Proceedings of the 2026 Lake Washington Basin Science Summit

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Executive Summary

The Lake Washington Basin Science Summit convened approximately 100 subject matter experts, including Tribal co-managers, federal and state agencies, municipal governments, and academic researchers, to address the survival of native fish populations in the Basin. Hosted by the U.S. Geological Survey's Western Fisheries Research Center, WRIA 8, and King County, the two-day event focused on integrating scientific knowledge to mitigate the dual pressures of climate change and urban development on Chinook, Sockeye, and Kokanee salmon.

Oral and poster presentations preceded facilitated group discussions which sought to identify primary research gaps and opportunities, clustered into four main themes:

1. Salmon Population Monitoring
2. Trophic Interactions and Predation Impacts on Native Fish
3. Exacerbating Factors of Predation
4. Water Quality Monitoring, Contaminants, Disease, and Parasites

This report synthesizes these discussions into five overarching research gaps:

- **Gap 1: Where are salmon dying and why?** This gap identifies the need for basin-wide accounting to determine how the Ballard Locks and Ship Canal amplify the effects of warming and urban infrastructure.
- **Gap 2: How is the food web restructuring under climate and human pressures?** This gap emphasizes the priority of quantifying how physical drivers and invasive species disrupt the synchrony between prey availability and juvenile salmon outmigration.
- **Gap 3: How are predation dynamics shifting with climate, human pressures, and invasive species?** This gap highlights the necessity of assessing how rising temperatures and low flows increase vulnerability to predators and identifying management targets for suppression.
- **Gap 4: How do we understand and mitigate exacerbating factors on predation?** This gap identifies the need to characterize how under-studied stressors like Artificial Light at Night (ALAN) and invasive aquatic vegetation create novel predation risks.
- **Gap 5: How do contaminants and disease compound as stressors?** This gap addresses the requirement for investigating the synergy between stormwater toxins like 6PPD-quinone, rising temperatures, and parasitic infections.

The report also synthesizes an identified opportunity to develop the Lake Washington Basin system as a natural research laboratory to support globally relevant studies of climate and urban impacts on fisheries.

Contents

Acronym List

ALAN	Artificial Light at Night
MIT	Muckleshoot Indian Tribe
PIT	Passive Integrated Transponder
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UW	University of Washington
WDFW	Washington Department of Fish and Wildlife
WFRC	Western Fisheries Research Center
WRIA	Watershed Resource Inventory Area

About the Lake Washington Basin Science Summit

The Lake Washington Basin serves as a vital resource for investigating native fish populations and the effects of urbanization and climate change. The Basin includes Lake Washington, Lake Sammamish, the Lake Washington Ship Canal, the Cedar River, and the surrounding streams and watersheds within WRIA 8 (see Appendix A for a map of WRIA 8). Scientific research has played a significant role in driving progress, from developing solutions for wastewater management to addressing current issues such as the effects of population growth. Research in the watershed is led by a diverse network of organizations dedicated to fisheries research, including state and Tribal co-managers, King County, USGS WFRC, and UW. Nevertheless, there remains a need for enhanced opportunities to share information across entities and to foster collaboration among partners.

The Lake Washington Basin Science Summit was designed to strengthen coordination among regional scientists and science-focused organizations by reviewing existing knowledge, identifying critical gaps, exploring collaborative opportunities, and allocating time for building new professional connections.

Climate Change and Urban Effects on Fish in the Lake Washington Basin

A primary focus of the Summit was to advance understanding of the impacts of climate and urban development on salmonids and other native fish within Lake Washington and adjacent water bodies.

The recovery of native salmonids within the Lake Washington Basin is increasingly impacted by the relationship between climatic shifts and urban development, which form compound stressors on fish in the region. Urban growth and climate change have increased water temperatures, shifted baseline trophic interactions, introduced invasive predators and aquatic vegetation, and impacted water quality, among other influences on the cold, clean waters salmonids need to survive.

Current trends within the basin underscore the urgency of investigating the concurrent stressors of climate change and urban impacts on fisheries in the Lake Washington Basin. The region is experiencing significant ecological restructuring as rising temperatures induce phenological shifts, rapid human population growth continues to increase the loading of contaminants, nutrients, and light pollution into the watershed, and warm-water invasive species, such as American shad, compete for limited resources and further displace native populations.

The overlapping nature of urban impacts and climate change in the Lake Washington Basin presents a unique opportunity to treat the system as a natural laboratory to study salmon recovery in the context of a warming, urbanized landscape. Paired with robust research infrastructure including federal, Tribal, state, county, and local governments as well as academic and nonprofit scientists, these traits make the Lake Washington Basin system a unique habitat in which to examine fisheries dynamics.

In recognition of the continuing need to study urban and climate impacts on salmonids in the basin and the multitude of parties researching the topic, the Lake Washington Basin Science Summit was initiated with four key goals:

1. Share scientific knowledge related to urban and climate impacts on fish populations in the Lake Washington Basin.
2. Identify key information gaps that are critical for guiding recovery efforts for salmonids and other native fish species.
3. Identify and share information about available technical and laboratory resources in the watershed and the concept of Lake Washington as a reference lab to support collaborative research and improve scientific outcomes.
4. Foster enhanced collaboration among scientists in the watershed and engage new scientists, students, and partners working on fisheries and watershed science locally.

Summit Structure

The first day of the Summit was focused on scientific presentations within a range of topics, including:

- Salmon Population Monitoring
- Trophic Interactions and Impacts Related to Predation
- Exacerbating Factors of Predation
- Water Quality Monitoring and Impacts in the Basin
- Disease in Chinook and Parasite Distribution

The second day included additional presentations, a poster presentation session, and breakout discussions. The objective of the discussions was to further identify areas where additional research and cooperation are needed to inform future scientific efforts. This report provides an overview of the presentations and summaries of the key findings from breakout group discussions.

The Lake Washington Basin Science Summit had approximately 100 participants, including:

- Scientists from local Tribal governments
- Scientists from local state and federal agencies
- Scientists from city and county governments
- Local university professors and graduate students
- Local science-focused non-profit organizations

A full list of attendees is available in Appendix B. The scientific focus and planning of the Summit was guided by members of the Steering Committee, listed in Appendix C.

Overview of Presentations

The Lake Washington Basin Science Summit included plenary sessions and poster presentations. Plenary sessions were arranged by topic (Table 1). Additional presentation details, including the titles, presenter names, and abstracts are available in Appendix D.

Table 1. The Lake Washington Basin Science Summit Oral Presentations

Presentation Title	Speaker(s)	Affiliation
Introduction		
WRIA 8: A watershed where salmon and people can live together (pdf)	Mary Ramirez	WRIA 8
Lake Washington as a reference laboratory: Factoring in urbanization and climate change (pdf)	Michael Schmidt	USGS WFRC
Session 1: Salmon Population Monitoring		
Juvenile salmon outmigration, life-history diversity, and survival in the Lake Washington watershed (pdf)	Peter Lisi	WDFW
A life cycle model to help guide Lake Sammamish kokanee recovery (pdf)	Rebekah Stiling	King County
Lake Washington sockeye: Abundance and the BLAST program (pdf)	Mike Mahovlich	MIT
Session 2: Trophic Interactions and Impacts Related to Predation		
Long-term changes and stability of Lake Washington zooplankton (pdf)	Arielle Tonus Ellis and Arni Litt	UW
Predation of juvenile Chinook salmon in the lower Lake Washington Basin: Overview of diet analysis and ALAN investigations (pdf)	Roger Tabor	USFWS, *Retired*
American shad in Lake Washington: Emerging evidence of freshwater residency and food web consequences	Lisa Wetzel	USGS WFRC
Pinniped predation at the Ballard Locks: Past and present (pdf)	Mike Mahovlich	MIT
Session 3: Exacerbating Factors of Predation		
Evaluating the effect of artificial light at night (ALAN) on predation risk in Lake Washington and the Ship Canal (pdf)	Tessa Code	USGS WFRC
Managing aquatic weeds for salmon recovery (pdf)	Dave Kyle	Trout Unlimited

Session 4: Water Quality Monitoring & Impacts in the Basin		
Cities can grow without harming lakes: Lake Washington has become less eutrophic despite rapid population growth (pdf)	Daniel Nidzgorski	King County
Cooling the canal: Problem and solutions (pdf)	Lucas Hall	Long Live the Kings
Field- and laboratory-based approaches to evaluate 6PPDQ exposure and toxicity in salmonids (pdf)	John Hansen and Prarthana Shankar	USGS WFRC
Addressing 6PPDQ in WRIA 8: Monitoring, treatment research, and retrofit prioritization	Chelsea Mitchell	King County
Contaminants in Lake Washington juvenile Chinook salmon: Evaluating exposure sites and possible health effects (pdf)	Sandra O'Neill	WDFW
Session 5: Disease in Chinook and Parasite Distribution		
Myxozoan environmental survey in the Lake Washington/Sammamish Basin (pdf)	Dave Kyle	Trout Unlimited
Ceratonova shasta in Chinook salmon from the Lake Washington watershed – potential impacts in an urban-influenced watershed	Sophie Hall	USGS WFRC

The poster session included presenters from WDFW, UW, the Wetland Ecosystem Team, and USGS. The list of poster presentation titles is summarized in Table 2. Appendix D provides additional poster presentation details, including abstracts when available.

