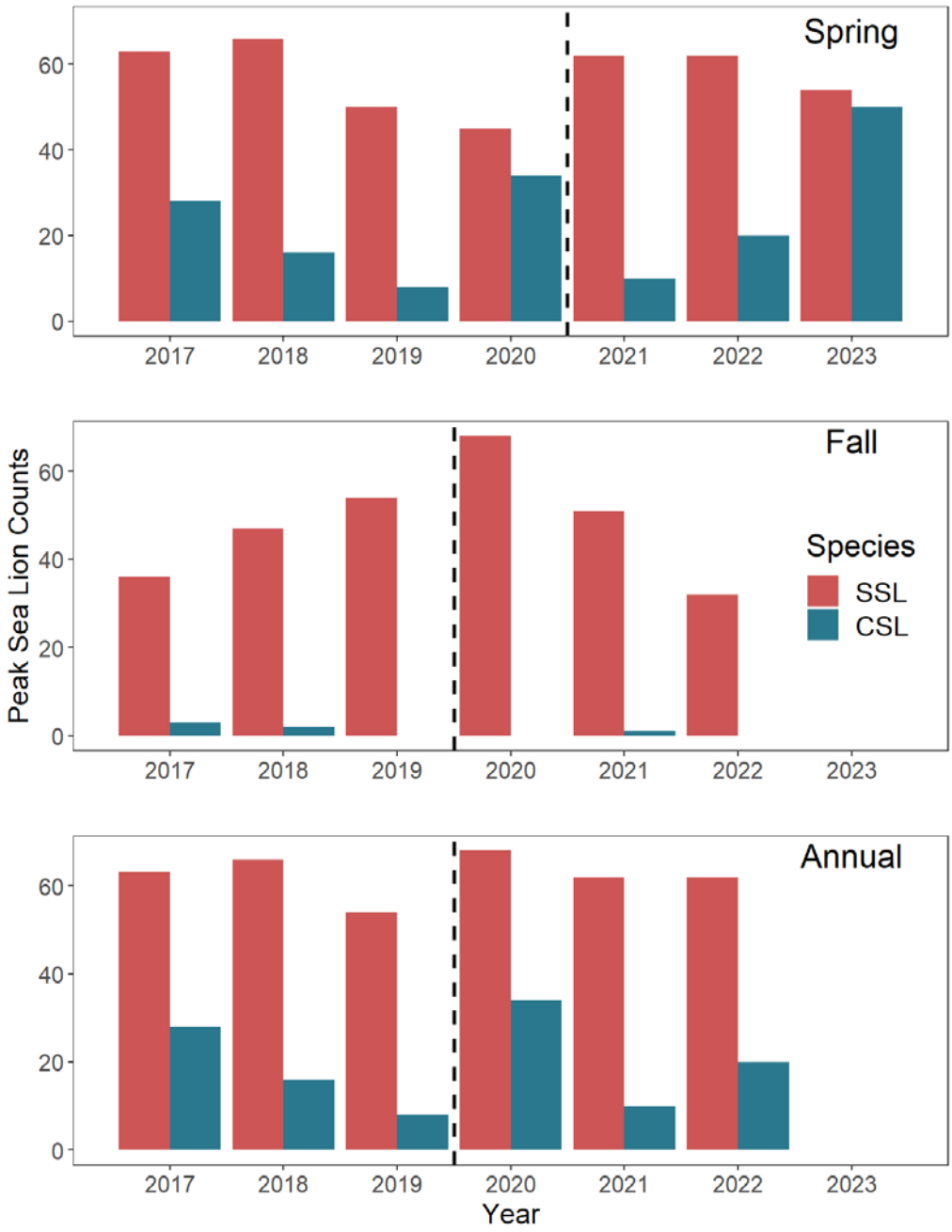

Figure B3. Yearly peak counts of California (CSL, blue) and Steller (SSL, red) sea lions at Bonneville Dam from 2017 (when USACE implemented consistent Fall monitoring) through Spring 2023. Top: peak sea lion counts from the Spring monitoring period (January – May); Middle: peak counts for the Fall monitoring period (August – December); Bottom: year-round peak counts. Vertical dashed line represents the beginning of the current removal permit in August 2020. Fall 2023 data are not included in this reporting period, so are omitted in the middle and bottom panels.

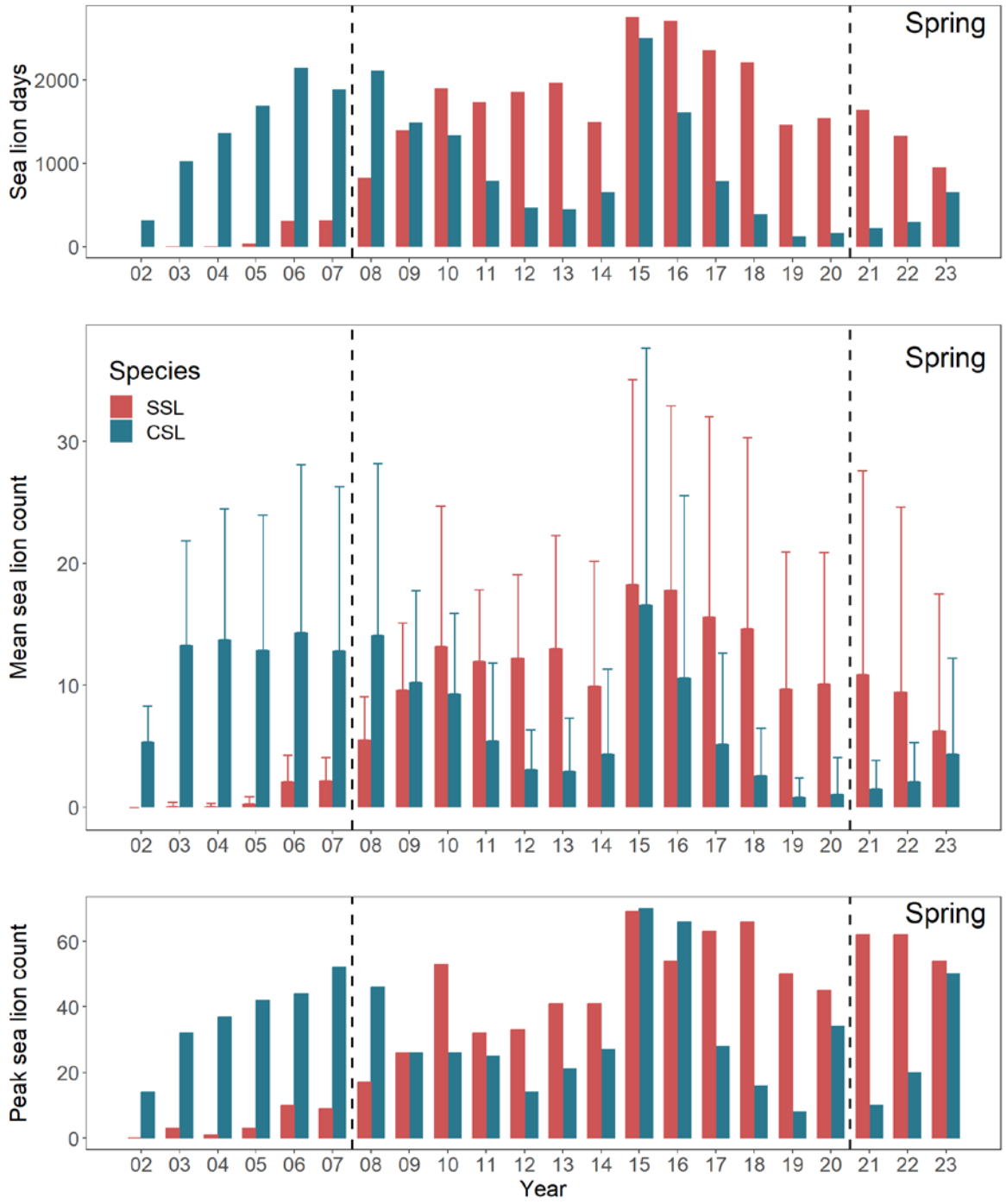

Figure B4. Yearly estimates of sea lion days, mean (± 1 standard deviation), and peak spring counts of California (CSL, blue) and Steller (SSL, red) sea lions at Bonneville Dam from 2002 (when USACE implemented Spring monitoring) through 2023. Top: sea lion day estimates; Middle: yearly mean (± 1 SD) counts; Bottom: peak counts. For each panel, the vertical dashed line prior to 2008 indicates the beginning of permanent removals of CSL at Bonneville Dam, and the vertical dashed line prior to Spring 2021 represents the beginning of the current removal permit in August 2020.

