Fish and Wildlife Program Performance Assessment, 1980-2022: Predator Management

Prepared by

Kate Self, Kris Homel

This is a staff product and has not been reviewed or approved by the Council. This working draft functions as supplementary documentation for the Categorical Assessment presentations and contains information to inform the upcoming amendment process. While elements within this document were developed in collaboration with the region's state and federal fish and wildlife agencies and tribes, the document itself has not been reviewed by anyone other than Council staff and should be considered preliminary. We welcome feedback and/or corrections for future drafts of this documentation.

Northwest **Power** and **Conservation** Council

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Purpose

The objective of this assessment is to describe the status of predator management under the Council's Fish and Wildlife Program over the last 40 years, and to describe key topics for the Council and the region to consider as we approach the next Program amendment cycle. The Council's Program does not address all possible predator management in the basin. Rather, it focuses on mitigation for the hydrosystem and that subset of predators that benefit directly or indirectly from the hydrosystem or affect other Program work to mitigate for the hydrosystem. The Council defines a predator as an animal that lives by killing and eating other animals for food. Some predators called out by the Council's Fish and Wildlife Program are native species and some are non-native species.

How does the hydrosystem affect predation?

The Columbia River Basin is a highly altered environment in large part due to extensive impacts of the hydrosystem. The construction and operation of the hydrosystem has changed the function of the ecosystem, which disproportionately benefits certain species and leads to increased negative interactions (competition, predation, exclusion from habitat, etc.). Notably, these alterations affect the ecosystem dynamics of predators and prey and the food web. Predation and other types of species interactions are a natural part of the ecosystem, but the altered habitat or operations can often benefit certain predators by altering the environment. For

example, it can make the environment more suitable for predator species or cause unnatural concentrations of prey because of hatchery releases or stunned fish at dam passages.

Approach to mitigation

Numerous factors determine whether or not predator management achieves its objectives. Predation can be an additive mortality source (reducing the number of predators may increase survival of prey), a compensatory mortality source (predators are consuming fish that would otherwise have died, so reducing the predator population may not result in improved survival of prey), or predation may be a partially additive mortality source. There are other environmental factors – like flow conditions, spill levels, temperature, prey abundance, and fish health, among many others – that also interact with any management actions that are taken.

Predator management is a complex issue that often pits one species against another. In an effort to balance a highly modified ecosystem like the Columbia River Basin, there will be short-term winners and losers but hopefully long-term improvement in the relative overall health of the ecosystem.

Program measures

Predator management measures cover principles and targeted actions to control avian, marine mammal and fish predators (Table 1). Both native and non-native predators are grouped in this topic.

The first limited efforts to evaluate and control predation on juvenile salmon and steelhead began in the early 1990s. Changes to the flow regime had been beneficial to northern pikeminnow and they became increasingly abundant, particularly in habitats downstream of dams. When juvenile salmon and steelhead passed through turbines on their migration, they became disoriented and highly susceptible to predation. Predator management measures were exclusively focused on identifying techniques that could be used to remove northern pikeminnow.

Predator management efforts increased and expanded in the mid-1990s and addressed predation by both non-native and native species. The Program identified principles calling to evaluate the impact of predation on listed fish species and on smolt-to-adult returns. For northern pikeminnow, prior removals had decreased population abundance by about 10%. The new direction in the 1990s was to increase that level to approximately 20%, which was expected to result in at least a 50% reduction in predation on juvenile salmonids (NPPC 1994). Additional predator management measures focused on avian predators and marine mammals. Calls were starting to monitor avian predation in the Columbia and Snake River reservoirs and the estuary and to identify non-lethal methods of control. Marine mammals had increased in abundance following passage of the Marine Mammal Protection Act (MMPA) of 1972.

In the current decade, there was an expanded emphasis on predation. The 2014 Program included numerous measures on predator management, both native species (sea lions, seals,

northern pikeminnow, double-crested cormorants, Caspian terns, white pelicans) and non-native species (northern pike and other game fish). This was re-emphasized in 2020 with a near-term priority of sustaining and supporting ongoing efforts to reduce predation by northern pike. Additionally, the ISAB published a report in 2019 titled: A Review of Predation Impacts and Management Effectiveness for the Columbia River Basin.

Table 1. Select predator management measures in the Council's Fish and Wildlife Program, 1991 – 2020

Years		Example measures *(about 45 measures have appeared since 1991)*
1991-2011	Birds	• **Monitor predation** in reservoirs - examine stomach contents. • **Identify non-lethal methods of control**. • Comprehensively study salmonid consumption in the estuary.
	Mammals	• Collect data on distribution, abundance, and interaction with salmonids on a year-round basis. • Seek to allow the **lethal removal once all reasonable non-lethal means exhausted**. • **Model the effects** of removing non-breeding male sea lions.
	Fish	• **Reduce smolt mortality** due to fish and avian predation at bypass system release sites. • **Expand monitoring** of pikeminnow control, identify non-lethal methods of control. • **Reduce the population** of pikeminnow by more than 20% .
2012-2020 *(ISAB predation reports: 2016, 2019, 2021)*	Birds	• **Reduce the number** of Caspian terns on East Sand Island and in the estuary. • Develop a double-crested cormorant **management plan**. • Encourage more aggressive efforts to remove or **manage avian predation impacting wild fish.**
	Mammals	• Continue land- and water-based harassment efforts below Bonneville Dam as well as lethal take. • Improve **exclusion of sea lions at all adult fish ladder entrances and navigation locks** at BON.
	Fish	• Bonneville shall **support/ evaluate/ implement predator management** programs where appropriate in the Columbia Basin, for example Lake Roosevelt. • Sustain and support ongoing efforts to **reduce predation** by northern pike

2014/2020 Fish and Wildlife Program strategies associated with assessment

Table 2. Summary of Fish and Wildlife Program strategy and strategy performance indicators (SPIs; NPCC 2020) associated with the predator management portion of the Habitat Assessment

Strategy ***SPI***	**Description**
Predator management	Improve the survival of salmon and steelhead and other native focal fish species by managing and controlling predation rates.
E4-1	The number of breeding pairs of Caspian Terns and availability of suitable nesting habitat on East Sand Island. 32 Compare the breeding pairs to the target range of 3,125 to 4,375, and the suitable nesting habitat to the target of one acre
E4-2	Cormorant colony size at East Sand Island. Compare to management goal that colony size does not exceed management average of 5600 breeding pairs
E4-3	Predation rate on ESA-listed juvenile salmonids by Caspian Terns in the Columbia Plateau region compares to target of less than 2%
E4-4	Exploitation rate on Northern Pikeminnow measuring eight inches or greater in total length (200 mm fork length). Compare the exploitation rate to the 10-20 percent annual target.
E4-5	Range expansion, spatial distribution, and number of non-native Northern Pike in the Columbia River Basin. Evaluate trend to determine if the numbers and range are reducing over time.
E4-6	Counts of sea lions observed at Bonneville Dam, the lower Columbia River, estuary and Willamette Falls. Compare trend to determine if the impacts are decreasing over time
E4-7	Proportion of the adult salmon and steelhead run consumed by sea lions below Bonneville Dam, in the lower Columbia/estuary, and at Willamette Falls.
E4-8	Number of adult spring Chinook salmon and winter steelhead, White Sturgeon, and Pacific Lamprey consumed by sea lions at Bonneville Dam, the lower Columbia/estuary and at Willamette Falls.
R1-1, R3-1	Annual average catch rate of Lake Trout in Upper Priest, Flathead, and Pend Oreille lakes.

Implementation

Birds

Background

The 1972 amendment to the Migratory Bird Treaty Act of 1918 resulted in new protections for some avian predators, like the double-crested cormorant (Wires et al. 2001). At the same time, the U.S. banned DDT, a chemical that bio-accumulated in birds and negatively affected their reproduction (Carson 1962). As a result of these actions and other changes to food availability and habitat, population abundance began to increase, and avian predators colonized new habitats in the Columbia River, including human-made dredge-spoil islands (Wires et al. 2001). They were able to exploit high smolt concentrations from hatchery releases and high concentrations of disoriented smolts below dams (NPPC 1994). The 1994 Program called for the immediate study of avian predation in the estuary associated with bird colonies on dredge-spoil islands. In the past, Caspian terns and double-crested cormorants nesting on East Sand Island (ESI) in the estuary consumed up to 25 million smolts annually, or roughly 15% of the surviving out-migrants prior to management. Prior to management, Caspian terns nesting upriver on Crescent and Goose islands in the Columbia Plateau region annually consumed 5 to 30% of out-migrating smolts from some listed steelhead populations. The management of terns and cormorants to reduce their impacts on smolts was called for in regional planning documents (Evans, 2024).

The 2023 Annual Report by Bird Research Northwest reported a total of 35 active breeding colonies of piscivorous (fish-eating) waterbirds detected in the CRB during the 2023 breeding season (Figure 1). Of those, cormorant and gull colonies were the most prevalent (14 and 11 colonies, respectively), followed by terns (8 colonies), and pelicans (2 colonies). Most of these breeding colonies (23) were in the Columbia Plateau, with 8 and 3 colonies located in the estuary and lower Columbia River, respectively.