Table 2. The Lake Washington Basin Science Summit Poster Presentations

Presentation Title	Speakers(s)	Affiliation
Guiding participatory research: What do you want to know about juvenile salmonid survival in Lake Washington? (pdf and Summit participation)	Emily Jameson	UW
Genetic and life history evidence for the persistence of native Lake Washington kokanee (pdf)	Jeffrey S. Jensen	UW
Multiple stressor effects on juvenile salmon in south Lake Washington (pdf)	Kerry Accola	UW
Tracking salmon migrations with an autonomous eDNA sampler (pdf)	Marshal Hoy *et al.*	USGS WFRC
Implementation of a stationary hydroacoustic array to monitor outmigration of juvenile salmonids from the Lake Washington Basin	Kirsten Simonsen, Alexandra Sawyer and Mickey Agha	WDFW

Increasing temperatures magnify the uptake of tire-wear contaminant 6PPD-Q in juvenile coho salmon (*Oncorhynchus kisutch*) (pdf)	Amirah Casey *et al.*	UW
Making a splash: The sizeable impact of two native predators on juvenile sockeye survival in Lake Washington	Shelley Johnson, Candice Powers and Chloe Pak	USGS WFRC

Synthesis of Identified Research Gaps

Following the Lake Washington Basin Science Summit, the insights gained from technical presentations and breakout sessions were synthesized into a series of overarching research themes presented on the following pages. These themes, framed as high-level questions, highlight the critical knowledge gaps regarding the intersection of fisheries health and the cumulative impacts of urbanization and climate change. To provide a structured approach to these challenges, the identified gaps are categorized into two distinct tracks: Basic Research and Monitoring Questions, which focus on the long-term data collection necessary to track shifting baselines in a changing climate, and Near-Term Recovery Science Needs, which prioritize targeted, actionable inquiries designed to inform immediate management interventions and recovery strategies.

While these gaps are not intended to be a comprehensive catalog of all potential research needs, they capture the overall themes of the collective expertise present at the Summit. For a more detailed summary of the proceedings and technical discussions, readers may refer to Appendix E. To ensure these findings remain integrated with existing recovery frameworks, a cross-reference table that maps these research themes against established WRIA 8 Priorities and the four primary discussion themes of the Summit was also developed (Table 3).

In addition to identifying five research gaps, a primary opportunity emerged from this synthesis: development of the Lake Washington Basin as a "Natural Laboratory." By leveraging the system's unique gradient of human impact, from the highly engineered Ship Canal to the relatively natural reaches of the Cedar River, researchers can pursue a coordinated, basin-wide framework for science as a model for global studies on fish in urban watersheds and a changing climate.

Each gap was reviewed by at least one expert reviewer. These reviewers provided comments on the technical accuracy of the synthesis and noted any relevant data or glaring omissions. Many reviewers also attended the symposium and elevated conversations they found particularly important. These comments have been summarized for each gap.

Research Gaps Summary Table

					Workshop Themes				WRIA 8 Priorities*	
			Basic Research & Monitoring Questions	Near-Term Recovery Science Needs	Salmon Population Monitoring	Trophic Interactions and Predation	Exacerbating Factors of Predation	Water quality monitoring, contaminants, disease, and parasites	2017 Research and Data Gap	2026 Monitoring and Assessment**
1	**Where are the fish dying and why?**									
	1.1	Long-Term Population Monitoring	X		X				11	A1, A4
	1.2	Dynamics at the Locks	X		X				1	A3, A4, B2
	1.3	Hatchery Impacts		X	X				9	
	1.4	Sammamish Restoration		X	X			X	3, 4	B3, B4, D1
	1.5	Locks and Ship Canal Operations		X	X			X	1	A2, A3, B1
	1.6	Recovery Planning		X	X				3	A2, A5, C1
2	**How is the food web restructuring with climate, human pressures, and invasive species?**									
	2.1	Phytoplankton and Zooplankton Dynamics	X			X		X		
	2.2	Mysid Dynamics	X			X				
	2.3	Juvenile Salmonid Growth	X			X				D4
	2.4	Invasive Species as Food Web Disruptors		X		X				C1
	2.5	Prey Availability		X		X				
3	**How are predation dynamics shifting with climate, human pressures, and invasive species?**									
	3.1	Predation Hotspot Dynamics	X			X	X		3, 6	C1, C3
	3.2	Pinniped Ecology and Behavior	X			X	X			C5
	3.3	Bird Predation	X			X	X			
	3.4	Primary Predator Identification		X		X	X			
	3.5	Predator Removal Efficacy and Targeting		X		X				C2
	3.6	Hotspot Management		X		X	X			C5

4	**How do we understand and mitigate exacerbating factors on predation?**									
	4.1	ALAN Effects on the Food Web	X			X	X			
	4.2	Predator Behavior Under ALAN	X				X		3	C4
	4.3	Dock and Shoreline Impacts	X				X		8	C3
	4.4	Invasive Aquatic Vegetation and Predation	X			X	X		7	B4, C3
	4.5	Light Threshold and Prioritization		X			X			
	4.6	Regulatory and Infrastructure Standards		X			X			
	4.7	Vegetation and Habitat Management		X			X		13	C3
5	**How do contaminants and disease compound as stressors?**									
	5.1	6PPD-q Mechanisms and Interactions	X					X		
	5.2	Contaminants of Emerging Concern	X					X	5	
	5.3	Disease Distribution and Hosts	X					X		B5
	5.4	Disease Dynamics and Temperature Interactions	X					X		
	5.5	Stormwater Management		X				X	5	
	5.6	Disease Management		X				X		
6	**Opportunity: Develop the Lake Washington System as Natural Laboratory**									
	6.1	Formalize a Natural Laboratory System	X	X	X	X	X	X		
	6.2	Develop Long-Term Monitoring	X		X	X		X		B1, D2
	6.3	Coordinate and Pool Data	X	X	X	X	X	X		

Table 3

* Key for WRIA 8 Priorities available as APPENDIX F: WRIA 8 Research and Data Gaps and Monitoring and Assessment Priorities

** The WRIA 8 Monitoring and Assessment Priorities represent priorities identified in 2026, and as such include only a snapshot of the WRIA's most urgent monitoring and research goals at the time of development.

Gap 1: Where are salmon dying and why?

A basin-wide accounting of salmonid mortality across life stages and locations is needed to determine where mortality is occurring, at what rate, and in response to which stressors. Warming temperatures likely increase adult recycling rates at the Ballard Locks, alter juvenile outmigration timing, and concentrate fish in thermally stressful conditions for longer periods. Urban infrastructure, including the Locks and Ship Canal, creates bottlenecks that amplify these effects, and additional data are needed to evaluate habitat restoration alternatives.

Basic Research & Monitoring Questions

- **1.1 Long-Term Population Monitoring for Chinook, Sockeye, and Kokanee**
    - 1.1.1 What are the dynamics of juvenile survival, especially in the fry stage, in the lake?
    - 1.1.2 Where is pre-spawn and en-route mortality happening and to what extent at each point within the Lake Washington system? What are the primary causes of pre-spawn mortality?
    - 1.1.3 What are drivers and patterns of sockeye and Chinook residualization?
    - 1.1.4 How do temperature and predation impact adult and juvenile survival in across the Basin?
- **1.2 Dynamics at the Locks**:
    - 1.2.1 What are rates of adult recycling at the Ship Canal and Ballard Locks, and how have they been impacted by warming?
    - 1.2.2 What is the survival rate of juveniles outmigrating through the Locks versus survival to the Locks? Does the path fish take through the Locks impact survival (in addition to PIT tag detection)?

Near-Term Recovery Science Needs

- **1.3 Hatchery Impacts:**
    - 1.3.1 Evaluate effectiveness of current sockeye hatchery release strategies, particularly whether later releases coincide with higher predator activity as temperatures warm.
    - 1.3.2 Identify optimal release timing to improve population outcomes.
- **1.4 Restoration in Sammamish River:**
    - 1.4.1 Evaluate effectiveness of restoration actions in the Sammamish River (also called Sammamish Slough) on temperature, predation, and juvenile survival.

  - 1.4.2 Identify priority interventions to reduce adult and juvenile mortality in the Sammamish River.
- **1.5 Locks and Ship Canal Operations:**
  - 1.5.1 Assess how Locks operations affect water quality and salmon behavior and identify operational adjustments that could improve passage, health, and survival.
  - 1.5.2 Improve PIT tagging infrastructure in the Ship Canal to increase detection rates and reduce gaps in survival modeling and improve fish passage.
- **1.6 Recovery Planning:**
  - 1.6.1 Evaluate changes in survival at specific life stages and identify life stages and habitats most limiting to salmon recovery and evaluate management scenarios to test conservation strategies.
  - 1.6.2 Evaluate life-stage specific data needed to support Cedar River Chinook lifecycle model development.
  - 1.6.3 Identify interventions to minimize juvenile mortality in the lake phase while balancing growth needs against the risks of extended lake residence.
  - 1.6.4 Evaluate whether WRIA 8 should set new near-term survival targets now that the 2025 benchmark has passed.

Potential barriers

- Navigation limitations in the Ship Canal and saltwater and electric interference constrain PIT tag antenna placement and detection coverage.
- Survival data for Chinook has a lag time of four years due to dependence on returning adults.
- En-route mortality is hard to monitor, and we may not be catching the loss happening in the Ship Canal and lakes.