ACKNOWLEDGEMENTS

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APPENDICES

Appendix 1. IACUC

Assurance of Animal Care and Use Form

IACUC Use Only

IACUC Number:
ODFW/WDFW/CRITFC/IDFG 2022-1
(Circle One)

Date Received: 09 7 2023

Initial Review Date: 09 7 2023
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:  **Date:** 09/11/2023

Columbia River Predatory California and Steller Sea Lion Lethal Removal §120(f) Authorization Animal Care and Use Form

09 7 2023

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 – Chair), Douglas Hatch (CRITFC), Robin Brown (Community Member At-Large), Colin Gillin (ODFW – Veterinarian)

Mailing Address: 17330 SE Evelyn street Oregon City Or. 97045

Telephone: 971-707-1764 **Fax: Email:** Michael.l.brown@odfw.oregon.gov

Initial Submission ☐ **Renewal** ☒ **or Modification** ☐

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

Anticipated Start Date: September 7, 2023 **Anticipated End Date:** Ongoing

Duration of Approved Protocol: September 7, 2023 through May 16, 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 §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)	Total # of animals needed for duration of project
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	540 maximum
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	176 maximum

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 §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 §120(f) Letter of Authorization, 14 Aug 2020).

Darting of animals under MMPA §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 §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[11], 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 §120(f) requirement.

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

[11] 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.

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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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, netsshade, 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 §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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3. Arluke A. Coping with euthanasia: a case study of shelter culture. Journal of the American Veterinary Medical Association. 1991 Apr 1;198(7):1176.
4. Bennett P, Rohlf V. Perpetration-induced traumatic stress in persons who euthanize nonhuman animals in surgeries, animal shelters, and laboratories. Society & Animals. 2005 Jan 1;13(3):201-20.
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8. Pierce J. Animal Euthanasia and Traumatic Stress: An Unexplored Area of Suffering? [Internet]. 15 October 2013 [Accessed 14 Mar 2020]. Available from: https://www.psychologytoday.com/us/blog/all-dogs-go-heaven/201310/animal-euthanasia-and-traumatic-stress
9. Whiting TL, Marion CR. Perpetration-induced traumatic stress—A risk for veterinarians involved in the destruction of healthy animals. The Canadian Veterinary Journal. 2011 Jul;52(7):794.

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
☒Y ☐N	Michael Brown	ODFW	971-707-1764	michael.l.brown@odfw.oregon.gov
☒Y ☐N	John Edwards	WDFW	360-280-2155	john.edwards@dfw.wa.gov
☒Y ☐N	Bryan Wright	ODFW	541-757-5225	bryan.e.wright@odfw.oregon.gov
☒Y ☐N	Shay Valentine	ODFW	360-789-2627	shay.w.valentine@odfw.oregon.gov
☒Y ☐N	Eric Nass	ODFW	971-209-5347	eric.r.nass@odfw.oregon.gov
☒Y ☐N	Zane Kroneberger	ODFW	928-814-6265	zane.p.kroneberger@odfw.oregon.gov
☒Y ☐N	Colin Gillin	ODFW (Vet)	541-231-9271	colin.m.gillin@odfw.oregon.gov
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☒Y ☐N	Mike Howell	IDFG (Vet)	425-754-5922	mike@evergreenequinevet.com
☒Y ☐N	Dyanna Lambourn	WDFW	253-208-2427	dyanna.lambourn@dfw.wa.gov
☒Y ☐N	Jeanne Ross	WDFW (Vet)	503-559-5303	jbrdvm@gmail.com
☐Y ☒N	Mark Drew	WDFW (Vet)	208-391-9890	mldcollege@outlook.com
☒Y ☐N	Trever Barker	WDFW	360-609-8128	trever.barker@dfw.wa.gov
☒Y ☐N	Doug Hatch	CRITFC	503-731-1263	hatd@critfc.org
☒Y ☐N	John Whiteaker	CRITFC	503-476-7649	whij@critfc.org
☒Y ☐N	Devayne Lewis	CRITFC	503-238-0667	dlewis@critfc.org
☒Y ☐N	Theodore Walsey	CRITFC	503-238-0667	rwalsey@critfc.org
☒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:

John Powell
Idaho Dept. of Fish and Game
John.Powell@idfg.idaho.gov
Signed: 09/7/2023

Casey Clark
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Douglas Hatch, signing for:

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IACUC Appendix A

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.

IACUC Appendix B

Training and Experience description(s)

The state program leaders directing this work (Brown, Valentine, Clark, Edwards) 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 state 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			
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
TMMC/SR3/EPMOHC	Blood serum	Renal Function, Comparative Proteomics	Collect up to 6 mL of blood into Red Top glass vials. Spin down and aliquot serum into 4 cryovials. CSL only
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
TMMC/SR3/EPMOHC	Kidney	Renal Function	Collect 2 samples with complete reniculi from each kidney, place one sample from each kidney into its own whirlpack, freeze at -20 or -80. Place 2nd samples from each kidney in shared formalin jar. CSL only
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
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
NOAA	Skin	Genetics	Stellers only. Take one small piece of skin and place in a labeled Cryovial filled with 95% EtOH. Freeze immediately
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
TMMC/SR3/EPMOHC	Urine	Renal Function, Comparative Proteomics, Stability study	Fill one 2ml cryovial, put remaining urine into a 50ml conical tube. Ship chilled overnight to TMMC. CSL only and not on all animals.

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; TMMC=The Marine Mammal Center; SR3=Sealife Response, Rehabilitation, and Research; EPMOHC=Eastern Pacific Marine One Health Coalition; WDFW=Washington Department of Fish and Wildlife; ODFW=Oregon Department of Fish and Wildlife; NOAA=National Oceanic and Atmospheric Administration

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 §120(f) 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., Tidwell et al. 2023, Wright et al. 2022). 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 unity. 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 annually 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 4.3.1 (R Core Team 2023).

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 1).

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) 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 observed 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 1).

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 2). 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 will 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 3, Figure 2). 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 will 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 will 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):

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

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 3). 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 4). 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 4, Figure 4).

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 5). 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 fish 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 6. (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 are now included and 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 runs of the ABM. The method of summary, however, 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 runs, 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 (≤20) such that the total number of records equals the product of run size and agents. Third, mean values per location-species-season-agent are calculated across runs such that the total number records equals 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 location-species-season combinations.

3. Results

The predicted post-removal salmonid requirements for the 119 sea lions removed under MMPA §120(f) was 28,696 salmonids (95% CI = 16,221-44,974) (Figure 5). Individual-level summary statistics are summarized in Table 7.