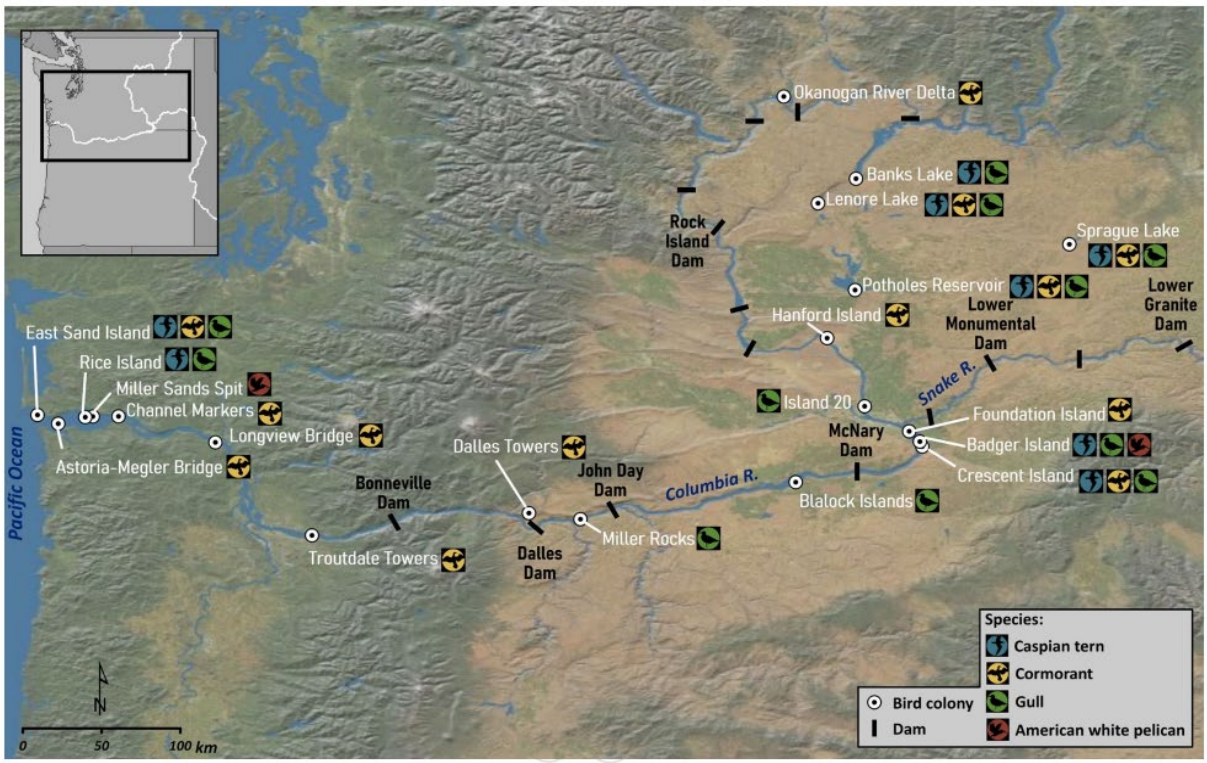

Figure 1. Colonies of Caspian terns, cormorants, gulls and American white pelicans in the Columbia Basin, 2024. Figure from Allen Evans, RTR, presentation to the Council (August 2024); Bird Research Northwest, 2023

Tern and cormorant colonies continue to be managed as part of three ongoing management plans. That management has resulted in a shift in the nesting distribution of these birds, prompting adaptive management at several previously unmanaged colony sites. As has been the case in the past, gulls were the most numerous (ca. 40,000 individuals) of all the piscivorous colonial waterbirds in the CRB, followed by cormorants (ca. 8,100 breeding pairs), pelicans (ca. 3,900 individuals), and terns (ca. 1,000 breeding pairs).

Recent data suggest that the numbers of terns and cormorants nesting in the CRB have declined, which was the objective of management, but has also resulted in declines in the Pacific Flyway breeding populations of both species. This raises concerns about the conservation status of these populations, especially for the rapidly declining Pacific Flyway breeding population of Caspian terns (RTR/OSU, 2023).

Summary of implementation

Current management of avian predators targets double-crested cormorants and Caspian Terns, although measures also call for management of other species such as pelicans Management is implemented by the majority of tribes and state and federal agencies via both individual and

collaborative monitoring programs and work groups. Bird Research Northwest is another important source of monitoring bird population abundance and predation impacts.

Double-crested cormorants

The double-crested cormorant (DCCO) is a locally common, piscivorous bird native to the Pacific Northwest whose abundance in the Columbia River estuary and the Columbia River Plateau has grown substantially since the early 1980s. Although not an original cause of declines in salmon and steelhead in the Columbian River Basin, predation of juvenile fish by double-crested cormorants potentially impedes recovery of basin salmonids listed under the federal Endangered Species Act (ESA).

Estuary-wide abundance of double-crested cormorants grew from 131 breeding pairs when the estuary was first surveyed in 1979–1980 to an average 13,337 breeding pairs during 2004–2014, the period of peak double-crested cormorant abundance in the estuary. To address predation on ESA-listed salmonids associated with the expanded local double-crested cormorant population, the U.S. Army Corps of Engineers implemented a management plan during 2015–2020 to reduce breeding abundance on East Sand Island, a human-modified island near the mouth of the Columbia River estuary that supported an average 12,982 breeding pairs during 2004–2014, about 97% of all nesting pairs within the estuary. Following the active phase of management under the East Sand Island management plan, abundance of double-crested cormorants nesting on East Sand Island declined to an average 1,694 breeding pairs during 2018–2021, although the average during 2019–2021 was only 258 pairs (Figure 2) (ODFW, 2022).

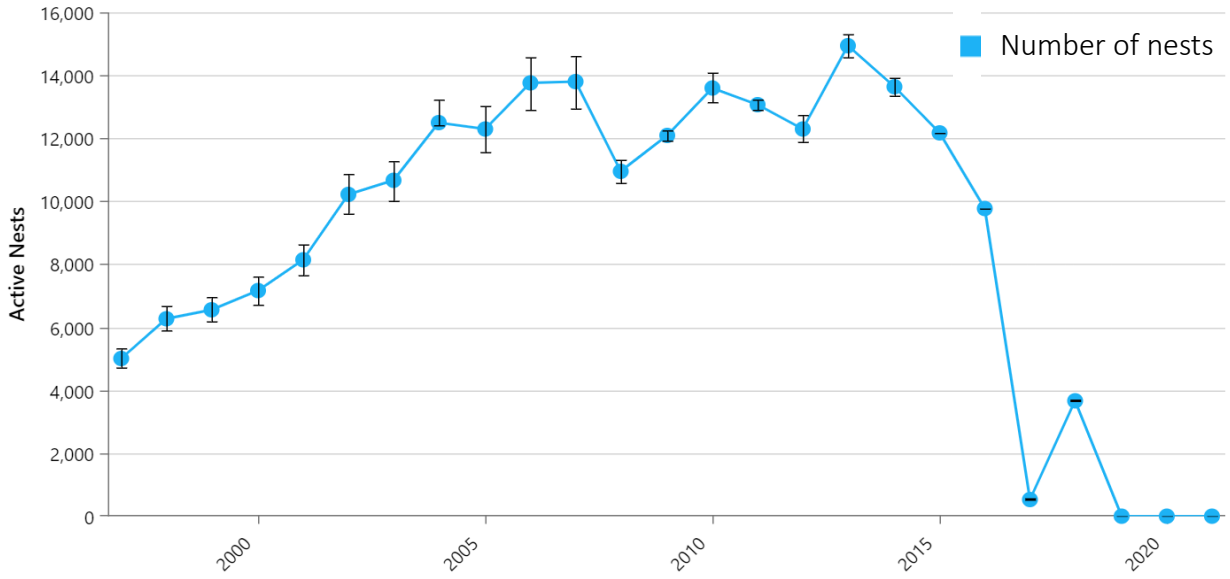

Figure 2. Cormorant breeding colony active nests on the East Sand Island Complex, Columbia River Estuary, 1997-2021. Data available on Program Tracker under Strategy Performance Indicator E4-2.

However, following the intensive management period, there's evidence that double-crested cormorants shifted their nesting sites upstream. This resulted in an increased per-capita predation rate on salmonids. In recent years, ODFW has estimated estuary-wide predation to have been about 12-14% (post East Sand Island vacancy). Of recent concern is that per-capita predation rates by the colony on the Astoria-Megler Bridge, along with potential growth of this colony (Figure 3), may pose a greater threat to salmonid restoration than the previous colony at East Sand Island.