Reviewer Comment

Understanding fry-stage survival is a top priority in Lake Washington. Currently, WDFW uses PIT tags and modeling to estimate juvenile survival, while USGS has historically estimated pre-smolt survival for sockeye. To better characterize where mortality occurs in the system, future work should explicitly distinguish between adult en-route mortality (death before reaching spawning grounds) and pre-spawn mortality (death at the spawning grounds prior to spawning). Current estimates rely on discrepancies between counts at the Ballard Locks and the spawning grounds, leveraging WDFW spawning ground tracking, literature estimates, and co-manager counts at the Locks. However, while survival to the Locks is approachable with PIT tags, tracking survival through the Locks remains difficult due to numerous un-instrumented passage pathways. Factors like recycling, residence time, temporal expansion, *and the unknown fraction migrating through the Locks introduce significant error that can artificially inflate return counts.*

Long-term monitoring is crucial to understand how climate-driven shifts in the frequency and severity of extreme weather events, such as high river flows, impact survival in subsequent years. These insights could inform managed water releases designed to dampen river scour and prevent redd loss. Finally, the data gaps highlighted for the Sammamish River are largely relevant to the Lake Washington Basin as a whole; in particular, the critical interaction between temperature and disease impacts both juveniles and adults across the entire basin (see Gap 5).

Gap 2: How is the food web restructuring with climate, human pressures, and invasive species?

The linkages between physical drivers, plankton dynamics, and fish community responses in the Lake Washington basin have not been fully quantified, and existing datasets across organizations have not been integrated to address them. Warming temperatures are altering thermal stratification, spring bloom timing, and zooplankton phenology in ways that may disrupt the synchrony between prey availability and juvenile salmon. Urbanization has introduced new competitors and predators including shad, rock bass, and Asian clams, and nutrient inputs from urban runoff are likely contributing to observed shifts in phytoplankton community composition. While current understanding suggests juvenile Chinook and sockeye are not food-limited, climate change and urbanization may alter dynamics such that updated bioenergetic models are necessary to understand the current system. *(Predation addressed in Gap 3).*

Basic Research & Monitoring Questions

- **2.1 Phytoplankton and Zooplankton Dynamics:**
    - 2.1.1 What is driving the observed decline in chlorophyll in Lake Washington, and how are shifts in phytoplankton community composition affecting zooplankton and fish?
    - 2.1.2 Are zooplankton diel vertical migration patterns changing, and if so, what is driving those changes including temperature gradients and ALAN?
    - 2.1.3 Can remote sensing tools such as the NASA PACE satellite model plankton seasonality, abundance, and distribution cost-effectively?
- **2.2 Mysid Dynamics:**
    - 2.2.1 What are mysid population dynamics in the lake, do they produce only one or more generations per year, and do they now follow a boom-bust cycle?
    - 2.2.2 How do mysids, a preferred diet of longfin smelt, impact *Daphnia* availability for juvenile sockeye?
    - 2.2.3 Do kokanee interact with the mysid-smelt-sockeye food web in the same way as sockeye?
    - 2.2.4 Re-establish longfin smelt population monitoring in Lake Washington and characterize even and odd year variability relative to mysid populations and shad establishment.
- **2.3 Juvenile Salmonid Growth:**
    - 2.3.1 What are the factors influencing growth and bioenergetics of Chinook and sockeye rearing in Lake Washington, and can we test if they are primarily food-limited?

  - 2.3.2 How are food sources that support salmonids in the lake, like *Daphnia*, larval fish, macroinvertebrates, insects and chironomids for Chinook, impacted by changing temperature and shifting food web dynamics?
  - 2.3.3 How do invasive shad impact seasonal energy pathways?

Near-Term Recovery Science Needs

- **2.4 Invasive Species as Food Web Disruptors:**
  - 2.4.1 Characterize invasive shad population dynamics including spawning locations, juvenile distribution, diet, and water column position, and determine at what population size they begin to significantly disrupt the food web through zooplankton depletion.
  - 2.4.2 Assess feasibility of a tribal shad fishery as a population control mechanism.
  - 2.4.3 Evaluate population-level impacts of Asian clams on filter feeding dynamics and rock bass on native fish communities and determine whether rock bass are spreading to Lake Sammamish.
- **2.5 Prey Availability:**
  - 2.5.1 Identify restoration or management interventions that could support prey availability for salmonids.

Potential Barriers

- The basin lacks continuous long-term monitoring data sets for certain species, for example mysid populations, making it difficult to establish population baselines or detect trends.

Reviewer Comment

While shifting diel vertical migration (DVM) was highlighted at the Symposium, it has not been a primary concern in Lake Washington because the primary prey of juvenile salmon (Daphnia) do not display DVM. However, Daphnia densities are much higher above the thermocline than below it, meaning summer temperature stratification may preclude salmon from accessing high-density prey layers during peak growing seasons. Concurrently, invasive species like American shad can feed in these warmer waters, potentially reducing the overall food supply for juvenile salmon and longfin smelt. The expanding resident shad population presents a disruptive threat to salmon and overall ecosystem integrity. Additional food web pressures include large yellow perch, which are expanding their use of the pelagic zone and driving climate-induced, seasonal shifts in competition-predation interactions with salmonids. The trophic role of longfin smelt, specifically their consumption of non-Daphnia zooplankton, also warrants further exploration.

Past data suggest that neither sockeye nor Chinook have been food-limited. Tracking trends in smolt size remains the most efficient method for evaluating this concern, with bioenergetics modeling as a potential next step. To catch these shifts and identify management opportunities quickly in an era of rapid change, a basic monitoring program is needed to detect trends in the relative abundance, size structure, trophic role, distribution, and new invasions of fishes across both benthic and pelagic habitats.

Gap 3: How are predation dynamics shifting with climate, human pressures, and invasive species?

Predation management including pinniped removal, non-native piscivorous fish suppression, and hotspot targeting is a major area of management investment, and improved science would help direct these efforts more effectively. Warming temperatures are extending adult salmon exposure to pinniped predation through increased recycling at the Locks, low-flow conditions are increasing juvenile vulnerability in river environments, and warming, urban infrastructure, and invasive aquatic vegetation are creating novel predation conditions. While the native northern pikeminnow and cutthroat trout currently account for about 50% mortality of juvenile salmon during lake-rearing and migration, warming conditions expand the threat from non-native cool- and warmwater predators by expanding overlap in time and space during juvenile migration periods.

Basic Research & Monitoring Questions

- **3.1 Predation Hotspot Dynamics:**
  - 3.1.1 What drives the formation of predation hotspots including temperature, light, physical structure, and prey concentration, and can a predictive hotspot model be developed?
  - 3.1.2 Are shallow environments predation hotspots or refugia for juvenile salmon, and does this vary by season, predator species, and light condition?
  - 3.1.3 What is the scale of river predation relative to lake predation, and does low flow increase river predation risk?
- **3.2 Pinniped Ecology and Behavior:**
  - 3.2.1 How abundant are pinnipeds at the Ballard Locks?
  - 3.2.2 Can individual identification confirm that a small number of individuals account for a disproportionate share of predation at the Locks?
  - 3.2.3 Are pinnipeds teaching pups to target salmon as a primary foraging strategy, and what are the long-term implications?
  - 3.2.4 What are the sublethal effects of pinniped predation including wounding and disease susceptibility, and do these interact with temperature and contaminant exposure?
- **3.3 Bird Predation:**
  - 3.3.1 What fraction of predation on juvenile salmon is attributable to mergansers, cormorants, gulls, and herons, and how does this vary with flow regime and season?
  - 3.3.2 Can citizen science and scat surveys be combined to map piscivorous bird distribution and diet across the basin?

Near-Term Recovery Science Needs

- **3.4 Primary Predator Identification:**
    - 3.4.1 Determine the primary predators of juvenile Chinook and sockeye by location, season, and life stage.
    - 3.4.2 Assess whether northern pikeminnow populations are declining or redistributing after removal.
- **3.5 Predator Removal Efficacy and Targeting:**
    - 3.5.1 Conduct forced perturbation studies in defined areas to assess whether predator removal affects community composition and juvenile salmon survival.
    - 3.5.2 Determine whether removal efforts can be targeted at size classes that meaningfully reduce fry predation and identify appropriate methods.
    - 3.5.3 Pair ongoing predator removal efforts with monitoring to assess shifts in predator composition (see also aquatic vegetation removal in Gap 4).
- **3.6 Hotspot Management:**
    - 3.6.1 Evaluate whether predator removal efforts should focus on tributary mouths and defined hotspots rather than diffuse lake-wide suppression.
    - 3.6.2 Identify strategies to encourage sockeye to disperse into the lake more quickly to reduce nearshore predation risk.

Potential Barriers

- Predation studies are site-specific and use non-standardized sensors, making watershed-scale comparison difficult.
- Northern pikeminnow population estimates are uncertain and may be lower than previously assumed.
- Monitoring has not been consistently paired with predator mitigation efforts to assess ecological response.