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) 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 observed 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 7) 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 ABM estimates of 12.9 and 14.1 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 modeled requirements ranging from 23.5-29.5 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 (Figure 5) compared to the spring. This was due to the fact that even though salmonids were assumed to be a smaller proportion of their diet (Table 5), higher rates of both fidelity and residency (Table 4) 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 (Tidwell et al. 2023), 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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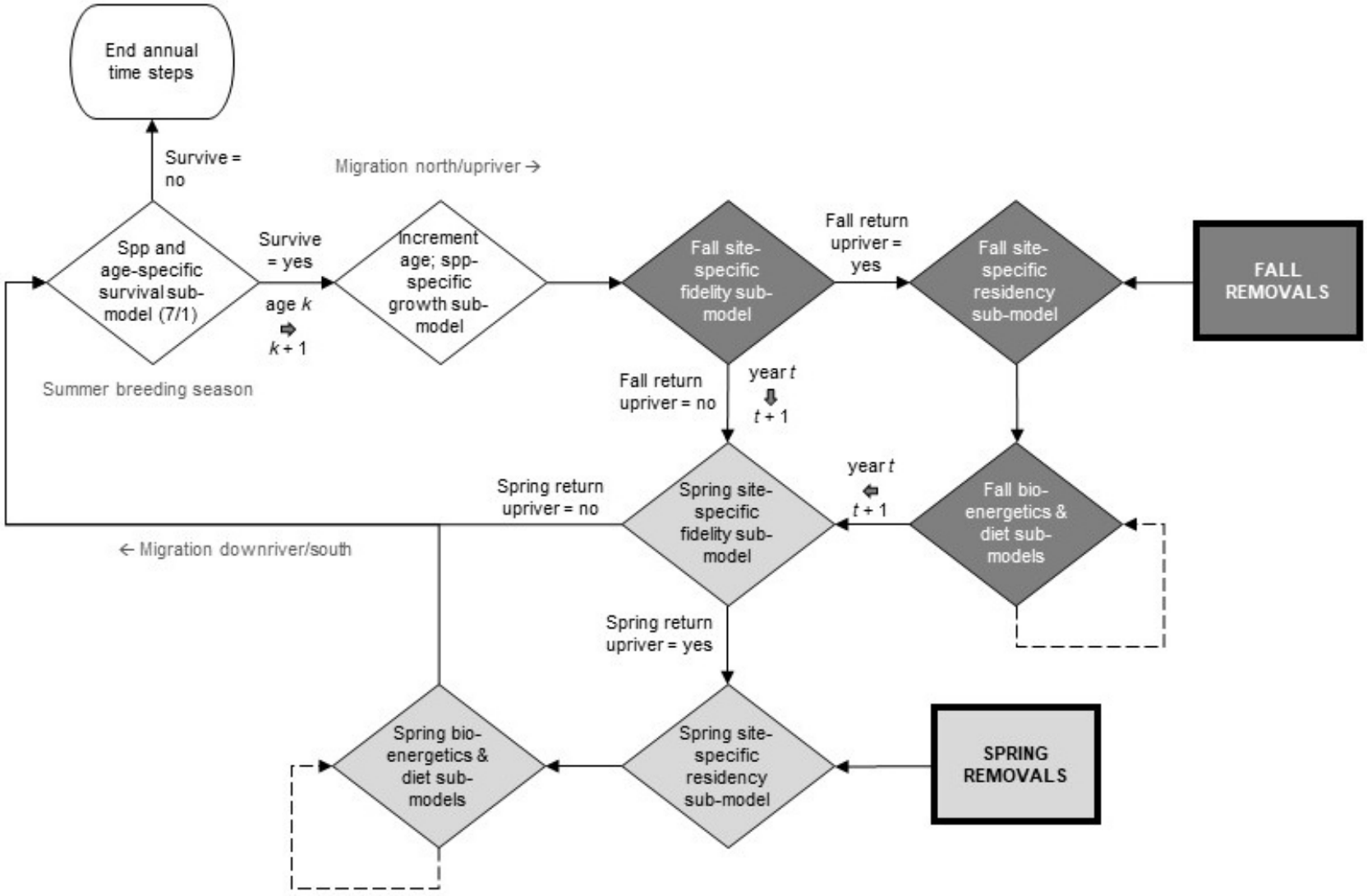

Figure 1. Flowchart of sea lion management agent-based model.

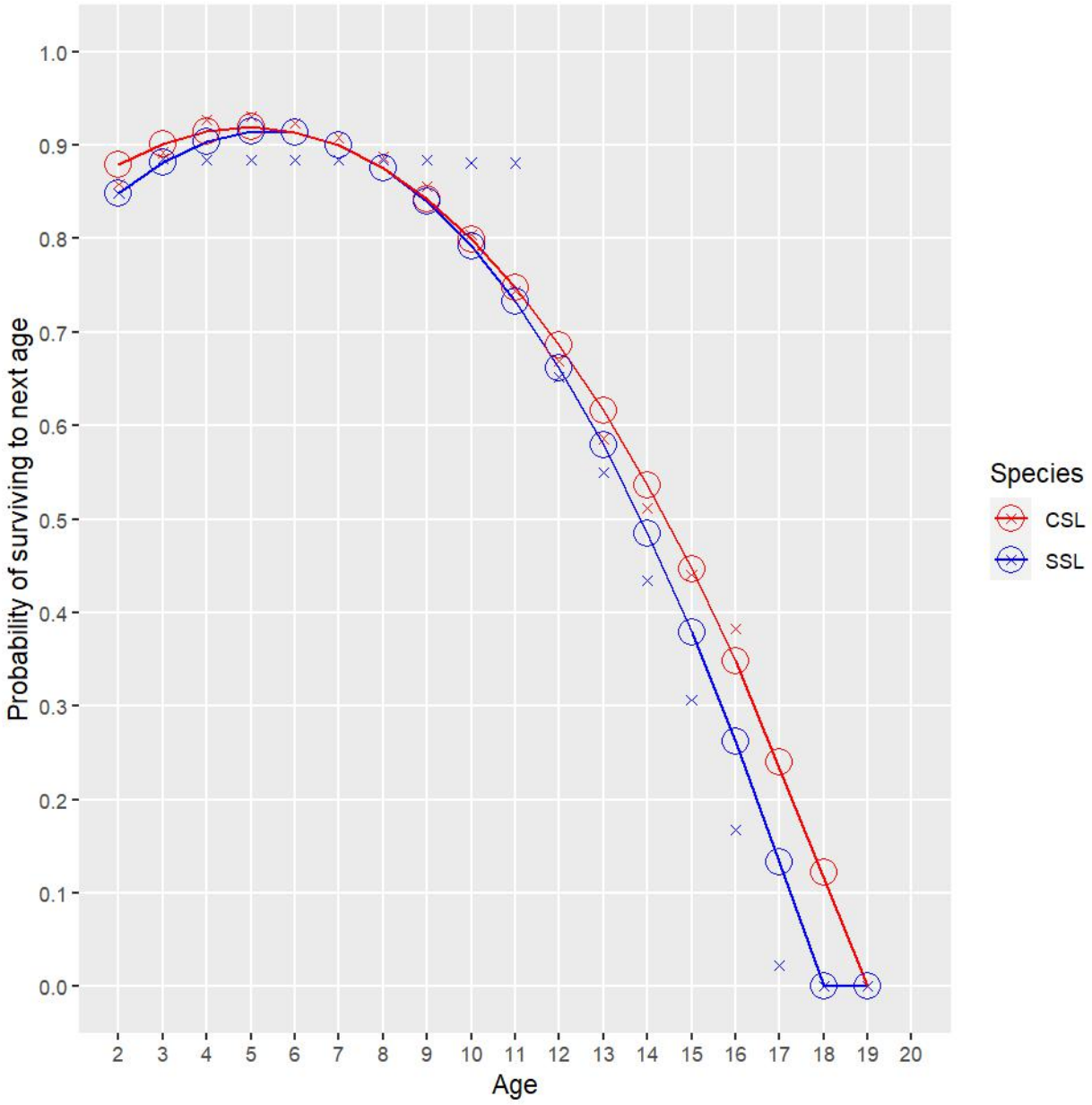

Figure 2. Survival sub-model. California sea lion (CSL) data from DeLong et al. (2017); Steller sea lion (SSL) data from Wright et al. (2017; ages 0-11) and Maniscalco et al. (2015; ages >11); lines indicate second order polynomial fits to data. See Table 3 for additional details.