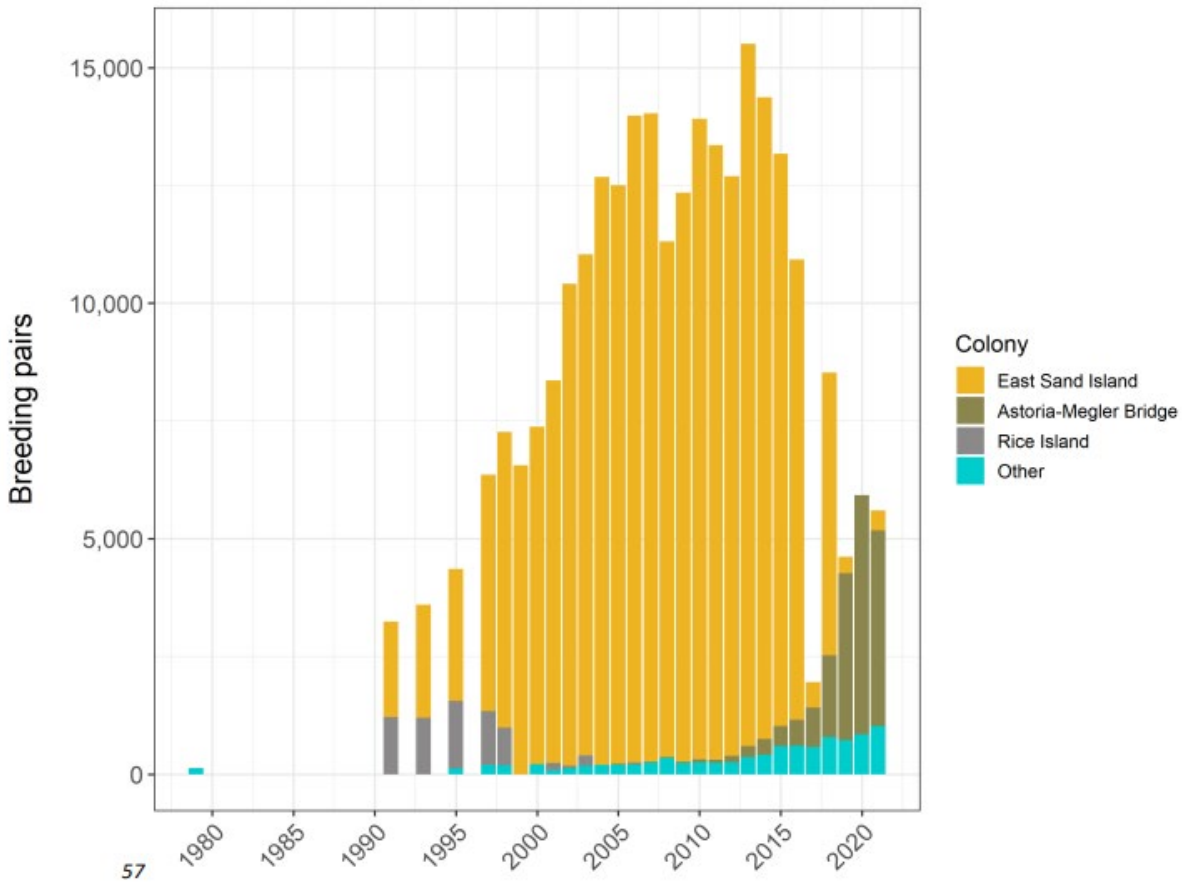

Figure 3. Number of breeding pairs of double-crested cormorants on East Sand Island, the Astoria-Megler Bridge, Rice Island, and other sites, 1979–2021 (ODFW, 2022).

The location of the colony and feeding behavior of different species of birds are important factors in determining what proportion of their diet is comprised of juvenile salmonids, versus other prey items that are available (Collis et al., 2002). Cormorants consume more salmonids as a proportion of their diet the farther upriver from the river mouth, at least up to the freshwater zone (Figure 4). This is important because relatively few DCCO can have a substantial impact. For example, double-crested cormorants consumed 4.3 times more steelhead on a per capita basis at the Astoria-Megler Bridge than East Sand Island and 8.6 times more steelhead in the freshwater zone than those at East Sand Island (Cramer et al., 2021).

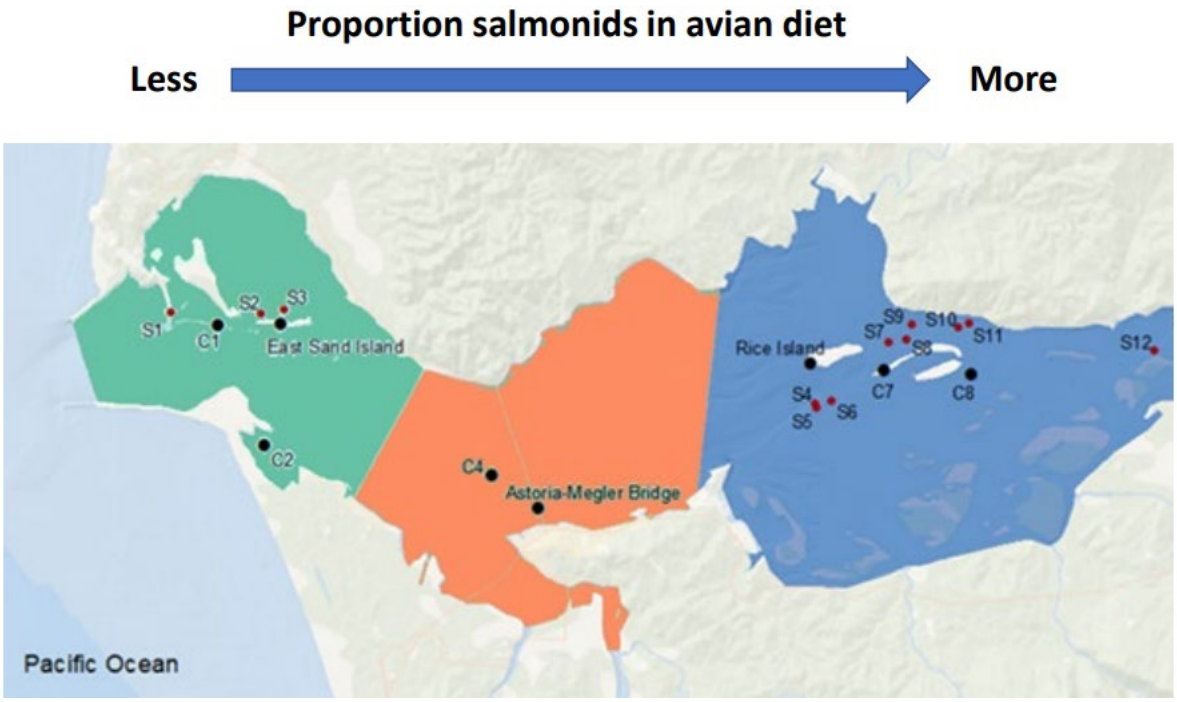

Figure 4. Map showing how saline, mixed, and freshwater zones in the estuary correspond to different amounts of prey available to double-crested cormorants and a different composition of salmonids in their diet (Collis et al. 2001, Collis et al. 2002, Roby et al. 2002, Cramer et al. 2021, Evans et al., 2022).

In 2021, DCCO predation across the estuary was estimated to be equivalent to 26,479 breeding pairs on ESI. That is 169% of the pre-management level of 15,670 pairs, and at least 446% of the RPA 46 target of 5,380-5,939 pairs. The unit "predation equivalents" stands for the number of breeding pairs on ESI that would cause equivalent predation impacts to cormorants breeding across the estuary (Figure 5). Federal management was a major contributing factor to this decline on East Sand Island and subsequent redistribution in the estuary. Cormorants went from downriver colonies to colonies farther upriver (Lawonn, 2024).

Figure 5. Relative predation by DCCO on juvenile salmon and steelhead between the marine (green), mixing (orange) and freshwater (blue) zones of the Columbia River Estuary 1979-2021 (Lawonn 2023; Evans et al. 2023, 2024).

Available evidence suggests implementation of the East Sand Island management plan was a pre-eminent causal factor in the redistribution of double-crested cormorants across the estuary, although management also coincided with other stressors that contributed to reduced double-crested cormorant fidelity to this colony (NPCC 2022). Management of the Astoria-Megler Bridge and possibly other estuary colony sites will be necessary if managers wish to reduce estuary-wide double-crested cormorant predation.

In 2023, the Oregon Department of Transportation (ODOT) and ODFW conducted a Value Engineering (VE) Study to evaluate the effects of the double-crested cormorant colony nesting on the Astoria-Megler Bridge and potential solutions. The study included 11 entities as official team members and an additional 6 as interested parties. Their November 2023 presentation to the Council detailed the process and provided a complete version of the VE Study outcome at that time. ODOT and ODFW presented jointly because the colony on the bridge poses potential threats to human safety as well as to actively migrating juvenile salmon and steelhead. Threats to human safety include bird strikes by cars, toxic guano buildup causes erosion and requires constant cleaning, and bird activity blocking routine safety inspections. The team unanimously recommended that the team members take immediate action to address the impacts to human safety on the Astoria-Megler Bridge. In addition, it was recommended to deter DCCO from using

the bridge, to attract and reestablish the colony at East Sand Island, and to prevent redistribution of DCCO upriver of the bridge. Finally, the team recommended creating a funded full-time position(s) to coordinate the effort between the dozens of agencies and entities involved.

Caspian terns

Caspian terns are a piscivorous waterbird native to the Pacific Northwest and have one of the highest per capita impacts on smolt survival. Terns disproportionately consume steelhead relative to salmon smolts and consumption rates can exceed 20% of available steelhead by some colonies (Evans, 2024).

The latest census of the Pacific Flyway breeding population of terns occurred in 2021 and indicates that the population has declined by more than 50% since management began in 2008 (Lawes et al. 2022). This population decline is due primarily to the decline in size of the East Sand Island colony in recent years; in 2008 this colony numbered over 10,000 breeding pairs and represented two-thirds of the entire Pacific Flyway breeding population (Suryan et al. 2004), while in 2023 the colony consisted of just 524 breeding pairs. Exacerbating the Flyway-wide population decline is the increasing frequency of complete nesting failures at the tern colony on East Sand Island (RTR, 2023).

Predator management initiated in 2009 with the target of reducing the population to 3,125 – 4,375 breeding pairs (Figure 6). This resulted in less than 3,000 pairs starting in 2020 with the colony only supporting 524 pairs in 2023 and causing their survival to become an emerging issue.