Reviewer Comment

Known predation hotspots in the basin include the southern portions of both Lake Sammamish and Lake Washington, Sand Point, Webster Point, and Gas Works Park. Other potential hotspots include Arrowhead Point, as well as large, deep pools with large woody debris in the Cedar River and Issaquah Creek. Notably, the Cedar River delta has changed dramatically over the last 30 years with the addition of shallow-water habitats, large wood, and aquatic macrophytes; future work should investigate how these structural changes affect predation dynamics, including avian predation increases post sediment deposition from floods. While typical monitoring focuses heavily on Chinook and sockeye, it should expand to include tributary mouths where Lake Sammamish kokanee fry enter the system. Furthermore, these spatial hotspots may apply primarily to aggregate predators like yellow *perch and northern pikeminnow, rather than non-aggregate piscivores like cutthroat trout and smallmouth bass.*

Pinniped predation at the Ballard Locks continues to be a high concern, as nuisance seals and California sea lions are abundant and frequent at the Locks. Evidence suggests that an increasing number of seal pups are indeed being taught to target salmon at the Locks as a primary food source. We also see evidence of salmon injured or dying as they attempt to avoid seal predation. The combined stress of avoiding predators and acclimating to warmer fresh water has been observed to kill the salmon, with Chinook especially vulnerable. Injured fish are also much more susceptible to disease and bacterial infection, especially in warmer water. Observations of seals living under the smolt slide at the Locks and eating juvenile Chinook suggest that pinniped predation of juvenile salmonids below the spill gates should be studied as an important source of mortality.

Understanding non-pinniped predator population dynamics and abundance patterns following removal efforts remains critical. Cutthroat trout populations should be assessed as a potentially major source of juvenile salmonid mortality, with particular focus on understanding dynamics after removals. Similarly, the relative abundance of rock bass should be monitored over time as they potentially migrate from Lake Sammamish into the Sammamish River, lower Cedar River, and lower Issaquah Creek. Finally, while evidence supports a northern pikeminnow population of over 100,000 (consistent with baselines spanning back to the 1970s), updated data on their abundance and diet are still required. To bridge these gaps in the absence of absolute abundance data, a formalized predation index, similar to the model used on the Columbia and Snake Rivers, could help identify key foraging areas. Existing, non-indexed monitoring approaches by WDFW and USFWS in Lake Washington and the Ship Canal provide a starting point for this effort.

Gap 4: How do we understand and mitigate exacerbating factors on predation like artificial light and invasive vegetation?

Urbanization and climate change have created novel conditions potentially exacerbating predation on salmonids, including prevalent artificial lighting and invasive aquatic vegetation. Artificial light at night (ALAN) is an under-characterized stressor in the Lake Washington basin, and current research has not been scaled to the watershed level or standardized across sites. Unlike temperature, ALAN can be directly reduced through targeted management, making it one of the more tractable anthropogenic influences in the system. Urbanization and a switch to LEDs is the primary driver, with skyglow, dock lighting, bridge lighting, and commercial and residential development expanding the light environment in ways that create new predation opportunities, suppress zooplankton vertical migration, and interact with warming temperatures to compound stress on migrating salmon.

At the same time, anthropogenic introductions of invasive aquatic plants like milfoil, elodea, water lilies, and watercress have altered the native landscape, providing structural habitat that benefit non-native piscivorous fish. Effects of urbanization and climate change, like warming temperatures and nutrient-rich waters, can further amplify the presence and impacts of invasive vegetation, complicating the interactions with salmonids and their predators.

Basic Research & Monitoring Questions

- **4.1. ALAN Effects on Zooplankton and Food Web:**
    - 4.1.1 How does ALAN affect zooplankton and mysid diel vertical migration, and does light-induced suppression reduce prey availability for juvenile salmon?
    - 4.1.2 How do temperature and ALAN interact to disrupt DVM?
- **4.2 Predator Behavior Under ALAN:**
    - 4.2.1 What are nighttime predation rates and predator diet composition in the nearshore and offshore regions of lakes and the Ship Canal, under docks, and at other ALAN-affected sites?
    - 4.2.2 What is the relationship between cormorant and heron foraging activity and dock lighting, and does ALAN near cormorant and heron rookeries meaningfully increase predation?
- **4.3 Dock and Shoreline Impacts:**
    - 4.3.1 How do dock structures create ambush habitat through reduced light penetration?
    - 4.3.2 How does shoreline softening affect predation outcomes?
- **4.4 Invasive Aquatic Vegetation and Predation:**

- 4.4.1 How does invasive aquatic vegetation in Lake Washington, including milfoil, elodea, water lilies, and watercress, create habitat structure that facilitates non-native ambush predators?
- 4.4.2 How does oxygen squeeze in Lake Sammamish driven by invasive vegetation, warming temperatures, and increasing fish biomass, affect the fish community composition and salmon survival?
- 4.4.3 What are the near and long-term ecological impacts of large scale weed management in Lake Sammamish?

Near-Term Recovery Science Needs

- **4.5 Light Threshold and Prioritization:**
  - 4.5.1 Establish the threshold of light reduction needed to produce a meaningful improvement in predation risk and salmon survival, particularly in bottlenecks like the relatively warm and shallow Ship Canal.
  - 4.5.2 Determine whether light reduction efforts should target diffuse residential lighting and/or high-impact centralized sources.
- **4.6 Regulatory and Infrastructure Standards:**
  - 4.6.1 Evaluate the effectiveness of the existing 60% light penetration standard for new docks and assess whether it should be strengthened or extended to existing structures.
  - 4.6.2 Develop a location-specific framework identifying high-priority lighting interventions by address or infrastructure owner.
- **4.7 Vegetation and Habitat Management:**
  - 4.7.1 Evaluate whether tree and shrub planting initiatives could meaningfully reduce ALAN penetration and skyglow within the broader watershed.
  - 4.7.2 Evaluate the ecological impacts of property owner's aquatic vegetation removal and determine whether patchy removal worsens conditions relative to coordinated management.

Potential Barriers

- Use of different light sensor types makes cross-site comparison difficult.
- Current research has not been scaled to all sites in the watershed potentially impacted by ALAN.

Reviewer Comment

As noted in Gap 2, Daphnia in Lake Washington do not exhibit diel vertical migration, but Neomysis DVM remains a lingering question. A critical corollary is whether artificial light *at night impacts salmon DVM, potentially creating a spatial depth mismatch between salmonids and their prey. Predator diet data in a 2024 synthesis report and a forthcoming manuscript on yellow perch in the lake may help elucidate predator-prey dynamics in areas lit by ALAN, although this is not a focus of the study. Reviewers suggested potential future discussions with regulatory agencies for overwater structures to ensure ALAN is reduced, noting it may conflict with requirements to ensure light penetration during the day.*

Beyond artificial light, invasive aquatic vegetation management presents a distinct challenge: two of the most prolific aquatic weeds in Lake Sammamish are Eurasian watermilfoil and elodea. Because both are classified as non-regulatory weeds, control is not legally mandated. Capitalizing on opportunities to control these invasive macrophytes will require additional effort to secure dedicated funding and establish effective cross-jurisdictional management structures.

Gap 5: How do contaminants and disease compound as stressors?

Contaminants and disease are present throughout the basin and are increasingly studied, but the interactions between these stressors and physical and biological conditions remain poorly characterized. Urban stormwater is the primary delivery mechanism for 6PPD-q, pharmaceuticals, microplastics, and other contaminants of emerging concern. Climate change compounds these effects, as warming temperatures are increasing the severity and seasonal window of bacterial infections, temperature stress reduces salmon immune function, and low-flow conditions concentrate contaminants and pathogens in tributary systems during critical migration periods.

Basic Research & Monitoring Questions

- **5.1 6PPD-q Mechanisms and Interactions:**
  - 5.1.1 What are the metabolites of 6PPD-q in fish tissue that could serve as biomarkers of exposure, and which are responsible for toxicity?
  - 5.1.2 How do 6PPD-q and other stormwater contaminants interact with elevated temperatures, dissolved oxygen stress, and infectious disease?
- **5.2 Contaminants of Emerging Concern:**
  - 5.2.1 How do pharmaceuticals, cosmetics, and microplastics affect juvenile salmon behavior, physiology, and survival in the Lake Washington system?
  - 5.2.2 What are the primary contaminants in fish across different regions of the basin?
- **5.3 Disease Distribution and Hosts:**
  - 5.3.1 Where are the primary environmental reservoirs of key fish pathogens in the basin, and what are the definitive and intermediate hosts of myxozoan parasites?
  - 5.3.2 Can eDNA surveys map bacterial pathogen distributions and identify primary and intermediate hosts including non-native vectors?
- **5.4 Disease Dynamics and Temperature Interactions:**
  - 5.4.1 How does columnaris (*F. columnare*) infection severity change with rising water temperatures?
  - 5.4.2 How and where is *C. shasta* infecting juvenile and adult salmonids?
  - 5.4.3 What are impacts of *C. shasta* infection on juvenile salmonids, and does infection during juvenile stages impact marine survival?
  - 5.4.4 Are salmonids able to shed *C. shasta* infections during smoltification, or do smolts carry infections and return as infected adults?

- 5.4.5 How does *P. minibicornis* in the Cedar River impact adult sockeye and Chinook?

Near-Term Recovery Science Needs

- **5.5 Stormwater Management:**
  - 5.5.1 Evaluate whether existing stormwater best management practices are effective at removing contaminants of emerging concern.
  - 5.5.2 Characterize sublethal endpoints of 6PPD-q exposure in juvenile Chinook and sockeye to inform stormwater management standards.
- **5.6 Disease Management:**
  - 5.6.1 Assess whether earlier introduction of juvenile salmonids to the lake would reduce exposure to *C. shasta.*
  - 5.6.2 Expand sockeye disease sampling to deeper water to identify hot spots.
  - 5.6.3 Develop and deploy rapid fish health assessment tools to improve disease surveillance cost-effectively.
  - 5.6.4 Develop management strategies for *C. shasta* and other pathogens based on improved understanding of host distribution and infection location.