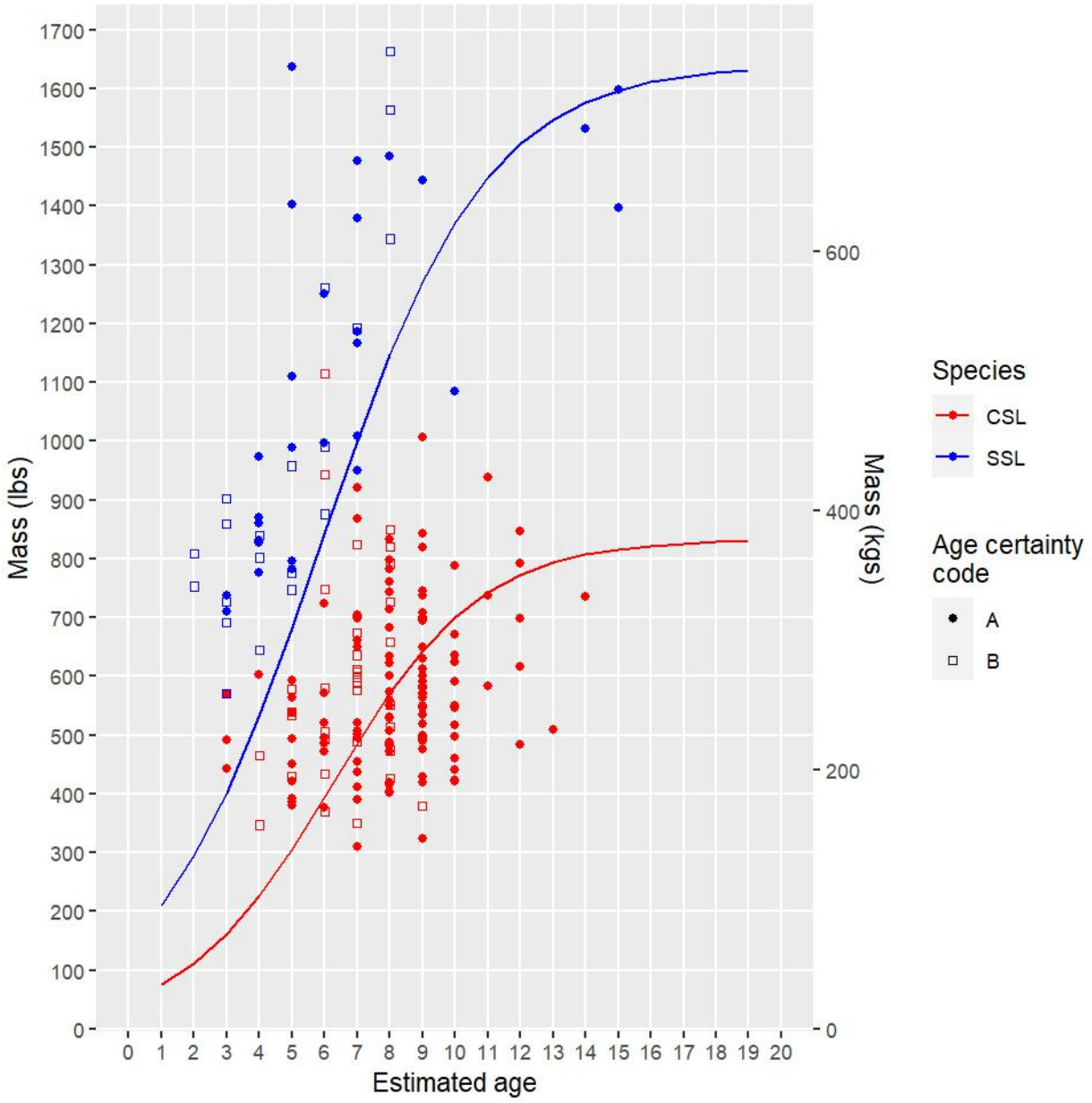

Figure 3. Growth sub-model. Lines represent mass-at-age growth curves for male California sea lions (CSL) and Steller sea lions (SSL) (Winship et al. 2006); points represent empirical age and weight data from sea lions removed at Bonneville Dam and Willamette Falls. Age certainty code is a reliability index provided by Matson's Laboratory, where “A” is the highest reliability rating.

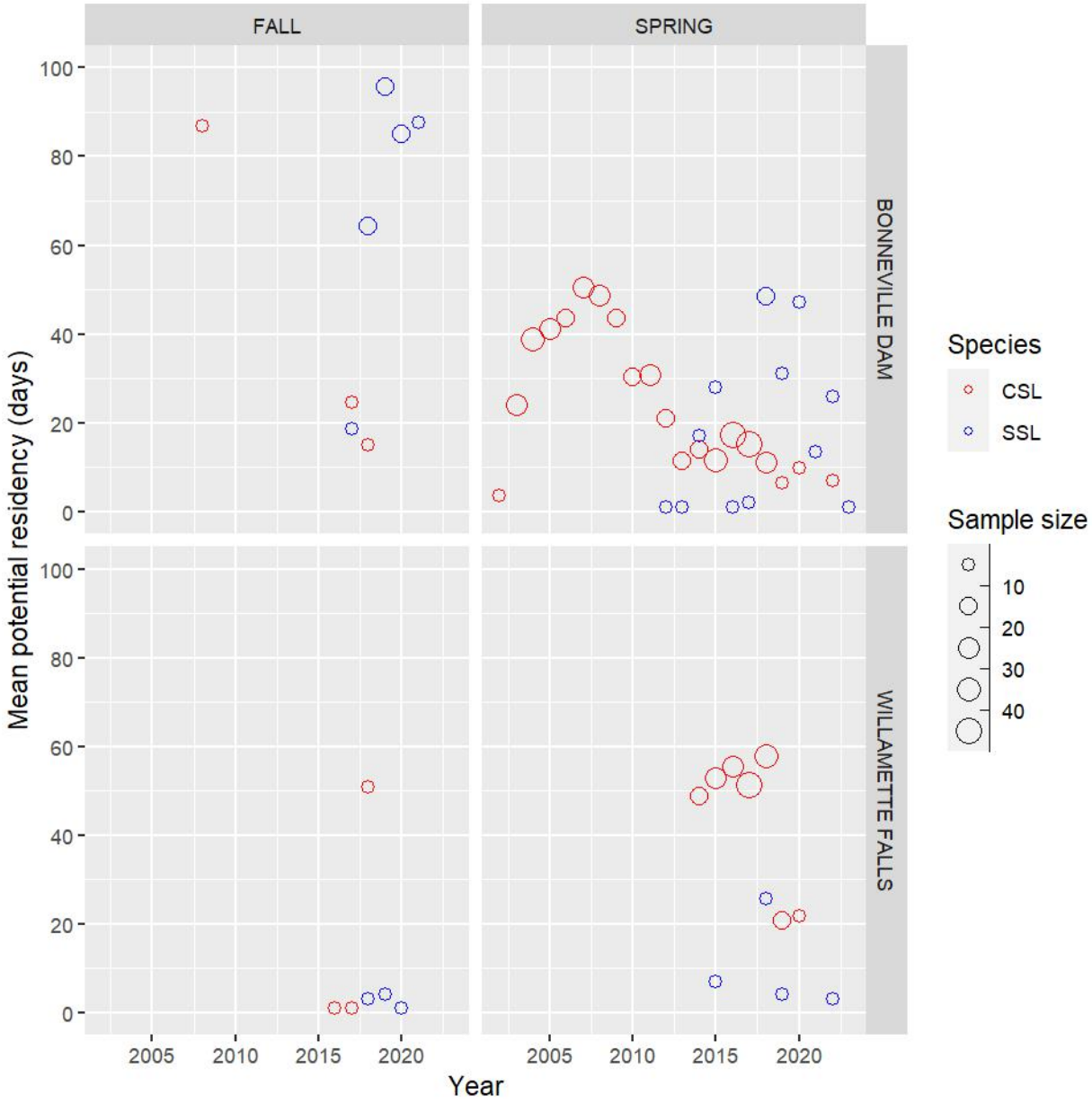

Figure 4. Residency sub-model. Annual average potential residency by year, season, location, and species (based on all identifiable upriver animals, not just removals).