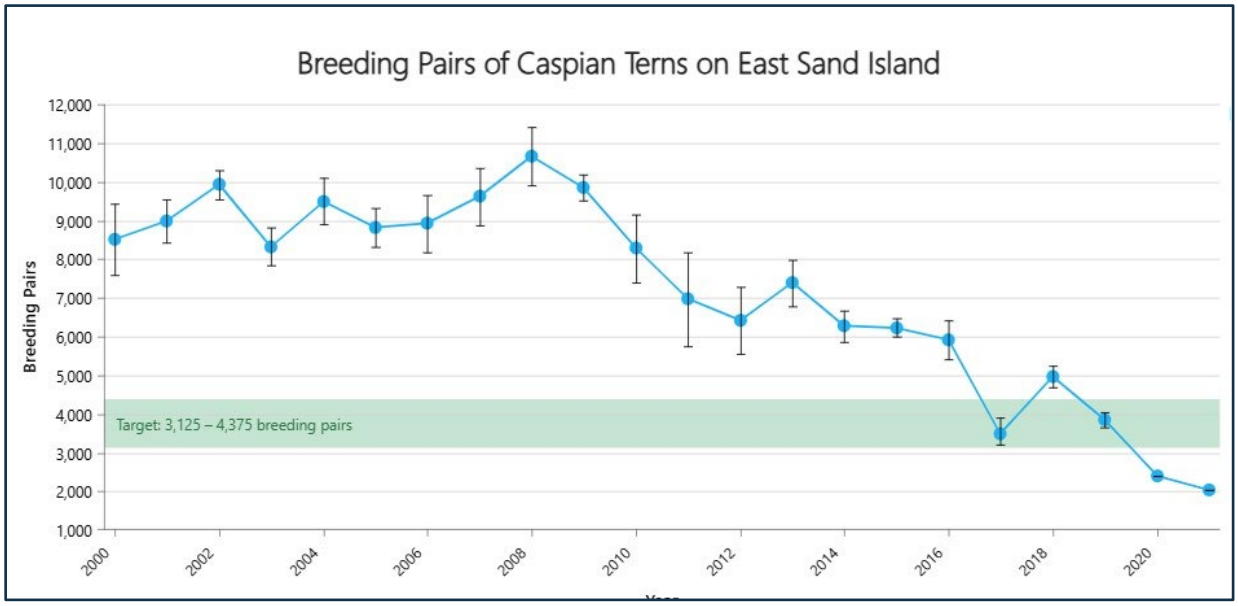

Figure 6. Number of breeding pairs of Caspian Terns on East Sand Island in the Columbia River Estuary, 2000 – 2021, as compared to the management target of 3,125 – 4,375 breeding pairs. Data available on Program Tracker under SPI E4-1

With the reduction in the East Sand Island colony to well below the target colony size of 3,125 pairs, there is concern growing for the future of this group. The colony has failed to produce young in recent years and the colony has been affected by avian influenza. In addition, the Pacific Flyway population has declined by more than 50% (as of 2021).

In conjunction with culling birds, management also targets reducing the total area available for Caspian terns to nest on East Sand Island to one acre (Figure 7). That target was reached in 2015 and has been maintained since that time.

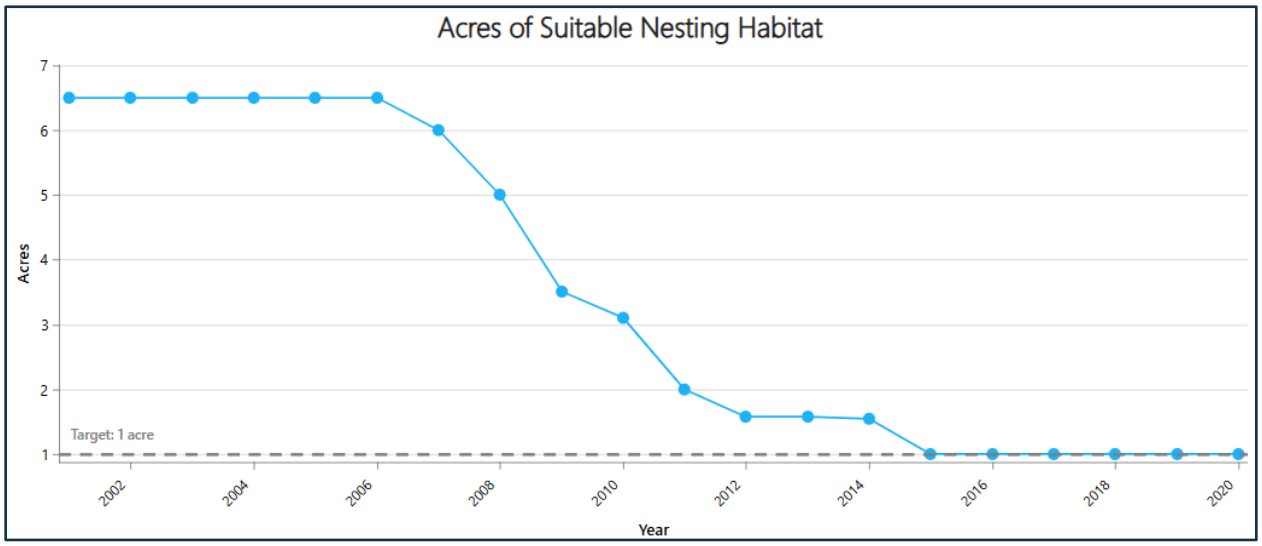

Figure 7. Acres of suitable nesting habitat for Caspian Terns on East Sand Island in the Columbia River Estuary, 2000 – 2021, as compared to the management target of 1 acre. Data available on the Program Tracker under SPI E4-1

Fish still aren't making it back to Bonneville Dam as measured by smolt-to-adult returns. The change in the relationship between survival and tern predation following management suggests covariates that were previously masked by tern predation are still(?) important factors influencing fish survival.

Table 3. Annual Caspian tern predation rates on ESA-listed salmonids in the Snake River and Upper Columbia, 2007-2023. Data available on Program Tracker under SPI E4-3

Species	Snake River	Upper Columbia
Chinook	0.1-1.6	0.2-5.5
Sockeye	0.1-2.4	
Steelhead	0.4-8.0	1.5-22.5

Caspian tern predation on the Columbia Plateau

On the Columbia Plateau, tern management calls for the elimination of tern colonies, the creation of alternative tern habitat outside of the Columbia Basin, and monitoring to inform adaptive management decisions. Management has seen the colony size reduced and a 46% decline in the regional breeding population (as of 2023).

Predation impacts on steelhead have been reduced at some but not all colonies with the greatest benefit being to Upper Columbia River steelhead. The terns have exhibited high fidelity to these sites which complicates relocation or elimination of colonies. In the case of a new colony being discovered in Potholes Reservoir in May of 2024, adaptive management was implemented to dissuade the terns from the island within 72 hours (Evans, 2024).

Goals and outcomes

Caspian tern management on the Columbia River Plateau has largely accomplished the proposed actions, many led by the Bureau of Reclamation.:

- Dispersal and subsequent “whack-a-mole”
- Decrease from about 900 to about 400 breeding pairs
- Decrease in tern predation on ESA-listed steelhead from about 20% to less than 5% (Figure 8)

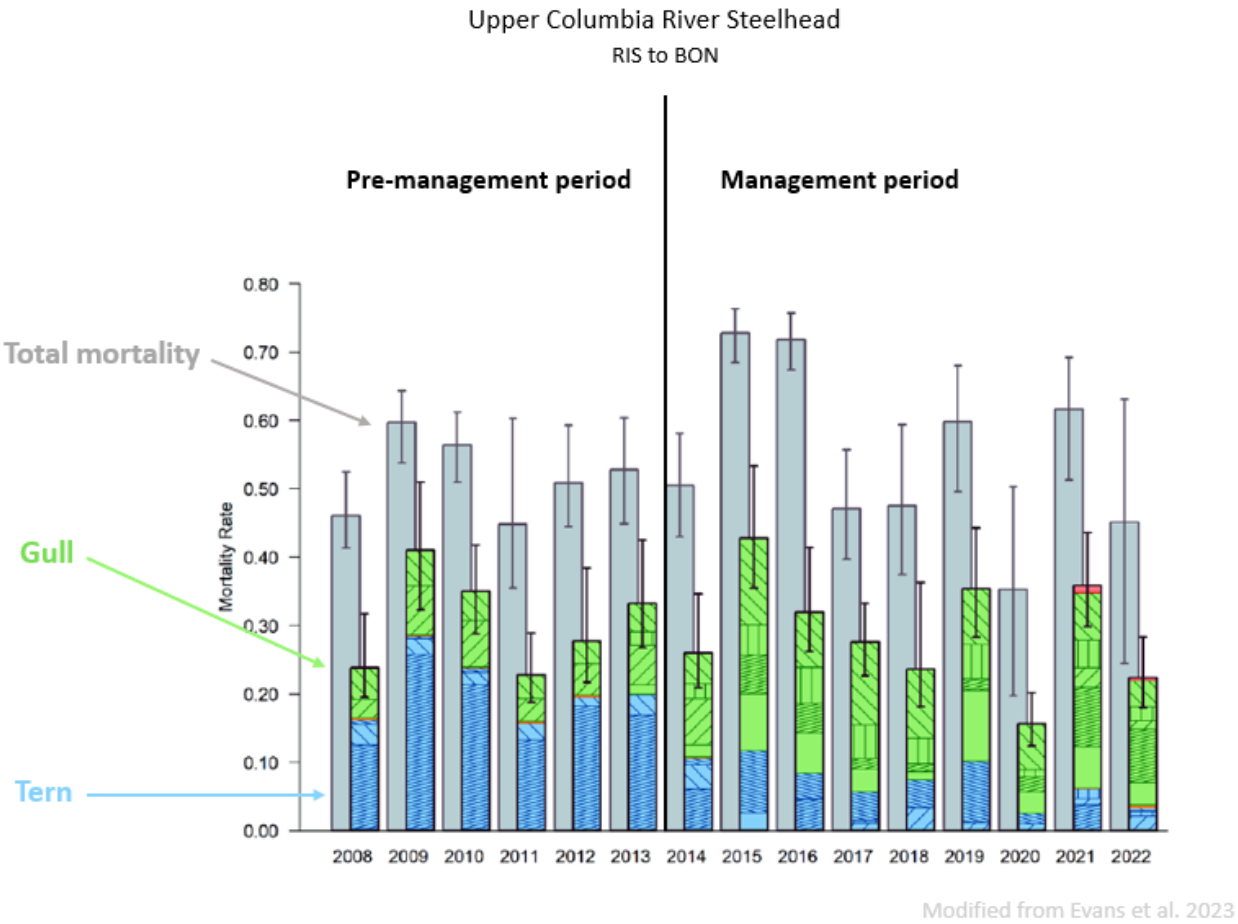

Figure 8. Annual predation rates by Caspian terns on ESA-listed salmonid populations originating from the Snake River (SR; based on detections at Lower Monumental Dam) and Upper Columbia River (UCR; based on detections at Rock Island Dam).