Potential Barriers

- Stormwater infrastructure around the lake is difficult to track according to King County, limiting the ability to attribute contamination to specific sources.
- Rapid fish health assessment capacity is limited across the basin.

Reviewer Comment

Inclusion of F. columnare infection is key for understanding the interactions of disease and contaminants in the Lake Washington basin. Ongoing work at WFRC is prioritizing these combined stressors with studies combining F. columnare and tire wear leachates, which may help managers target columnaris infections in hatcheries near major roadways. Additional ongoing monitoring of P. minibicornis and C. shasta in the region may help answer some of the additional gaps flagged during the discussion.

Opportunity: Develop the Lake Washington System as a Natural Laboratory

Lake Washington, Lake Sammamish, and the Ship Canal form a rare comparative system within a single urban watershed, with different flow regimes, thermal profiles, light environments, and management histories. Realizing the full potential of this system as a Natural Laboratory for understanding effects of climate and urban effects on fish communities will require improved coordination across organizations, standardized monitoring protocols, and integration of data across the WRIA. The basin's long history of human modification makes it a valuable place to study dynamics that other systems may face in the future.

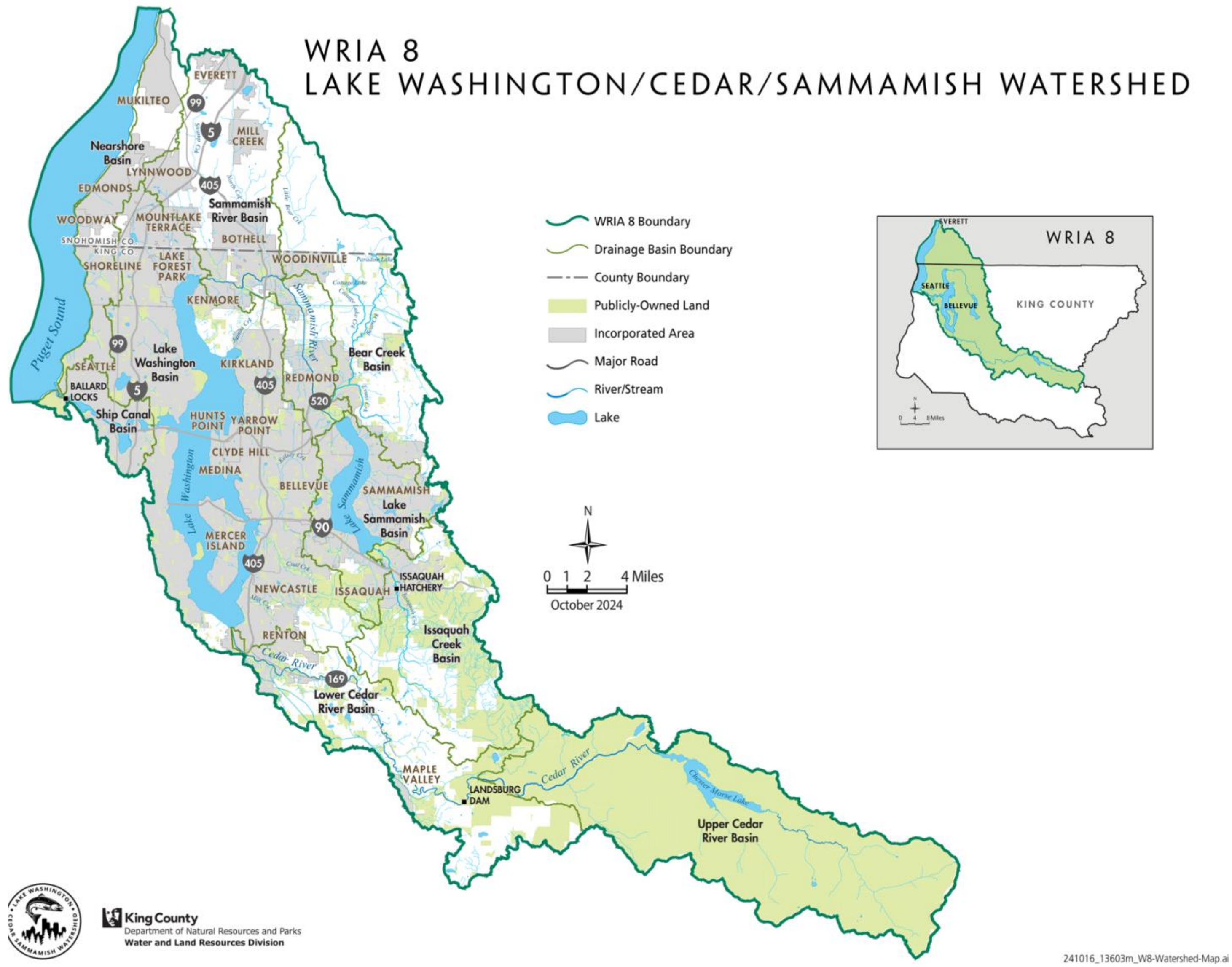
Recommendations to Develop Natural Laboratory System

- **6.1 Formalize a Natural Laboratory System, Prioritize the Science, and Maintain and Grow Partnerships:**
    - 6.1.1 Create a natural laboratory steering committee to establish a formal framework, help maintain collaboration, prioritize activities, maintain data sharing, identify funds, and uplift the development of a Lake Washington Natural Laboratory. Additional work groups for focal areas like the Lake Washington ship canal should be considered.
    - 6.1.2 Continue to host coordination workshops at regular intervals in support of the natural laboratory framework.
    - 6.1.3 Use a Natural Laboratory framework to identify which research questions can only be answered in this system and prioritize funding accordingly.
    - 6.1.4 Develop connections between researchers, permitting and regulatory agencies, and community education efforts to maximize the applied value of basin science
- **6.2 Develop Long-term Monitoring to Support Targeted Inquiries**:
    - 6.2.1 Identify key physical, chemical, and biological variables that need to be monitored consistently across all three water bodies to support modeling and hypothesis-driven studies.
    - 6.2.2 Develop long-term monitoring to track fish populations and determine how urban and climate effects in Lake Washington, Lake Sammamish, and the Ship Canal impact salmonids.
    - 6.2.3 Build foundational long-term data sets of water quality, including tracking nitrogen, phosphorus, and sewage entering the system.
    - 6.2.4 Integrate data across systems and consider models linking trophic interactions, disease, and urban and climate impacts.

  - 6.2.5 Harmonize existing long-term datasets from King County, WDFW, UW, USGS, and Tribal monitoring to support cross-system analysis.

- **6.3 Coordinate and Pool Data:**
  - 6.3.1 Develop a data pooling framework across WRIA 8 and other relevant entities that reduces duplication and fills spatial gaps.
  - 6.3.2 Establish standardized monitoring protocols and data-sharing agreements across organizations.
  - 6.3.3 Integrate citizen science efforts into a basin-wide monitoring framework like using eBird for piscivorous bird mapping and community light monitoring.
  - 6.3.4 Establish a working group for priority topics like the Ship Canal that incorporates all necessary parties to discuss data.

APPENDIX A: Map of WRIA 8



APPENDIX B: Lake Washington Basin Science Summit Participant List

Name	Affiliation
Aaron Bosworth	WDFW
Alexandra Sawyer	WDFW
Alison Agness	King County
Alix Lee-Tigner	Trout Unlimited
Amirah Casey	UW
Andrea Carey	WDFW
Arielle Tonus- Ellis	UW
Arni Litt	UW
Ava Fuller	MIT
Brianna Pierce	City of Bellevue
Candice Powers	USGS
Carl Ostberg	USGS
Carol Volk	Seattle Public Utilities
Carrie Byron	King County
Casey Schmidt	Suquamish Tribe
Chelsea Mitchell	King County
Chloe Pak	USGS
Christa Heller	Seattle Public Utilities
Cleo Neculae	Washington Department of Ecology
Daniel Nidzgorski	King County
Daniel Schindler	UW
Danielle Devier	City of Seattle
Dave Kyle	Trout Unlimited
Emily French	UW
Emily Jameson	UW
Evan Russell	Snohomish County
Ewan Henderson	UW
Freida Taub	UW (retired)
Ian Anderson	WDFW
James Bower	King County
Jason Mulvihill-Kuntz	WRIA 8
Jason Toft	UW
Jesse Dykstra	WDFW
Jillian Howard	MIT
Jeff Duda	USGS
Jeff Jensen	UW
Jenee Colton	King County
Jen Schulien	Schulien Consulting
Jess Diallo	USGS
Joe Short	WDFW
John Hansen	USGS