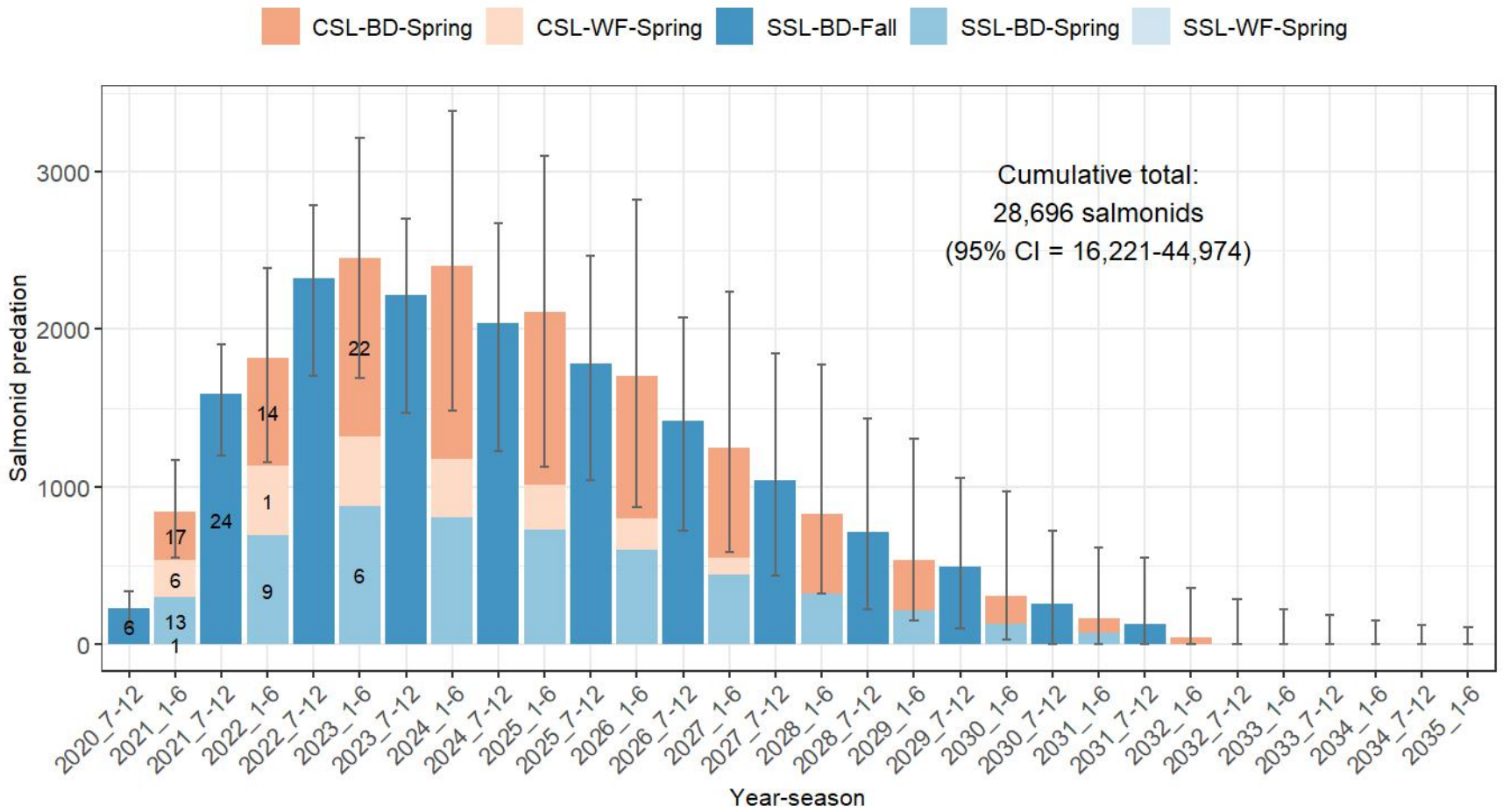

Figure 5. Predicted post-removal salmonid requirements for 60 California sea lions (CSLs) and 59 Steller sea lions (SSLs; includes one suspected hybrid) removed at Bonneville Dam (BD) and Willamette Falls (WF) from fall 2020 to spring 2023 under MMPA §120(f). Predictions based on 2.5th, 50th, and 97.5th percentiles from 300 ABM simulations; numbers overlaid on bars indicate number of animals removed for the species-location-season combination indicated.

Table 1. California sea lions (CSLs) and Steller sea lions (SSLs) removed at Bonneville Dam (BD) and Willamette Falls (WF) from fall 2020 to spring 2023 under MMPA §120(f).

Location	Species	Season	2020	2021	2022	2023	Total removals
BD	CSL	Spring	NA	17	14	22	53
	SSL	Spring	NA	13	9	6	28
		Fall	6	24	0	NA	30
WF	CSL	Spring	NA	6	1	0	7
	SSL	Spring	NA	1	0	0	1
Total			6	61	24	28	119

Table 2. Dataset used to initiate the ABM, sorted by date of capture. The variable 'Actual' indicates whether actual individual-level (1), or estimated population-level (0), data was used to parameterize the preceding variable to its left.

Individual	Spp	ID	Location	Season	Date	Age	Actual	Mass_kgs	Actual	Fidelity_p	Actual	Residency_d	Actual
1	SSL	EB001	BD	Fall	20201014	8	0	403	1	0.84	0	57	0
2	SSL	EB002	BD	Fall	20201015	3	1	322	1	0.84	0	57	0
3	SSL	O53	BD	Fall	20201022	5	1	339	1	1.00	1	123	1
	SSL	O53	BD	Spring	20201022	5	1	339	1	1.00	1	25	0
4	SSL	EB003	BD	Fall	20201103	4	1	352	1	0.84	0	57	0
5	SSL	O44	BD	Fall	20201104	7	1	431	1	1.00	1	48	1
	SSL	O44	BD	Spring	20201104	7	1	431	1	0.67	1	1	1
6	SSL	EB004	BD	Fall	20201105	3	1	409	1	0.84	0	57	0
7	SSL	EW001	WF	Spring	20210302	8	0	420	0	0.10	0	16	0
8	SSL	EB005	BD	Spring	20210406	4	1	364	1	0.37	0	25	0
9	CSL	ZW001	WF	Spring	20210413	8	0	259	0	0.87	0	39	0
10	CSL	ZW002	WF	Spring	20210413	8	0	259	0	0.87	0	39	0
11	CSL	ZW003	WF	Spring	20210413	8	0	259	0	0.87	0	39	0
12	SSL	EB006	BD	Spring	20210414	6	1	567	1	0.37	0	25	0
13	CSL	ZB001	BD	Spring	20210414	5	1	242	1	0.72	0	22	0
14	SSL	EB007	BD	Spring	20210415	3	1	390	1	0.37	0	25	0
15	SSL	EB008	BD	Spring	20210415	2	1	367	1	0.37	0	25	0
16	CSL	ZB002	BD	Spring	20210415	9	1	338	1	0.72	0	22	0
17	CSL	ZW004	WF	Spring	20210415	8	0	259	0	0.87	0	39	0
18	SSL	O41	BD	Fall	20210420	5	1	636	1	1.00	1	1	1
	SSL	O41	BD	Spring	20210420	5	1	636	1	0.75	1	22	1
19	CSL	ZW005	WF	Spring	20210420	8	0	259	0	0.87	0	39	0
20	CSL	ZW006	WF	Spring	20210420	8	0	259	0	0.87	0	39	0
21	SSL	EB009	BD	Spring	20210421	6	1	397	1	0.37	0	25	0
22	SSL	EB010	BD	Spring	20210422	6	1	452	1	0.37	0	25	0
23	SSL	EB011	BD	Spring	20210428	2	1	342	1	0.37	0	25	0
24	SSL	EB012	BD	Spring	20210428	4	1	381	1	0.37	0	25	0
25	CSL	ZB003	BD	Spring	20210428	10	1	250	1	0.72	0	22	0

26	SSL	EB013	BD	Spring	20210429	3	1	313	1	0.37	0	25	0
27	CSL	06n3	BD	Spring	20210429	8	1	282	1	1.00	1	1	1
28	CSL	ZB004	BD	Spring	20210429	6	1	506	1	0.72	0	22	0
29	CSL	X693	BD	Spring	20210504	10	1	209	1	0.72	0	22	0
30	CSL	ZB005	BD	Spring	20210504	8	1	288	1	0.72	0	22	0
31	CSL	ZB006	BD	Spring	20210504	9	1	272	1	0.72	0	22	0
32	CSL	ZB007	BD	Spring	20210504	6	1	264	1	0.72	0	22	0
33	CSL	ZB008	BD	Spring	20210504	5	1	245	1	0.72	0	22	0
34	SSL	EB014	BD	Spring	20210505	3	1	335	1	0.37	0	25	0
35	CSL	ZB009	BD	Spring	20210505	6	1	339	1	0.72	0	22	0
36	CSL	ZB010	BD	Spring	20210505	6	1	259	1	0.72	0	22	0
37	CSL	ZB011	BD	Spring	20210505	5	1	262	1	0.72	0	22	0
38	SSL	EB015	BD	Spring	20210506	5	1	355	1	0.37	0	25	0
39	CSL	ZB012	BD	Spring	20210506	3	1	223	1	0.72	0	22	0
40	CSL	ZB013	BD	Spring	20210511	5	1	244	1	0.72	0	22	0
41	CSL	ZB014	BD	Spring	20210511	6	1	224	1	0.72	0	22	0
42	CSL	ZB015	BD	Spring	20210511	8	0	552	1	0.72	0	22	0
43	SSL	EB016	BD	Spring	20210512	8	0	721	1	0.37	0	25	0
44	SSL	EB017	BD	Fall	20210914	5	1	352	1	0.84	0	57	0
45	SSL	EB018	BD	Fall	20210915	5	1	435	1	0.84	0	57	0
46	SSL	EB019	BD	Fall	20210915	3	1	259	1	0.84	0	57	0
47	SSL	EB020	BD	Fall	20210916	5	1	361	1	0.84	0	57	0
48	SSL	O49	BD	Fall	20210921	5	1	504	1	1.00	1	133	1
	SSL	O49	BD	Spring	20210921	5	1	504	1	1.00	1	2	1
49	SSL	EB021	BD	Fall	20210922	10	1	492	1	0.84	0	57	0
50	SSL	EB022	BD	Fall	20210923	15	1	634	1	0.84	0	57	0
51	SSL	EB023	BD	Fall	20210928	4	1	390	1	0.84	0	57	0
52	SSL	EB024	BD	Fall	20210929	8	1	709	1	0.84	0	57	0
53	SSL	EB025	BD	Fall	20210930	4	1	292	1	0.84	0	57	0
54	SSL	EB026	BD	Fall	20211006	8	1	673	1	0.84	0	57	0
55	SSL	EB027	BD	Fall	20211006	7	1	626	1	0.84	0	57	0