Discussion

Double-crested cormorants

- Double-crested cormorant populations have shifted in number and location due to both hydrosystem impacts and direct management actions.
- Double-crested cormorants have a larger predation impact on migrating juvenile salmonids the more upstream from the Columbia River estuary they are found.
- Human health and safety concerns have been identified on the Astoria-Megler bridge due to the current DCCO colony through observations by ODOT and the Value Engineering Study they led with ODFW.
    - Immediate action should be taken to ensure human health and safety

- If birds can be lured back to East Sand Island, there would be less predation concern than if the birds move upstream to one of the 4 highlighted colonies (for example)

Caspian terns

- Different challenges exist for terns throughout the Columbia River Basin.
  - In some areas like the Columbia Plateau, they are being actively managed to reduce the population size.
  - In other places, like the estuary, there are concerns that the population has responded too strongly to management actions and declined to lower numbers than intended by a specific conservation goal.
- Growing conservation concern for regional population
- Conservation efforts will be most effective if focused on multiple fronts, including (NPCC 2004):
  - Monitoring tern populations
  - Resolving management conflicts with other species by addressing root causes
  - Reducing risks to the tern population by distributing breeding colonies among a greater number of sites
  - Filling gaps in knowledge of biology and threats on migration and the wintering grounds
  - Educating the public about the value of colonial waterbirds and possible effects of human actions on Caspian terns

For more information and links provided by Bird Research Northwest, see the August 2024 Council presentation by Allen Evans.

Marine mammals

Background and risk from predation

Marine mammals (pinnipeds), including California sea lion, Steller sea lion, and Pacific harbor seal are native predators in the lower Columbia River and estuary, where they forage on many of the Council's focal fish species (salmon, steelhead, Pacific lamprey, white sturgeon, and eulachon) as well as many other fish species. Pinniped predators in marine ecosystems are typically opportunistic carnivores, feeding on seasonally and locally abundant species of squid and fish, including juvenile and adult salmonids (e.g., Reimer et al. 2011, Steingass 2017, Robinson et al. 2018) (ISAB 2019).

Columbia and Willamette river salmon and steelhead face serious threats from California and Steller sea lions that prey on fish waiting to move up the fish ladders at Bonneville Dam and

Willamette Falls and other pinch points. Since the 1990s, a small number of habituated male sea lions have consumed migrating fish at these locations, many from threatened and endangered runs protected under the federal Endangered Species Act (ESA) (ODFW 2024). Construction of the hydrosystem has created locations where adult salmon and steelhead concentrate- such as flow attraction points at Willamette Falls or fish ladders. Marine mammals congregate where fish are concentrated and prey upon them to a greater extent than might occur in the absence of the hydrosystem. The Marine Mammal Protection Act (MMPA) of 1972 allowed marine mammal population abundance to increase in the Columbia River Basin, resulting in increased predation on ESA-listed salmon and steelhead.

Management of marine mammals originally focused on hazing them away from concentrations of migrating fish, monitoring their abundance, observing their predation, estimating predation rates, and trapping individuals observed to be preying on salmon and steelhead and transporting them to the coast. Many of these individuals would rapidly return. Because of the MMPA, marine mammals could not be lethally removed, but the Program called for investigating opportunities to modify the MMPA to allow some control activities under Section 120. The US Congress amended the MMPA in 1994 to allow states to apply for limited lethal removal authority under a narrow set of circumstances.

Multiple revisions to Section 120 of the Marine Mammal Protection Act since 2008 have allowed for lethal removal of certain individuals. Comprehensive information on the 120 Pinniped Removal Program can be found here and a detailed chronology of events of the MMPA Section 120 Pinniped Removal on the Columbia River can be found here. The 120(f) management area in the mainstem extends from the I205 bridge to McNary Dam although there has never been a confirmed sea lion upstream of The Dalles Dam. Also, the permit allows removal of sea lions in any Columbia River tributary that is salmon-bearing (Doug Hatch, CRITFC, personal communication).

In March 2008, NOAA Fisheries authorized Washington, Oregon, and Idaho to remove individual California sea lions documented as preying on salmon and steelhead below Bonneville Dam. The five-year extension, granted under Section 120 of the Marine Mammal Protection Act, allowed the states to use lethal or nonlethal measures to remove California sea lions that 1) can be identified by markings, 2) have been hazed to discourage them from predation and 3) have been documented feeding on salmon and steelhead below the dam. The states' federal permit, which was renewed in 2016 for another five years, did not authorize removal of Steller sea lions.

Under new authorization issued in 2020, the states and tribes were issued a permit that gives wildlife managers more flexibility to remove sea lions by:

- Expanding sea lion removal area both above and below Bonneville Dam, from River Mile 112 near the I-205 bridge to McNary Dam, and from adjacent tributaries
- Allowing the removal of Steller sea lions as well as California sea lions

- Less stringent procedures to qualify sea lions for removal as the current permit (i.e. identifying individuals by markings, previously hazing them, and documenting predation on salmon or steelhead)

Current permitting allows removal of sea lions in any Columbia River tributary that is salmon-bearing (Figure 9):

- Willamette Falls
- I-205 Bridge to Bonneville Dam
- Above Bonneville Dam to McNary Dam but, again, a sea lion has never been confirmed upstream of The Dalles Dam

Figure 9. Marine mammal management areas on the Columbia River between Bonneville and McNary Dams, in the lower Columbia River between the I-205 bridge and Bonneville Dam, and in the Willamette River below Willamette Falls. Map produced by USACE.

Summary of implementation

Current management of marine mammal predators targets Stellar and California sea lions, although measures call for research and management of harbor seals as well. Whereas Stellar and California sea lions have been observed eating adult salmon and steelhead, harbor seals are rarely sighted at Bonneville Dam and more frequently observed at the mouth of the Cowlitz River, in conjunction with the presence of eulachon.

There is an important timing difference between California sea lions and Stellar sea lions at Bonneville Dam. California sea lions are primarily a spring event, showing up around April 1 and leaving by the end of May. Therefore, impacts are focused on spring chinook and a bit on winter

steelhead. Stellar sea lions reside at Bonneville in all months except June, July, and early August so they have a better chance of impacting every upriver run except sockeye (Doug Hatch, CRITFC, personal communication). The proportion and magnitude of California sea lions and Stellar sea lions have fluctuated over the past two decades at Bonneville Dam (Figure 10).

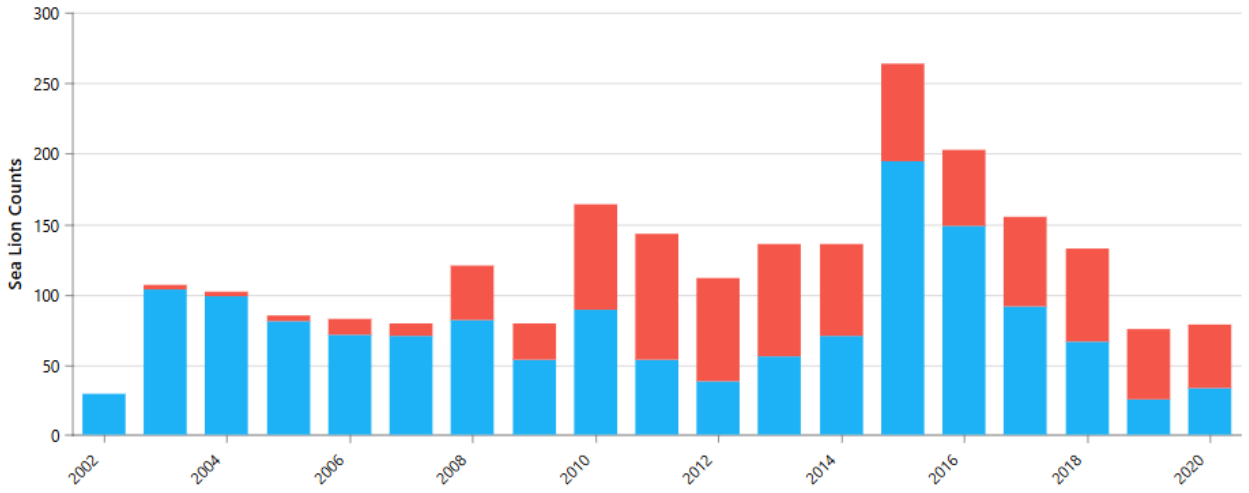

Figure 10. Annual California and Stellar sea lion counts below Bonneville Dam, 2002 – 2020. Data available on the Program Tracker under SPI E4-6

Removal of problem sea lions has proven to be the most effective means of protecting fish from predation by marine mammals – and was a significant factor in 2020 being the best return of wild Willamette steelhead in years after biologists believed they were on the verge of extinction in 2017 due to increasing sea lion presence at Willamette Falls. Removal occurred after ODFW was granted authorization to begin removing California sea lions preying on threatened salmon and steelhead below Willamette Falls in 2018 (ODFW 2024). Prior to this success, the main impact on salmon and steelhead was observed in the first 22 weeks of the year, or winter and spring (Figure 11).