Josh Kubo	King County
Josh Latterell	King County
Julia Unrein	Seattle Public Utilities
Kara Nelson	Consultant
Karl Burton	Seattle Public Utilities
Kaelie Spencer	Long Live the Kings
Katie Queen	Trout Unlimited
Kerry Accola	UW
Kirsten Simonsen	WDFW
Kirsten Vacura	MIT
Lief Horwitz	USGS (retired)
Lisa Wetzel	USGS
Liz Allyn	Coast Salmon Partnership
Lucas Hall	Long Live the Kings
Luke Skowronek	WDFW
Madisen Norton	City of Seattle
Maria McNaughton	WDFW
Mary Ramirez	WRIA 8
Mark Celedonia	National Oceanic and Atmospheric Administration (retired)
Mark Scheuerell	UW
Marshal Hoy	USGS
Mathieu Marineau	USGS
Michael Schmidt	USGS
Michelle Green	King County
Michele Koehler	Seattle Public Utilities
Mickey Agha	WDFW
Mike Mahovlich	Muckleshoot Indian Tribe
Nandita Kohli	USGS
Natasha Winnacott	WDFW
Neala Kendall	WDFW
Nicole Doran	UW
Paul Hershberger	USGS
Peter Lisi	WDFW
Phoebe Berghout	UW
Piper Hanson	Mid Sound Fisheries Enhancement Group
Prarthana Shankar	USGS
Rachael Gravon	King County
Rebecca Sessa	WDFW
Rebecca Stiling	King County
Regan McNatt	USFWS
Rich Sheibley	USGS
Roger Tabor	USFWS (retired)
Sandie O'Neill	WDFW
Sarah Converse	UW
Shelley Johnson	USGS
Sophie Hall	USGS

Stan Gosliner	U.S. Army Corps of Engineers
Stewart Reinbold	WDFW
Susan O'Neil	Environmental Science Associates
Tessa Code	USGS
Tiffany Armstrong	MIT
Tim Kuzan	WDFW
Todd Zackey	Tulalip Tribes
Tom Hardy	City of Redmond

APPENDIX C: Summit Steering Committee

Name	Affiliation
Aaron Bosworth	WDFW
Alison Agness	King County
Carol Volk	Seattle Public Utilities
Jason Mulvihill-Kuntz	WRIA 8
Jason Schaffler	MIT
John Hanson	USGS WFRC
Kara Nelson	Consultant
Mark Scheuerell	UW
Mary Ramirez	WRIA 8
Michael Schmidt	USGS WFRC
Michelle Green	King County
Mike Mahovlich	MIT
Nandita Kohli	USGS WFRC
Neala Kendall	WDFW
Peter Lisi	WDFW
Piper Hanson	Mid-Sound Fisheries Enhancement Group
Prarthana Shankar	USGS WFRC
Sarah Converse	UW
Shelley Johnson	USGS WFRC

APPENDIX D: Presentation Abstracts

Oral Presentations

Presentation details including titles, presenters and abstracts are included below, arranged by session. Abstracts were not available in all cases. Abstract texts have been included as submitted by the authors and have not been edited.

Session 1: Salmon Population Monitoring

Title: Juvenile Salmon Outmigration, Life-History Diversity and Survival in the Lake Washington Watershed
Presenters: Peter Lisi and Ian Anderson, Washington Department of Fish and Wildlife
Abstract: Climate change, invasive species, and habitat degradation pose significant challenges for salmon recovery in urbanized watersheds like Lake Washington. To support recovery efforts, WDFW has estimated juvenile salmon outmigration and life-history diversity in the Cedar River and Bear Creek watersheds using smolt traps for over 25 years. Annual variability offers a long-term context for understanding how salmonids respond to shifting environmental conditions.

Our data show that egg-to-fry survival is sensitive to peak winter discharge, and that density-dependent processes influence Chinook parr life histories. We also quantify survival of juvenile Chinook salmon though Lake Washington and the Shipping Canal during their seaward migration to the Ballard Locks. Results indicate that age-1+ coho smolts exhibit high and relatively stable apparent survival (~85%), whereas subyearling Chinook parr experience lower and more variable survival (~58%) through this migration corridor. These survival patterns are further shaped by migration timing from tributaries and body size, likely reflecting interactions with thermal conditions and predation risk within Lake Washington.

Title: A Life Cycle Model to Help Guide Lake Sammamish Kokanee Recovery
Presenter: Rebekah Stiling
Abstract: The Lake Sammamish kokanee lifecycle model is an adaptive management tool for the Lake Sammamish Kokanee Recovery Program. The model explores how habitat and/or hatchery improvements may impact future numbers of adult kokanee returning to spawn. Outputs from the kokanee life cycle model suggest that if the pre-2019 survival rates went unchanged, the Lake Sammamish kokanee population would continue to decline. Results suggest that the life stage most limiting the kokanee population is fry-to-adult survival in Lake Sammamish and that actions taken to increase fry-to-adult survival rates could aid in population recovery. Model outputs show that the kokanee hatchery program could promote population growth if hatchery-origin fry-to-adult survival rates can match or exceed natural-origin fry-to-adult survival rates.

Title: Lake Washington Sockeye: Abundance and the BLAST Program
Presenter: Mike Mahovlich, Muckleshoot Indian Tribe

Abstract: There has been a substantial decline in Lake Washington sockeye, which has led to a high likelihood of extirpation. Due to many variables, there is high en-route and pre-spawning mortality in returning adults that is negatively affecting natural and hatchery production. The Muckleshoot Indian Tribe and the Washington Department of Fish and Wildlife (the co-managers) have developed a solution that will help rebuild the population abundances where sustainable harvest is possible. The Ballard Locks Adult Sockeye Transfer (BLAST) program, involves collecting adult sockeye at the Hiram M. Chittenden Locks (Ballard Locks) and transporting them directly to the Cedar River Hatchery. Adult sockeye are held at the hatchery for three to five months before maturation and spawning. The BLAST program was initiated as a way of bypassing multiple sources of stress and mortality associated with adult sockeye migration through the Lake Washington system. The program started in 2021 with 279 sockeye transferred and has increased to over 3480 transferred in 2025. This program has demonstrated success in safeguarding the broodstock program. This is accomplished by providing healthy adults which reduces pre-spawn mortality and increases egg take compared adult sockeye that have navigated through Lake Washington and were collected in the Cedar River. Co-managers are working towards significantly growing the BLAST program by increasing hatchery infrastructure that will result in increased production.

Session 2: Trophic Interactions and Impacts Related to Predation

Title: Long-Term Changes and Stability of Lake Washington Zooplankton
Presenters: Arielle Tonus Ellis and Arni Litt, University of Washington

Title: Predation of Juvenile Chinook Salmon in the Lower Lake Washington Basin: Overview of Diet Analysis and ALAN Investigations
Presenters: Roger Tabor, retired USFWS, coauthors are Regan McNatt (USFWS), Aaron Bosworth (WDFW), and Joseph Short (WDFW)

Title: American Shad in Lake Washington: Emerging Evidence of Freshwater Residency and Food-Web Consequences
Presenter: Lisa Wetzel, US Geological Survey, Western Fisheries Research Center
Abstract: American shad (*Alosa sapidissima*) are rapidly increasing in Lake Washington, with gill-net catches rising from ~215 fish in 2022 to over 3,000 in 2025. This surge raises critical questions about shad life history and the potential ecosystem impacts. Evidence from otolith microchemistry, parasite screening, and size distributions suggests that some individuals may be completing their entire life cycle in freshwater – a novel scenario for this species. This talk synthesizes recent catch trends and preliminary residency indicators, explores potential food-web interactions with juvenile salmonids and the greater aquatic community. We conclude with research priorities and monitoring strategies to assess ecological consequences and inform future research and management in Lake Washington.

Title: Pinniped Predation at the Ballard Locks: Past and Present
Presenter: Mike Mahovlich, Muckleshoot Indian Tribe
Abstract: For over 45 years, the Ballard Locks has been a hotspot for pinniped predation on salmonids. Anadromous salmonids in the Lake Washington Basin pass through the Ballard

Locks at least twice in their life, once as juveniles during their outmigration and again as returning adults. The Ballard Locks is a bottleneck, providing pinnipeds easy opportunity to stage, hunt and feed on juvenile and adult salmon. California sea lions were identified as the primary culprit responsible for the functional extirpation of Lake Washington steelhead. From the mid-1980s to the early 2000s tremendous multi-agency efforts occurred including trying multiple hazing techniques, relocations, and limited permanent removals. Pinniped predation at the Ballard Locks remains a major issue and has detrimental impacts on the status and rebuilding of Lake Washington salmon populations, including ESA-listed Chinook. At the Ballard Locks, salmon migration is delayed due to an abrupt change in salinity and temperature which exacerbates their vulnerability to pinniped predation. In addition to direct mortality, many salmon are wounded or otherwise stressed during pinniped encounters. Many of these individuals later succumb to mortality due to stress and/or diseases from wounds sustained. With low salmon returns, the impacts of pinniped predation on adult and juvenile salmon increase exponentially. In more recent years, harbor seals have increased in abundance and have aggressively harassed and preyed upon salmon. Pinnipeds at the Ballard Locks must be managed to protect and recover salmonids in the Lake Washington Basin. Managers are faced with obstacles from the current Marine Mammal Protection Act, which greatly limits the only known effective management options. While efforts are ongoing to allow permanent removal, other efforts are being implemented at the Ballard Locks.