56	SSL	O48	BD	Fall	20211007	8	1	610	1	1.00	1	84	1
	SSL	O48	BD	Spring	20211007	8	1	610	1	1.00	1	89	1
57	SSL	O42	BD	Fall	20211014	7	1	541	1	1.00	1	76	1
	SSL	O42	BD	Spring	20211014	7	1	541	1	1.00	1	33	1
58	SSL	EB028	BD	Fall	20211102	7	1	457	1	0.84	0	57	0
59	SSL	EB029	BD	Fall	20211103	6	1	450	1	0.84	0	57	0
60	SSL	O47	BD	Fall	20211103	7	1	670	1	1.00	1	83	1
	SSL	O47	BD	Spring	20211103	7	1	670	1	1.00	1	14	1
61	SSL	EB030	BD	Fall	20211109	4	1	377	1	0.84	0	57	0
62	SSL	EB031	BD	Fall	20211109	7	1	529	1	0.84	0	57	0
63	SSL	EB032	BD	Fall	20211110	5	1	449	1	0.84	0	57	0
64	SSL	EB033	BD	Fall	20211116	6	1	572	1	0.84	0	57	0
65	SSL	EB034	BD	Fall	20211116	8	0	784	1	0.84	0	57	0
66	SSL	EB035	BD	Fall	20211117	15	1	724	1	0.84	0	57	0
67	SSL	EB036	BD	Fall	20211117	14	1	695	1	0.84	0	57	0
68	SSL	EB037	BD	Spring	20220419	7	1	538	1	0.37	0	25	0
69	SSL	EB038	BD	Spring	20220420	9	1	655	1	0.37	0	25	0
70	SSL	EB039	BD	Spring	20220420	8	1	754	1	0.37	0	25	0
71	CSL	ZB016	BD	Spring	20220420	5	1	195	1	0.72	0	22	0
72	SSL	O37	BD	Spring	20220422	8	0	873	1	0.56	1	36	1
73	CSL	X842	BD	Spring	20220426	6	1	230	1	0.72	0	22	0
74	CSL	ZB017	BD	Spring	20220426	8	1	329	1	0.72	0	22	0
75	CSL	ZV018	BD	Spring	20220426	7	1	317	1	0.72	0	22	0
76	SSL	EB040	BD	Spring	20220427	4	1	441	1	0.37	0	25	0
77	SSL	EB041	BD	Spring	20220428	5	1	743	1	0.37	0	25	0
78	CSL	ZB019	BD	Spring	20220428	8	1	362	1	0.72	0	22	0
79	SSL	EB042	BD	Spring	20220503	4	1	375	1	0.37	0	25	0
80	CSL	C096	BD	Spring	20220503	8	1	378	1	0.57	1	13	1
81	CSL	ZB020	BD	Spring	20220503	5	1	224	1	0.72	0	22	0
82	CSL	ZB021	BD	Spring	20220503	3	1	201	1	0.72	0	22	0
83	CSL	ZB022	BD	Spring	20220503	4	1	211	1	0.72	0	22	0

84	CSL	2n61	BD	Spring	20220504	9	1	316	1	0.50	1	1	1
85	CSL	ZB023	BD	Spring	20220505	9	1	371	1	0.72	0	22	0
86	SSL	EB043	BD	Spring	20220510	4	1	395	1	0.37	0	25	0
87	SSL	EB044	BD	Spring	20220510	3	1	330	1	0.37	0	25	0
88	CSL	ZB024	BD	Spring	20220510	8	0	298	1	0.72	0	22	0
89	CSL	ZB025	BD	Spring	20220511	5	1	269	1	0.72	0	22	0
90	CSL	ZB026	BD	Spring	20220511	7	1	272	1	0.72	0	22	0
91	CSL	ZW007	WF	Spring	20220516	8	0	311	1	0.87	0	39	0
92	CSL	ZB027	BD	Spring	20230420	8	0	329	1	0.72	0	22	0
93	CSL	ZB028	BD	Spring	20230420	8	0	277	1	0.72	0	22	0
94	SSL	EB045	BD	Spring	20230502	8	0	279	1	0.37	0	25	0
95	SSL	EB046	BD	Spring	20230502	8	0	301	1	0.37	0	25	0
96	CSL	ZB029	BD	Spring	20230502	8	0	286	1	0.72	0	22	0
97	CSL	ZB030	BD	Spring	20230502	8	0	171	1	0.72	0	22	0
98	SSL	EB047	BD	Spring	20230503	8	0	389	1	0.37	0	25	0
99	CSL	ZB031	BD	Spring	20230503	8	0	245	1	0.72	0	22	0
100	CSL	ZB032	BD	Spring	20230503	8	0	373	1	0.72	0	22	0
101	CSL	ZB033	BD	Spring	20230504	8	0	224	1	0.72	0	22	0
102	CSL	ZB034	BD	Spring	20230504	8	0	106	1	0.72	0	22	0
103	CSL	ZB035	BD	Spring	20230504	8	0	293	1	0.72	0	22	0
104	CSL	ZB036	BD	Spring	20230504	8	0	199	1	0.72	0	22	0
105	SSL	EB048	BD	Spring	20230509	8	0	311	1	0.37	0	25	0
106	CSL	ZB037	BD	Spring	20230509	8	0	342	1	0.72	0	22	0
107	SSL	EB049	BD	Spring	20230510	8	0	354	1	0.37	0	25	0
108	CSL	ZB038	BD	Spring	20230510	8	0	348	1	0.72	0	22	0
109	CSL	ZB039	BD	Spring	20230510	8	0	270	1	0.72	0	22	0
110	CSL	ZB040	BD	Spring	20230510	8	0	286	1	0.72	0	22	0
111	SSL	EB050	BD	Spring	20230511	8	0	220	1	0.37	0	25	0
112	CSL	ZB041	BD	Spring	20230511	8	0	113	1	0.72	0	22	0
113	CSL	ZB042	BD	Spring	20230511	8	0	312	1	0.72	0	22	0
114	CSL	ZB043	BD	Spring	20230511	8	0	263	1	0.72	0	22	0

115	CSL	ZB044	BD	Spring	20230516	8	0	169	1	0.72	0	22	0
116	CSL	ZB045	BD	Spring	20230516	8	0	148	1	0.72	0	22	0
117	CSL	ZB046	BD	Spring	20230516	8	0	297	1	0.72	0	22	0
118	CSL	ZB047	BD	Spring	20230516	8	0	124	1	0.72	0	22	0
119	CSL	ZB048	BD	Spring	20230516	8	0	202	1	0.72	0	22	0

*O37 (individual #72) was a suspected hybrid SSL-CSL but was modeled as a SSL.

Table 3. 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 4. 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	Removals (agents)	Fidelity*		Residency (days)**	
				Mean	n	Mean	n
Bonneville	CSL	Spring	53	0.72	361	21.6	252
	SSL	Spring	28 (34)	0.37	49	24.6	31
		Fall	30 (31)	0.84	20	57.2	24
Willamette	CSL	Spring	7	0.87	56	39.2	71
	SSL	Spring	1	0.10	6	16.1	6

* Base dataset consisted of 16,278 resights of 569 individual sea lions. Excluding cases where an animal was only seen upriver one season and then never again (anywhere) resulted in 14,214 resights of 437 individual sea lions.

**Base dataset consisted of 16,278 resights of 569 animals. Excluding season of initial marking and/or removal resulted in 12,736 resights of 368 animals. Further excluding cases where <20% of the residency was actually resighted resulted in a dataset of 11,800 resights of 341 animals.

Table 5. Diet sub-model parameters based on scat and gastro-intestinal tract analyses as well as surface feeding observations at and below Bonneville Dam (BD) and Willamette Falls (WF).