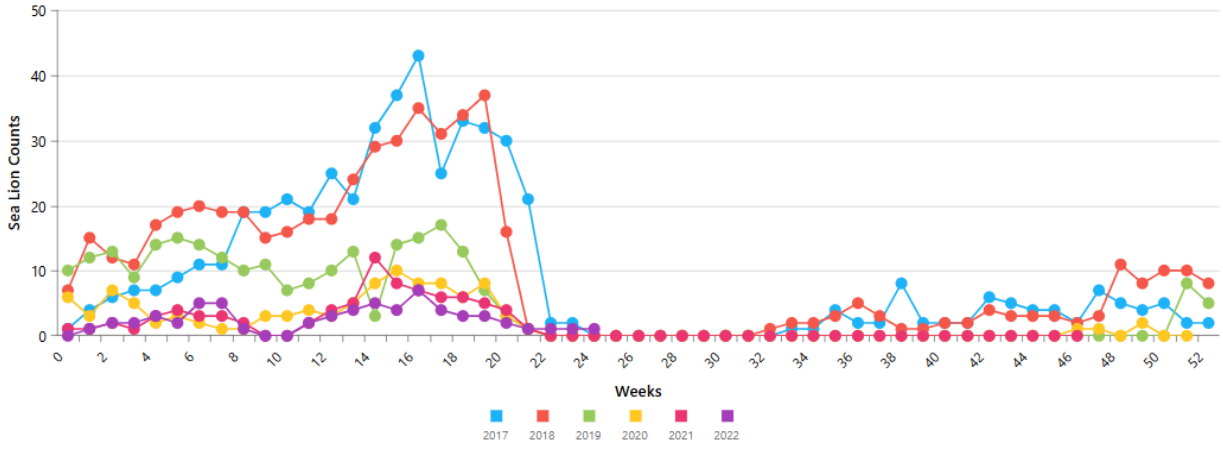

Figure 11. California and Stellar sea lion counts by week below Willamette Falls, 2002–2022. Data available on the Program Tracker under SPI E4-6.

In addition to monitoring abundance, managers also record observations of predation on salmon and steelhead and estimate predation rates. Figure 12 estimates that a higher percentage of adult steelhead is consumed by sea lions below Bonneville Dam than spring Chinook.

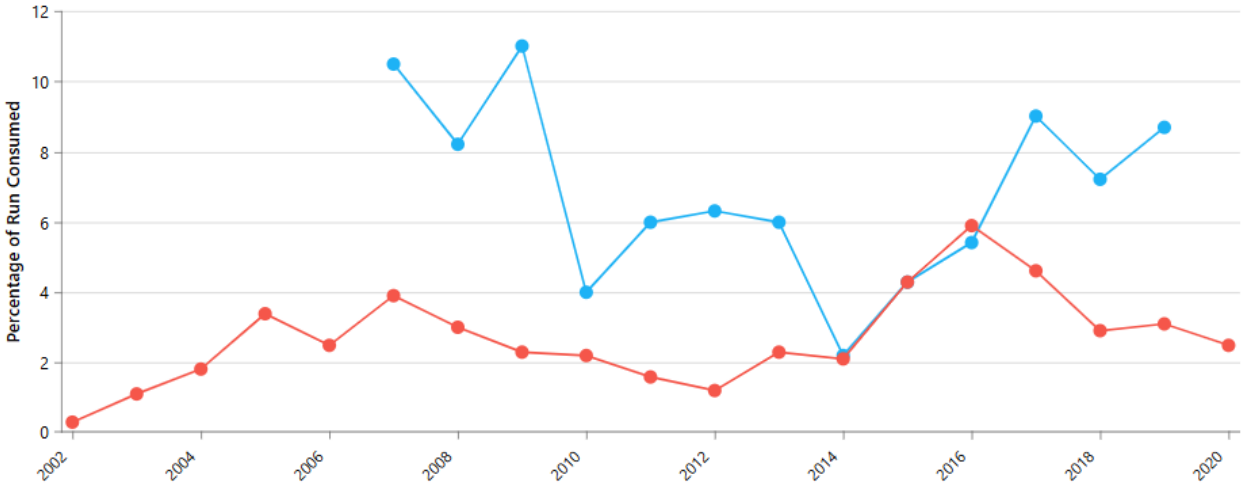

Figure 12. Annual estimate of the percentage of adult steelhead (blue) and Spring Chinook (red) runs consumed by sea lions below Bonneville Dam, 2002 – 2020. Data available on the Program Tracker under SPI E4-7

Figure 13 again shows the highest predation rate on winter steelhead below Willamette Falls compared to summer steelhead and chinook runs.

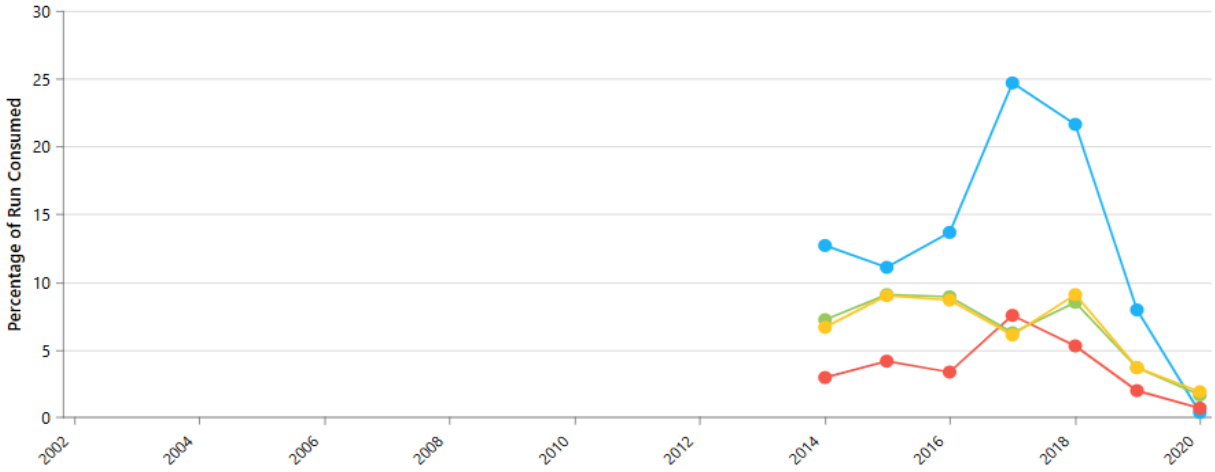

Figure 13. Annual estimate of the percentage of winter steelhead (blue), summer steelhead (red), natural-origin spring Chinook (green), and hatchery-origin spring Chinook (yellow) runs consumed by sea lions below Willamette Falls, 2014 – 2020. Data available on the Program Tracker under SPI E4-7.

Although data on predation by marine mammals in the lower Columbia River (far below Bonneville Dam) are limited, we know that pinniped predation occurs throughout the lower Columbia River and estuary and can be substantial. For example, in 2019 Rub et al. reported that over 200,000 spring Chinook were consumed by sea lions in 2015, which represented almost 50% of the run.

Discussion

- Removal of problem sea lions has proven to be the most effective means of protecting fish from predation
- Current management of marine mammal predators targets Stellar and California sea lions
- Marine mammals in the Columbia River Basin have expanded their range and local populations at least partially in response to impacts of the hydrosystem
- Hazing and lethal removal management has changed over time with modifications to the Marine Mammal Protection Act
    - Comprehensive information on the 120 Pinniped Removal Program can be found here and a detailed chronology of events of the MMPA Section 120 Pinniped Removal on the Columbia River can be found here.
- Removal efforts below Willamette Falls is believed to have been a significant factor in 2020 being the best return of wild Willamette steelhead in years after biologists believed they were on the verge of extinction in 2017 due to increasing sea lion presence (ODFW 2024)

Fish

Background

Many species of fish in the Columbia basin prey upon other fish at some life-stage. Construction of the hydrosystem has created locations where juvenile salmon and steelhead concentrate- such as the outfalls at juvenile bypass systems- and disoriented fish can be easy targets for predators. Fish predators may be native- such as Northern pikeminnow, or lake trout, or non-native- such as northern pike, walleye, and bass.

Northern Pike

The native range of northern pike is Alaska, much of Canada, the northeast and parts of the midwest USA. They take 2-4 years to mature and produce 40,000 eggs per spawn on average. They can live for over 20 years. 50-70% of their diet can be salmon and they can consume fish that are 60% of their total body length (USFWS 2024).

Northern Pikeminnow

The northern pikeminnow is native to the Pacific Northwest. They are a slow-growing, long-lived fish reaching 13-16 years age in the Columbia and Snake rivers. The diet of northern pikeminnow varies with their size with invertebrates dominating the diets of smaller individuals. Pikeminnow are effective predators on juvenile salmonids at 8-9" total length (age 4-5). The altered habitat in the Columbia River (ie, dams) has resulted in an increase in the number of predator-sized fish in their local population.

Northern pikeminnow eat millions of salmon and steelhead juveniles each year in the Columbia and Snake River systems. The goal of the long-running pikeminnow reward program (detailed later) is not to eliminate Northern pikeminnow, but rather to reduce the number of large fish. The idea is that by reducing the number of these larger predators, chances of salmon and steelhead juveniles making it out to sea greatly increases.

Lake Trout

Lake trout are the largest of the freshwater char and they are native to northern North America, from Alaska to Nova Scotia and throughout the Great Lakes (FWS, 2024). They are considered invasive in the western United States. They have been reported to live up to 70 years in some Canadian lakes, and were first discovered in Yellowstone Lake in 1994.