Session 3: The Exacerbating Factors of Predation

Title: Evaluating the Effect of Artificial Light at Night (ALAN) On Predation Risk in Lake Washington and the Ship Canal
Presenters: Tessa Code, US Geological Survey, Western Fisheries Research Center (presenter), Jennifer Schulien, Rachelle Johnson, and David Beauchamp

Title: Managing Aquatic Weeds for Salmon Recovery
Presenter: David Kyle, Trout Unlimited

Session 4: Water Quality Monitoring & Impacts in the Basin

Title: Cities Can Grow Without Harming Lakes: Lake Washington has Become Less Eutrophic Despite Rapid Population Growth
Presenter: Daniel Nidzgorski, King County Department of Natural Resources & Parks
Abstract: As cities grow, lakes are often assumed to suffer from increasing non-point pollution. But when we examined water-quality trends in Lake Washington over the past 25 years (1998–2022), we found the opposite. The watershed population grew rapidly during that time (34% from 2000–2020), yet Lake Washington became substantially less eutrophic, and indicators of development impacts stabilized or decreased. Chlorophyll concentrations during the main spring bloom decreased sharply, partly driven by a decrease in phosphorus concentrations. Water clarity and near-bottom dissolved oxygen also increased. Clearer water is good news for people swimming and boating in the lake, but we do not yet know what effects a decrease in phytoplankton has had on the food web and fish species. Chlorophyll decreased much more strongly than phosphorus did, which suggests

that phytoplankton species have likely shifted, which can further affect the food web. We also do not yet know the main reasons why phosphorus inputs decreased. Many regulatory and voluntary protections likely contributed, starting in the 1990s, ranging from fertilizer restrictions to erosion controls. The type of development during this time was likely a key contributor: we found no net loss of forest area and little increase in developed land area (4.7% from 2001–2021). Instead of expanding into new areas, redevelopment increased density on already-developed land and likely drove improvements in stormwater treatment and other environmental protections.

Title: Cooling the Canal: Problem and Solutions
Presenter: Lucas Hall, Long Live the Kings

Title: Field- and Laboratory-Based Approaches to Evaluate 6PPDQ Exposure and Toxicity in Salmonids
Presenters: John Hansen and Prarthana Shankar, U.S. Geological Survey, Western Fisheries Research Center
Abstract: Urban stormwater runoff carries hundreds of pollutants including pharmaceuticals and pesticides into surrounding freshwater. One such pollutant prominent in urban watersheds is 6PPD-quinone, a transformation product of 6PPD which is an antioxidant used globally in vehicles to significantly extend tire life and increase safety. In 2021, 6PPD-quinone was implicated in inducing mass pre-spawn mortality events in adult coho salmon in the Pacific Northwest (PNW) United States. Since then, the USGS Western Fisheries Research Center among other agencies has been investigating additional impacts of 6PPDQ exposure on native fish species. This presentation describes two recent studies. 1) In collaboration with UW/WSU, we used a small field-facility at Miller Creek, a runoff-impacted watershed in Normandy Park, WA, to investigate the mortality risks for juvenile life stages of coho salmon during spring storms, and 2) using controlled laboratory experiments, we identified coastal cutthroat trout as a species sensitive to 6PPDQ exposure at environmental levels, and evaluated the chemical's effects on disease susceptibility and swimming performance, endpoints important for species health and survival. We also highlight current research that is being done by the USGS Washington Water Science Center and acknowledge data gaps and our ongoing work related to this topic.

Title: Addressing 6PPDQ in WRIA 8: Monitoring, Treatment Research, and Retrofit Prioritization
Presenter: Chelsea Mitchell, King County Water and Land Resources Division
Abstract: The presentation provides an overview on efforts King County is taking to monitor 6PPDQ in our waterways, research effective stormwater treatment, and prioritize placement of treatment retrofits to address the problem, with an emphasis on WRIA 8.

Title: Contaminants in Lake Washington Juvenile Chinook Salmon: Evaluating Exposure Sites and Possible Health Effects
Presenter: Sandra O'Neill, Washington Department of Fish and Wildlife

<u>Session 5: Disease in Chinook and Parasite Distribution</u>

Title: Parasite Distribution: Myxozoan Environmental Survey in the Lake Washington/Sammamish Basin
Presenter: David Kyle, Trout Unlimited

Title: *Ceratonova shasta* in Chinook Salmon from the Lake Washington Watershed – Potential Impacts in an Urban-Influenced Watershed
Presenters: Sophie A. Hall (USGS WFRC), Timothy J. Kuzan (WDFW), Jan Lovy (USGS WFRC)
Abstract: The Lake Washington watershed, located in Seattle, King County, Washington, is home to several Pacific salmon species, including threatened Chinook Salmon (*Oncorhynchus tshawytscha*). The watershed has undergone significant anthropogenic alteration due to urbanization, including the construction of the Lake Washington Ship Canal (LWSC), causing changes in fish migration behaviors and declining LWSC water quality. Understanding the impacts of these changes in the context of fish disease and its influence on salmon population management and recovery efforts is especially important. Examination of adult Chinook Salmon returning to spawn at the Issaquah Salmon Hatchery had 100% *C. shasta* infection prevalence, with significantly higher parasitic loads in pre-spawn mortalities compared to surviving spawners. Sentinel exposures via fish caging revealed varying severity of *C. shasta* infection in the watershed, with increased parasitic load and juvenile mortality in the LWSC compared to the Cedar and Sammamish Rivers. *Ceratonova shasta* genotype and patterns of sentinel caging mortality are discussed in context of understanding juvenile and adult Chinook Salmon survival during freshwater migrations. This data can help support fishery management and recovery in this urban-influenced watershed.

Poster Presentations

Presentation details including titles, presenters and abstracts are included below. Abstracts are not available in all cases. Submission text has been included as submitted by the authors and have not been edited.

Title: Guiding participatory research: what do you want to know about juvenile salmonid survival in Lake Washington?
Presenter: Emily Jameson, University of Washington
Abstract: Juvenile salmonids have higher lake-phase mortality in Lake Washington than in other lakes, impairing the recovery of Chinook and sockeye salmon populations. Therefore, much work has been done and is ongoing to address the causes behind this high mortality. There is growing concern that changing abiotic conditions in Lake Washington such as warming waters and light pollution are increasing predation on juvenile salmonids by native and nonnative piscivores, thereby increasing lake-phase mortality. In response to these concerns the Washington Department of Fish and Wildlife have paired outmigration monitoring in the Lake Washington Shipping Canal with a predatory fishes removal effort. However, there are many unknowns that could impact the effectiveness of these management efforts. In this poster I seek the input of symposium attendees on research priorities for improving the effectiveness and efficiency of management actions aiming to improve the survival of juvenile salmonids in Lake Washington. Additionally, I aim to evaluate the need for a series of formal, structured workshops to address these topics as part of a

participatory science process. By using a participatory science technique I aim to identify and address the most pressing questions for practitioners.

Title: Genetic and life history evidence for the persistence of native Lake Washington kokanee
Presenter: Dr. Jeffrey S. Jensen**,** University of Washington
Abstract: Native kokanee were once widespread and abundant throughout the Lake Washington/Sammamish watershed. Kokanee were an important cultural and subsistence resource for Native Americans prior to European colonization, and early settler accounts describe the "Little Red Fish" as spawning by the thousands in small tributaries. Three genetically distinct populations are thought to have been native to the system – "Early Run" kokanee spawning in Issaquah Creek, "Late Run" kokanee spawning in small tributaries of Lake Sammamish, and "Middle Run" kokanee spawning in Lake Washington tributaries, the Sammamish River, and Sammamish River tributaries. By the early 2000's, most biologists believed only the Lake Sammamish Late Run remained. Lake Sammamish Early Run kokanee were declared extirpated in 2002, and the effects of urbanization and non-native species introductions were thought to have extirpated the Lake Washington Middle Run as well. Surveys and early genetic studies indicated that the kokanee-like nerka occasionally encountered were actually residual sockeye rather than native or introduced kokanee. Beginning in 2011, and on a three-year cycle since, large numbers of kokanee-like nerka have been observed spawning in the Sammamish River. Notably, these spawning runs peaked well-past the time that sockeye were present. Based on genetic work in collaboration with WDFW, I've found that these late-returning Lake Washington nerka are 1) not residual sockeye; 2) not kokanee introduced from outside the Basin, and 3) genetically distinct from but most closely related to native Lake Sammamish Early and Late Run kokanee. Analysis of otolith microchemistry confirms that Lake Washington kokanee are non-anadromous and were produced by non-anadromous mothers, whereas small nerka that genotype as sockeye (i.e. residual sockeye) were produced by anadromous mothers and show an elevated Sr/Ca ratio at the otolith core. The presence of a non-anadromous, genetically distinct population of kokanee that is most closely related to native Lake Sammamish kokanee indicates that the native Lake Washington Middle Run has survived after all! Remaining knowledge gaps and conservation challenges and strategies will be presented during the session.

Title: Multiple Stressor Effects on Juvenile Salmon in South Lake Washington
Presenter: Kerry Accola, University of Washington WET Lab
Abstract: In 2024, the UW Wetland Ecosystem Team used day and night snorkel surveys to study the influence of artificial light at night (ALAN) and docks on juvenile salmon. In our study, we found few fish along shorelines during the day, and high densities of fish along the shoreline at night. The highest densities of salmon and other fish were in shallow water habitats, which had lower levels of ALAN compared to sites with deeper shoreline habitats (e.g., Boeing, Hyatt). Additionally, 30% of the Chinook we counted at night were in extra shallow pocket habitats, even though these pocket habitats comprised a small portion of the sampling area. In 2026, we will monitor the extra shallow pocket habitats along residential shorelines to see if they are refuge for salmon or predation hotspots, and how their role may change based on residential lighting modifications.