				Diet component #1				Diet component #2			Diet component #3		
Location	Spp	Season	Removals (agents)	Prey	%	ED (kJ/g)*	Weight (kg)**	Prey	%	ED (kJ/g)*	Prey	%	ED (kJ/g)*
BD	CSL	Spring	53	Spring Chinook salmon	90	7.2	5.7	Pacific lamprey	5	25.65	Other	5	*U*(3, 7.2)
	SSL	Spring	28 (34)	Spring Chinook salmon	70	7.2	5.7	White sturgeon	20	4.4	Other	10	*U*(3, 7.2)
		Fall	30 (31)	Salmonid	40	5.9	5.4	White sturgeon	40	4.4	Other	20	*U*(3, 7.2)
WF	CSL	Spring	7	Salmonid	85	5.9	5.4	Pacific lamprey	10	25.65	Other	5	*U*(3, 7.2)
	SSL	Spring	1	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 6. 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 7. Individual-level results summary for sea lion management ABM.

Location	Species	Season	Removals (agents)	Mean (range)					
				Recurrence, years	Residency, days	Daily biomass requirement, kgs	Daily biomass requirement, % body mass	Daily salmonid biomass requirement, kgs	Daily salmonid requirement, # fish
BD	CSL	Spring	53	2.7 (0.9-4.2)	20.7 (1.6-22.0)	12.9 (6.1-18.1)	3.7 (3.3-4.7)	11.7 (5.6-16.5)	2.1 (1.0-2.9)
	SSL	Spring	28 (34)	2.0 (1.0-4.8)	25.3 (1.6-89.2)	23.5 (11.9-29.7)	3.6 (3.2-4.4)	14.0 (7.1-17.7)	2.5 (1.2-3.1)
		Fall	30 (31)	3.4 (0.4-5.0)	61.9 (1.6-133)	29.5 (22.6-35.8)	4.3 (4.0-4.7)	10.0 (7.6-12.1)	1.8 (1.4-2.2)
WF	CSL	Spring	7	2.9 (2.8-3.1)	39.3 (39.1-39.6)	14.1 (13.8-15.9)	4.3 (4.1-4.3)	12.9 (12.6-14.5)	2.4 (2.3-2.7)
	SSL	Spring	1	0.3 (0.3-0.3)	16.2 (16.2-16.2)	25.0 (25.0-25.0)	5.0 (5.0-5.0)	2.9 (2.9-2.9)	0.5 (0.5-0.5)

Appendix 4. Effects of reduced predation rates due to sea lion removals at Bonneville dam on the quasi-extinction risk of upper Columbia River spring Chinook salmon populations

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METHODS

To assess the effect of the pinniped management on the viability of imperiled salmon populations, we synthesized information on pinniped predation below Bonneville Dam and quasi-extinction risk for the Endangered Upper Columbia River spring Chinook and the Threatened Snake River spring/summer Chinook Evolutionarily Significant Units (ESUs). We focused on these ESUs because of their risk status, because they pass Bonneville Dam during the spring period when sea lion predation and management have been considerable, and because there is an existing population viability analysis conducted by Buhle et al. (2018) that estimated the quasi-extinction probability for 29 populations in these ESUs over a range of fishing mortality rates. Because pinniped predation is analogous to fishing mortality in the way it impacts populations by removing adults on their return migration to the spawning grounds, we could use the results from Buhle et al. (2018) to estimate quasi extinction risk at different mortality rates that reflect different pinniped management strategies.
The population viability analysis conducted by Buhle et al. (2018) was conducted using an integrated population model (IPM) fit to data on spawning escapement, proportion of hatchery-origin spawners, spawner age composition, fishing mortality, and broodstock removals from 1952–2016. The IPM was used to simulate many possible 25-year population trajectories, accounting for uncertainty about population dynamics, and assuming different adult mortality rates from fishing. An individual simulated population trajectory was identified as a quasi-extinction event if the four-year running mean of total wild spawner abundance fell below a quasi-extinction threshold of 50. This threshold was used by the Interior Columbia Technical Recovery Team due to a scarcity of historical observations of <50 spawners and for consistency with other Technical Recovery Teams. Thus, a quasi-extinction event does not necessarily represent a complete extinction, but rather a high-risk event which could lead to an extinction due to Allee effects as well as increasing demographic stochasticity and the potential for loss of genetic diversity as populations approach zero. The probability of quasi-extinction for a given population and adult mortality rate was calculated as the proportion of all simulated trajectories in which a quasi-extinction event, as described above, occurred.

Numbers of Chinook salmon consumed by pinnipeds directly (within sight) downstream of Bonneville Dam have been estimated by the U.S. Army Corps of Engineers (USACE) since 2002 by counting observations of sea lions taking Chinook salmon to the surface for consumption (Tidwell et al. 2023). The estimates of total numbers of Chinook consumed are then divided by the counts of fish passing the dam plus the number of fish consumed to calculate a predation rate on the spring Chinook salmon run. In addition to pinniped mortality at the dam, pinniped

mortality occurs throughout the lower Columbia River. However, project objectives were to evaluate effects of predation and pinniped removal on salmon population viability only within the area directly below the dam rather than throughout the lower Columbia estuary.

We compared the quasi-extinction probability (QEP) across three different adult mortality rates designed to represent a no-removal strategy and two possible predation responses to removals. To represent what predation would be in the absence of removals, we used the highest estimated predation rate of 6% prior to the issuance of the permit in 2019 (Tidwell et al. 2023), which makes the conservative assumption that predation rates would not have continued to increase in the absence of removals. To represent a scenario where removals result in predation remaining at recent rates, we used the average predation rate in 2019–2022 of 3%. Finally, to represent a scenario where removals cause predation to continue to decline, we considered a rate of 0%.

In using these three rates (0%, 3% and 6%), we make several assumptions about predation. Firstly, we assume that predation rates will be relatively constant through time for a given management strategy (removals or no removals) and predation response to removals (i.e., remain at recent average of 3% or decline to 0%). We also assume that management has no effect on predation outside of the area monitored by the USACE directly below Bonneville Dam nor on delayed mortality (e.g., from pinniped-induced injuries). Thus, our evaluation could be viewed as an estimate of the minimum benefit of management for increasing the viability of these Chinook salmon populations. Finally, we assume that predation is equal across populations.

We added each pinniped predation mortality to fishing mortality to obtain a total mortality at which quasi-extinction risk from the population viability analysis was obtained. We assumed that fishing mortality would be constant at 15%, which represents the average over the past 20 years (Joint Columbia River Management Staff 2023). Thus, we obtained quasi-extinction probabilities for each population at 15%, 18%, and 21%, where the difference between quasi-extinction probability at 15% or 18%, representing pinniped removals, and at 21% represents the net reduction in risk due to pinniped management.

RESULTS

Projected quasi-extinction probabilities (QEPs) varied widely among spring Chinook salmon populations. For example, assuming predation mortality rates of 6% and historical fishing mortality rates of 15%, projected QEPs across all populations varied from 0.070 to 0.726, with median and mean probabilities of 0.266 and 0.329, respectively (Figure 1, left). The simulations showed that QEPs assuming current predation mortality rates (mean of 3% since 2019) are lower than QEPs assuming peak predation mortality rates (6% prior to 2019), suggesting a positive effect of recent predator removals on quasi-extinction probabilities in all populations. The percent reduction in QEPs due to predator removals ranged from 2.4% to 12.2% across populations, with a median and mean reduction of 5.6%. In other words, reducing predation rates from around 6% (peak scenario) to 3% resulted in an average reduction in the probability of

quasi-extinction of 5.6% (Figure 1, right). In case of a scenario where removals cause predation to continue to decline to 0%, the reduction in QEPs across all populations ranged from 4.1 to 26.8% with a median and mean reduction of 10.7% and 10.5%, respectively (not shown).