Their main impacts in the Columbia River Basin are on kokanee, bull trout, and cutthroat trout. Efforts to reduce or suppress lake trout have, in some cases, been related to competition and displacement of native bull trout, which has a different distribution but overlaps with lake trout in western North America (Donald and Alger 1993). In other bodies of water, predation by lake trout on native salmonids such as cutthroat trout, and kokanee are a main concern, although the kokanee are often nonnative (ISAB 2019).

Summary of implementation

Current management of piscivore (fish-eating-fish) predators targets northern pike, Northern pikeminnow, and lake trout.

Northern Pike

Currently, there are only 57 miles separating northern pike and salmon (Figure 14). The threats to fish and wildlife investments by BPA are estimated at $176 million. A total of13 populations of threatened or endangered salmon and steelhead would be at risk if an invasion were to occur. The potential for lost economic value could be $89 million. Managing northern pike currently costs about $175,000 in continuing annual investments (removals etc.) (NPCC 2024).

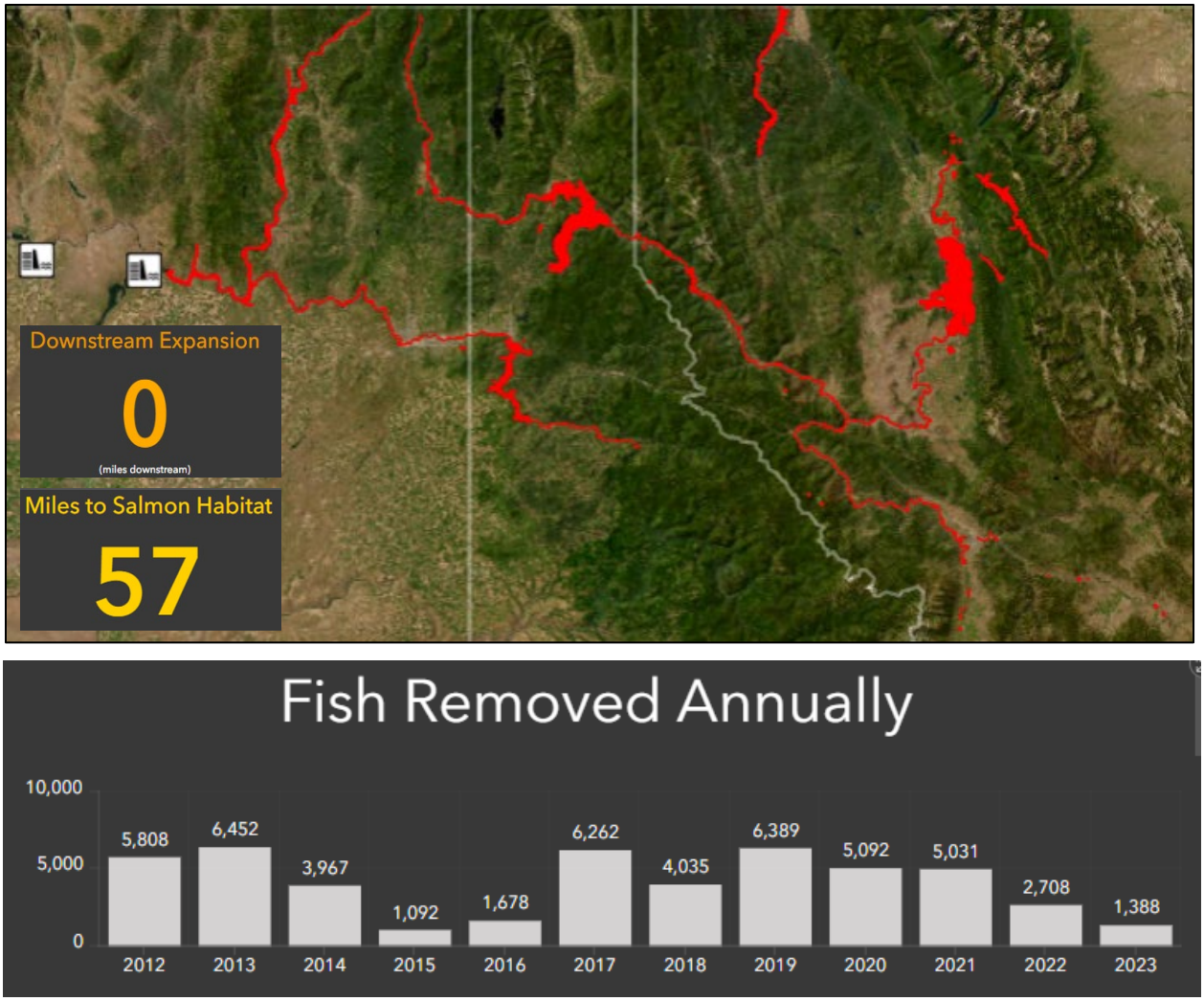

Figure 14. Range expansion, spatial distribution, and number of non-native northern pike removed in the Columbia River Basin. Data available on Program Tracker under SPI E4-5.

Northern pikeminnow

Northern pikeminnow eat millions of salmon and steelhead juveniles each year in the Columbia and Snake River systems. Pikeminnow control has been called for since the Program's inception. Removal of Northern Pikeminnow in the 1980s decreased population abundance by about 10%. Program measures in the 1990s called for increasing that level to approximately 20%, which was expected to result in at least a 50% reduction in predation on juvenile salmonids (NPPC, 1994).

- Management of Northern pikeminnow occurs through dam angling, commercial harvest, and a sport-reward fishery. The Pacific States Marine Fisheries Commission administers the overall Northern Pikeminnow Sport-Reward Program. The program is run in cooperation with Northwest fish management agencies and tribes. The Bonneville Power Administration funds the program to partially mitigate the impacts of the federal Columbia River hydroelectric system on salmon and steelhead.

- The goal of the sport-reward program is not to eliminate Northern pikeminnow, a native species, but rather to reduce the number of large fish. Reducing the number of these larger predators can greatly increase the salmon and steelhead juveniles making it out to sea.
- Results indicate the program is successful. Since the Sport-Reward Fishery was implemented in 1991, predation of juvenile salmon by Northern pikeminnow has been reduced up to 40% through the removal of more than 5.4 million Northern pikeminnow.
- Moreover, the Sport Reward Fishery has successfully reached the 10-20% exploitation objective each year since 1997 (Figure 15).

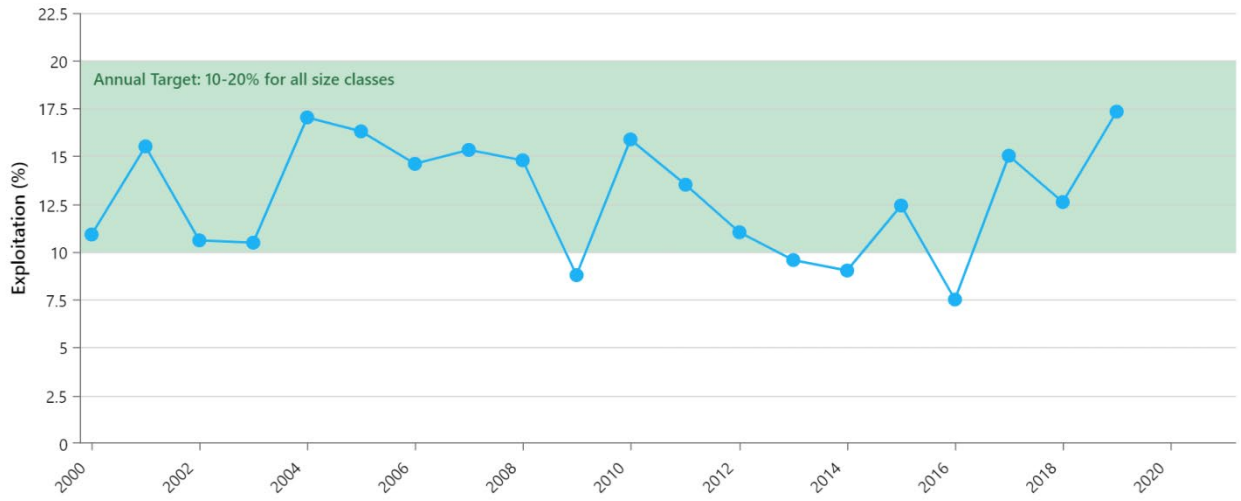

Figure 15. Exploitation rate on Northern pikeminnow measuring 200 mm (~8 inches) or greater in fork length. Data available on the Program Tracker under SPI E4-4

Since 1990, potential predation on juvenile salmonids has decreased by approximately 10-50% (Figure 16).

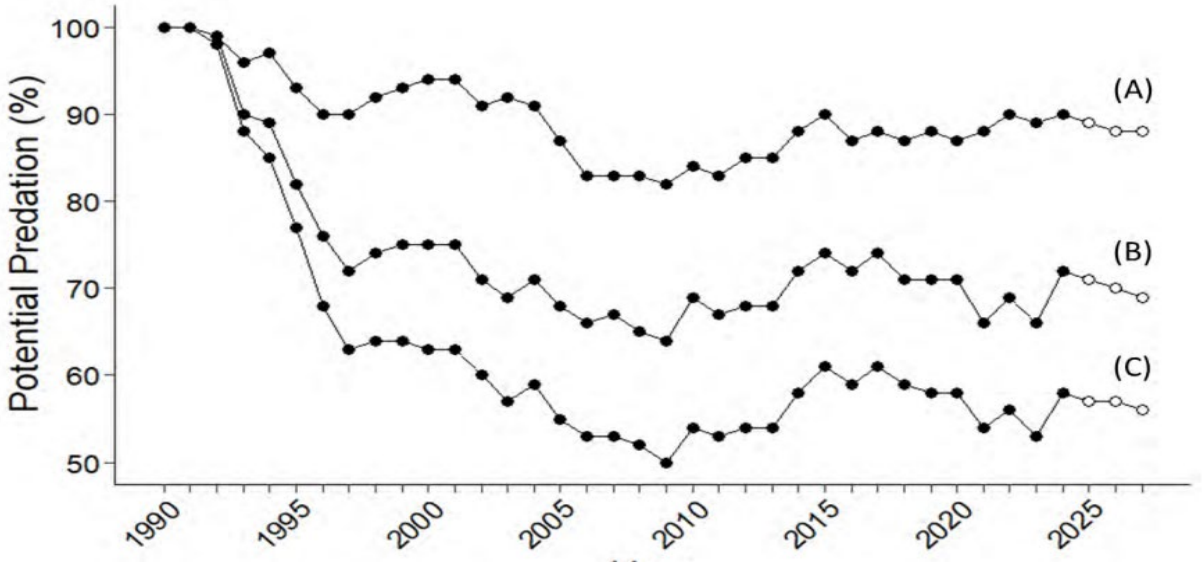

Figure 16. Estimates of (A) maximum, (B) median, and (C) minimum annual levels of potential predation by Northern pikeminnow on juvenile salmon relative to predation levels before implementation of the Northern Pikeminnow Management Program. Figure and data from 2023 annual report, available online at pikeminnow.org in the 2023 Annual Report.

Lake Trout

Lake trout have established in the western U.S. most often by deliberate introduction, often as a sport fishery (Figure 17). The species' main impacts are on kokanee, bull trout, and cutthroat trout. Currently, lake trout abundances are monitored in Flathead Lake, Cle Elum Lake, Priest Lake, and Lake Pend Oreille (Table 4).

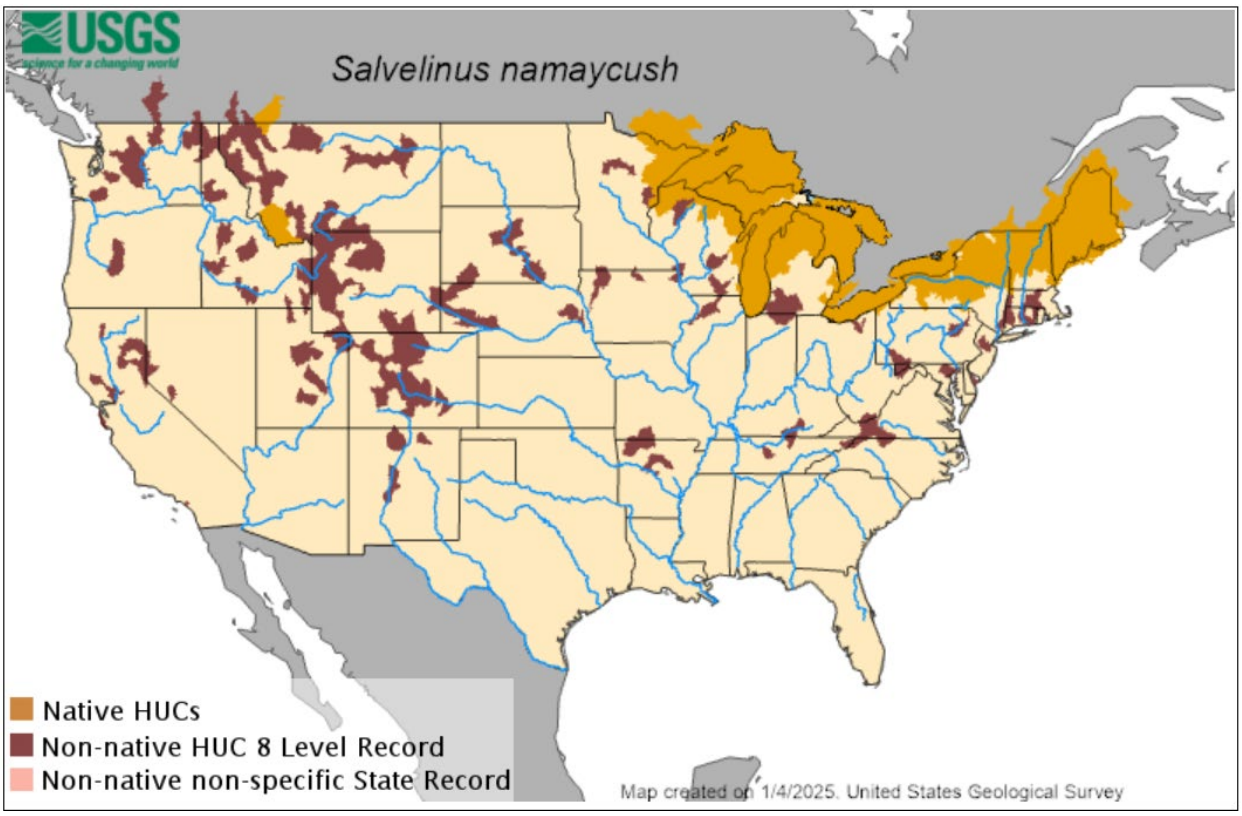

Figure 17. Current native (gold) and non-native (dark red) ranges of lake trout in the Continental United States (USGS, 2021).

Table 4. Status of current-year juvenile and adult lake trout abundances (increasing, decreasing, or stable) relative to the most recent 5-year average at each site listed. Data available on the Program Tracker under SPI R1-1/ R3-1.

Monitored lakes	Juveniles	Adults
Flathead Lake	Data not Available	Data not Available
Cle Elum Lake	Data not Available	Data not Available
Priest Lake	Decreasing	Decreasing
Lake Pend Oreille	Decreasing	Decreasing

Management considerations include:

- Feasibility and cost of suppression increases with the size of the lake
- Combination of efforts directed at both juveniles and adults needed
- Public support is important
- Ongoing monitoring and suppression efforts may be needed

Discussion

Northern pike

- Northern pike range has slowly expanded in the area above Grand Coulee Dam. It is imperative that this extremely piscivorous predator not make it downstream of Chief Joseph Dam.
- What might the effects of Northern pike be on salmon reintroductions into the blocked areas? Is additional funding/ effort for predator management needed?
- Reducing the numbers of fish emigrating from Lake Roosevelt is likely to reduce the chances that pike will establish new populations downstream and hence delay the invasion (ISAB 2019).
- Illegal introductions by humans are difficult to control, and more could be invested in efforts to measure, understand, and reduce illegal stocking of pike.
- Genetic tools (eDNA) are cost-effective for rapid early detection of the presence of pike but could require several decades to develop and implement (ISAB 2019).
- Early detection and rapid suppression efforts are cost-effective and paramount for eradicating this species or slowing its spread compared to the cost effectiveness of efforts after the pike are established.

Northern Pikeminnow

- Pikeminnow population monitoring also allows for some tracking of bass and walleye in certain areas. These other predators have been increasing in abundance. More data on their abundance, diet composition, and predation may be needed.
    - Potential for updates or research to better understand potential changes in the relative abundance of pikeminnow and other piscivore predators, and the distribution of prey in their diets since the early studies.
- Targeted efforts to remove pikeminnow near areas of greatest pikeminnow predation, such as forebays and tailraces of dams, might more effectively reduce pikeminnow predation. The Program pays for pikeminnow harvested anywhere from the mouth to Priest Rapids Dam on the Columbia River and Hells Canyon Dam on the Snake River.

Lake Trout

The 2019 ISAB Predation Review offered some high-level recommendations for lake trout control by pointing out:

- The feasibility and cost of suppression increases with the size of the lake
- This will require a combination of efforts directed at both juveniles and adults
- Public support is imperative
- Ongoing monitoring and suppression efforts will likely be needed

The lake trout in the Columbia Basin were introduced by authorized agencies or surreptitiously by unknown individuals, and then thrived and in some cases colonized nearby waters as well. Each body of water is unique (e.g., area, depth, native and nonnative fishes) and the results of invasion and suppression efforts need to be tailored to each situation.

General Discussion

- Predator management techniques and implementation in the Columbia Basin vary widely based on the species
    - Management of predators is one tool to address altered interaction of predators and prey, when predation is thought to be additive or partially additive
    - Other tools include addressing human created habitats that perpetuate increased predation (e.g., dredge spoil islands that become breeding colonies), hydrosystem structures that concentrate fish (such as outfalls), etc.
    - Additional effort on reducing these habitats is needed
- Priorities tend to shift with ESA listings, regional focus, and funding opportunities
- Incentive programs can be useful to engage the public and ensure continued monitoring
- Relieving the pressure of one type of predation can invite other types to fill that niche
- We have learned to expect unexpected results – predators moving, populations declining, altered behaviors – and develop adaptive management plans to minimize unplanned, negative consequences from management actions
- Need for comprehensive approach throughout Basin – thinking about multiple species and managing holistically
    - Whack-a-mole is costly and does not fix the problem long-term
    - Need to take care in not suppressing species that are managed for increased abundance elsewhere (e.g., some wildlife management plans have Pelicans as a target species)
- Importantly, we need to understand the relationship between actions taken and the hydrosystem share of mitigation
- To reduce the impacts of nonnative predators in tributaries of the Columbia River, efforts to minimize stream warming through riparian and hyporheic restoration should be targeted at the current upstream limits of warmwater predators to maintain cooler water for native salmonids and restrict the invasion by nonnative predators, such as smallmouth bass (ISAB 2019)

Future Program questions:

- Is the current monitoring on predator species sufficient?
- Which predator species may be able to capitalize on climate change impacts? How can the region prepare?

- Other predator species like bass and walleye also exist and may influence the survival of focal species
    - Is there a need to more fully assess the impacts of these species?
    - Does predation by these species offset gains made by other predator management actions? Are patterns changing over time?

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