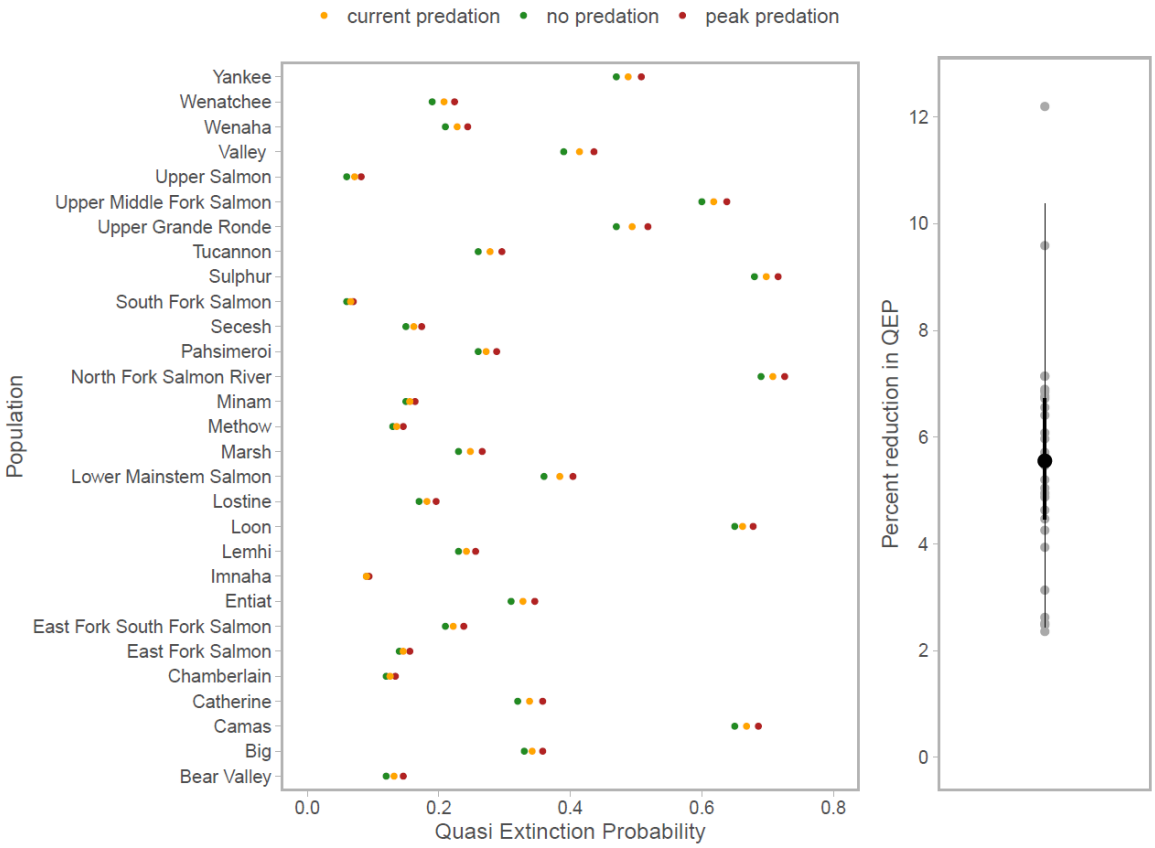

Figure 1: Quasi-extinction probability (QEP) in each population for three different predation scenarios. *Left*: Predation scenarios are 'current predation' (orange), 'no predation' (green), and 'peak predation' (red). The 'current predation' scenario was based on an average predation mortality rate since 2019 of 3% and the 'peak predation' scenario was based on a peak predation mortality rate of 6% prior to 2019. Fishing mortality rate was assumed to be 15% in all predation scenarios, which were run for 25 years. *Right*: Percent reduction in quasi-extinction probabilities across all spring Chinook salmon populations comparing scenarios of assumed predation mortality rates of 6% (pre removals) and 3% (post removals). Shown are estimates for individual populations (gray circles) as well as the median (black circle) with 50% quantiles (thick lines) and 95% quantiles (thin lines). The mean reduction in QEP was about 5.6%.

DISCUSSION

Our results suggest that lower predation rates due to recent sea lion removals at Bonneville Dam may have reduced the probability of quasi-extinction of spring Chinook salmon populations by an average of about 5.6%. This translates to an average reduction in the absolute magnitude of quasi-extinction probability of 1.5% for all runs. These results suggest that completely eliminating predation at Bonneville Dam could reduce the probability of quasi-extinction of spring Chinook populations by an average of 10.7%, which translates to an average reduction in the absolute magnitude of quasi-extinction probability of 2.9% for all runs.

While these simulations show that predator removal can decrease the probability of quasi-extinction of these listed populations, they should be interpreted with caution because our simulations make several simplifying assumptions. First, our simulations assume equal susceptibility of all stocks to predation, but previous studies have shown that predation is higher on earlier-migrating populations (Keefer et al. 2012; Sorel et al. 2021). Second, we used a fixed fishing mortality rate of 15% thus assuming no changes to fishing impacts over the next 25 years. Third, our approach is limited to evaluating effects of predation and reductions in predation at Bonneville dam, whereas previous work suggested that predation rates at the river scale were about ten times higher than at Bonneville dam (Rub et al. 2014). Our estimates of predation rates therefore do not fully quantify impacts of all pinniped predation in the lower Columbia River on migrating salmon populations but rather the small fraction occurring within line of sight of Bonneville Dam. Such an evaluation of changes in predation rates at one specific location provides an incomplete assessment of the magnitude of predation effects and possible benefits of pinniped removals at a river scale. Finally, the IPM used for our analysis did not include pinniped predation, yet data used to fit the model and thus estimated QEPs (Buhle et al. 2018) were likely influenced by historical predation and thus emulate quasi-extinction probabilities under long term average predation rate. While it would be appropriate to re-run the IPM and QEP analysis by explicitly accounting for historical predation, we do not expect the presented results to change substantively due to rather low historical predation rates.

In addition to the reasons discussed above, several other factors likely mean that the results presented here represent a conservative estimate of the benefits of lethal removals to upper Columbia spring Chinook. As stated, this analysis focuses solely on the reduction of predation within the limited area observable from Bonneville Dam; however, the sea lions removed at Bonneville Dam are not limited in range to this area and their permanent removal undoubtedly contributes to some unquantified reduction in salmon predation occurring elsewhere in the river. This predation at other locations in the river is already incorporated into the IPM encapsulated within the survival estimates for returning spring Chinook, but we do not currently have enough information to be able quantify the proportion of the run consumed or how permanent removals at Bonneville Dam and Willamette Falls may have reduced this predation. Second, though the modeling approach employed here assumes constant rates of predation and assumes predation would have peaked at the 6% observed in 2019, the recruitment of new sea lions to Bonneville Dam as habituated salmon predators is known to have a social component and is driven at least in part by the social attraction represented by sea lions already habituated to this food source (Schakner et al. 2017). Removal of habituated sea lions has likely reduced the recruitment of new individuals to Bonneville Dam and elsewhere in the Columbia River, and there is no reason to expect that predation rates on spring Chinook would have peaked at 6% if permanent removals of habituated sea lions had not occurred.

Table 1: Quasi-extinction probabilities (QEP) of Columbia River spring Chinook salmon populations for three hypothetical future predation scenarios: without predation, peak predation rate pre permit, and mean predation rate post permit.

Population	**QEP with 0% predation and 15% fishing mortality**	**QEP with 6% predation (peak rate pre permit) and 15% fishing mortality**	**QEP with 3% predation (mean rate post-permit) and 15% fishing mortality**
Catherine	0.32	0.358	0.338
Lostine	0.17	0.196	0.182
Minam	0.15	0.164	0.156
Upper Grande Ronde	0.47	0.518	0.494
Wenaha	0.21	0.244	0.228
Imnaha	0.09	0.094	0.09
Bear Valley	0.12	0.146	0.132
Big	0.33	0.358	0.342
Camas	0.65	0.686	0.668
Chamberlain	0.12	0.134	0.126
Loon	0.65	0.678	0.662
Marsh	0.23	0.266	0.248
Sulphur	0.68	0.716	0.698
Upper Middle Fork Salmon	0.6	0.638	0.618
East Fork South Fork Salmon	0.21	0.238	0.222
South Fork Salmon	0.06	0.07	0.066
Secesh	0.15	0.174	0.162
Tucannon	0.26	0.296	0.278
East Fork Salmon	0.14	0.156	0.146
Lemhi	0.23	0.256	0.242
Lower Mainstem Salmon	0.36	0.404	0.384
North Fork Salmon River	0.69	0.726	0.708
Pahsimeroi	0.26	0.288	0.272
Upper Salmon	0.06	0.082	0.072
Valley	0.39	0.436	0.414
Yankee	0.47	0.508	0.488
Entiat	0.31	0.346	0.328
Methow	0.13	0.146	0.136
Wenatchee	0.19	0.224	0.208

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