Title: Tracking salmon migrations with an autonomous eDNA sampler
Presenters: Marshal Hoy[1], Austen Thomas[2], Dorothy Chase[1], Ryan Kelly[3], Jean Power[4], and Carl Ostberg[1]
[1]U.S. Geological Survey, Western Fisheries Research Center
[2]Molecular Division, Smith-Root Inc.
[3]University of Washington, School of Marine and Environmental Affairs
[4]King County Environmental Lab
Abstract: Elevated water temperatures, like those seen in the Lake Washington Ship Canal (LWSC) during the summer, can cause stress and mortality in adult salmon and disrupt their migration. For instance, adult Chinook Salmon (*Oncorhynchus tshawytscha*) exhibit prolonged migration delays through the LWSC compared to Sockeye Salmon (*O. nerka*) and Coho Salmon (*O. kisutch*), likely due to a thermal barrier created by warm fresh water and recycling behavior at the Ballard Locks. Delayed migration can lead to depletion of energy reserves, reduced reproductive success, and pre-spawn mortality. Environmental DNA (eDNA) offers a non-invasive method for monitoring migration, but most salmon eDNA surveys rely on discrete manual sampling that limits temporal resolution. Here, we evaluated a prototype autonomous eDNA sampler for fine-scale tracking of adult salmon migrations in the LWSC. The autosampler was deployed approximately 3 km upstream of the Ballard Locks for 4 months during the adult salmon return in 2022 and collected eDNA samples twice daily (day and night) onto self-preserving filter. Species-specific qPCR assays were used to quantify Sockeye, Chinook, and Coho salmon eDNA, and results were compared with daily adult counts at the Ballard Locks fish ladder. eDNA detection lagged visual counts by approximately 5 days for Sockeye and Coho salmon and approximately 25 days for Chinook Salmon, coinciding with freshwater temperatures cooling below 20°C. Autonomous eDNA sampling offers a scalable, efficient approach for monitoring migration timing and holding behavior, providing critical insights as climate-driven warming extends migration delays and increases stress on salmon populations.

Title: Implementation of a stationary hydroacoustic array to monitor outmigration of juvenile salmonids from the Lake Washington Basin
Presenters: Kirsten Simonsen, Alexandra Sawyer and Mickey Agha, Washington Department of Fish and Wildlife

Title: Increasing temperatures magnify the uptake of tire-wear contaminant 6PPD-Q in juvenile coho salmon (*Oncorhynchus kisutch*)
Presenter: Amirah Casey (University of Washington), Nathaniel Scholz (NOAA, retired), Julann Spromberg (NOAA), Denis da Silva (NOAA), Blake Feist (NOAA), Mark Scheuerell (University of Washington, USGS)
Abstract: Urbanization and climate change are two of the greatest threats to freshwater ecosystems. While their isolated impacts are well studied, their combined effects are increasingly concerning. Pacific salmon (*Oncorhynchus* spp.) are culturally, ecologically, and economically important, yet many populations remain threatened despite recovery efforts. Coho salmon (*O. kisutch*) are especially vulnerable to urban stormwater runoff, with pre-spawn die-offs up to 90%. The driver of this mortality syndrome is the globally ubiquitous tire-wear chemical 6PPD-Quinone (6PPD-Q). Additionally, warming surface waters are intensifying physiological stress in salmon. Although both climate change and urbanization independently elevate extinction risk, the interactive effects of temperature and 6PPD-Q

remain poorly understood. To address this, we exposed juvenile coho to environmentally relevant 6PPD-Q concentrations (~50 ng/L) across a temperature gradient (8-14°C). Water chemistry analyses and state-space modeling showed uptake at 12 and 14°C was nearly 50% faster than at 8 and 10°C. Combining these results with future stream temperature projections for Puget Sound, we find juvenile salmon will increasingly face conditions that accelerate 6PPD-Q uptake, even under moderate warming scenarios. By linking contaminant uptake with rising temperatures, our work highlights emerging threats to salmon survival and critical challenges for conservation.

APPENDIX E: Summary of Research Gap Conversations

On the second day of the Lake Washington Basin Science Summit, there were two sessions of break-out group discussions to inform research gaps and future scientific direction. The sessions discussed the primary knowledge gaps related to salmon and the Lake Washington Basin, within the following four categories:

- Salmon population monitoring
- Trophic interactions and predation impacts on native fish
- Exacerbating factors of predation (e.g., artificial light levels)
- Water quality monitoring, contaminants, disease and parasites

In addition, the groups identified ongoing research and examined the uncertainties that need to be resolved to ensure science informs our understanding of how climate change and urbanization are impacting the Lake Washington ecosystem. The primary knowledge gaps are summarized below by category.

A. Salmon Population Monitoring

The effectiveness of management actions on salmon survival

- Research is needed on how habitat restoration affects juvenile survival.
- The predator suppression effect on juvenile survival should be evaluated, noting that the Muckleshoot Indian Tribe plans to monitor the effectiveness of suppression in Lake Sammamish, including smolt survival and adult returns.
- WDFW is conducting hydroacoustic monitoring in the Lake Washington Ship Canal at the Locks to investigate school size and density to extrapolate abundance counts and to evaluate the effectiveness of predator removal efforts over time.

Cedar River Chinook Life Cycle Model

- Life cycle models require life-stage specific metrics, including adult abundance, juvenile outmigrant abundance to measure egg-to-migrant survival, and smolt detections at the Locks to measure parr-to-smolt survival.
- Apparent survival data is available over a time lag of about 4 years with some returning adult detections, though only adult abundance data is technically needed for the life cycle model because we currently have the data to develop it.

WDFW is proposing an Integrated Population Model

- The value of this modeling is to look at the effects on fundamental objectives, such as population growth and viability, and to determine how recovery actions ultimately affect the population.
- The results will help inform survival targets, and WRIA 8 may want to set new near-term targets now that we are past 2025.

Understanding adult recycling behavior at the Locks

- Understanding adult recycling behavior at the Locks is needed, specifically regarding adults returning to Puget Sound after passing through the Locks and how they may return multiple times.
- Earlier tagging studies led by the Muckleshoot Indian Tribe from roughly 2010 to 2016 of sockeye and Chinook showed a lot of recycling behavior in those years, and temperatures have continued to warm, which likely exacerbates the issue and raises questions about what recycling rates are now.
- This recycling behavior has negative implications for prolonged exposure to pinniped predation.
- This behavior has implications for evaluating freshwater survival and pre-spawn mortality.
- This behavior has implications for Locks counting methods.

Lake survivorship of juvenile salmon and adult pre-spawn mortality and en-route mortality

- There are observations but no consistent data regarding lake survivorship of juvenile salmon, adult pre-spawn mortality, and en-route mortality.
- It is very difficult to monitor mortality in the lake or Ship Canal, leaving it unknown if significant numbers are dying and if carcasses are sinking to the bottom of the lake or Canal without being detected.
- Research is needed on how many salmon enter the lake, how many leave, and when they die.
- Management must determine how to minimize juvenile salmon mortality in the lake phase, balancing the time needed for juvenile growth versus expediting the lake phase to reduce mortality.
- Counting numbers of salmon entering the Ship Canal at the Montlake Cut and comparing Cedar River entry versus Lake Sammamish entry is needed to see how many fish get lost to the lake environment.
- The Sammamish River is an important habitat.

Evaluation of hatchery programs and adaptive approaches

- Spawn timing and extended rearing for sockeye require evaluation.
- Monitoring is needed to see how these hatchery practices ultimately impact the population in terms of adult abundance.
- The timing of sockeye hatchery spawning changes each year, making releases now more of a continuum.
- BLAST fish spawning is more spread out, and the timing of releases is getting later, which approaches periods with more predator activity as temperatures warm.

Improving PIT tagging system and detection rates

- Improving the PIT tagging system and detection rates is necessary, though it is difficult to position antennas in the Ship Canal due to navigation limitations on infrastructure.
- PIT tagging is cheaper than acoustics and provides good coverage.
- WDFW targets about 3,000 Chinook tagged, which means a lot of fish are needed given current survival rates and detection efficiency.
- The relationship between survival and detection needs exploration to determine if the path salmon take, which influences whether or not they are detected, is related to survival.
- Additional detection points are needed to improve modeling.
- A new antenna in the forebay helps, but not all fish detected at the forebay are detected again at the flumes or ladder, which may help answer questions about survival depending on the path taken through the Locks.
- There remains a critical need to mark a lot of fish to understand survival *through* the Locks.
- Resources are being invested in efforts to understand survival to the Locks, but not through the Locks and in Shilshole Bay.
- It is assumed that juveniles are at such low levels that density dependence is not affecting survival, but this impact is currently unknown.

Residualization

- A gap exists on how many Chinook and sockeye are residualizing in Lake Washington and trend over time. Related questions include:
- What factors drive the residualization of salmon (e.g., warming Ship Canal temperatures potentially prevent outmigration later in the season)?
- Dietary differentiation between residual sockeye and kokanee?
- There are two genetically distinct populations (residual sockeye and native kokanee)
- How many sockeye coming into Lake Washington are becoming residualized?

B. Trophic Interactions & Predation Impacts on Native Fish

In general, expand monitoring across both lakes and the Ship Canal for comparative insights.

Salmonid Diets and Trophic Interactions

- A study on the bioenergetics of Chinook and sockeye in Lake Washington is needed to help determine whether focus should be more on bottom-up or top-down.
- Bioenergetics modeling of Chinook in Lake Washington should investigate what is known about their needs and how motivated they are by feeding.
- Information is needed on what we know about other, non-plankton food sources like macroinvertebrates and insects, their role in supporting salmonids in the lake, and

whether we can support non-planktonic Chinook prey to help support these salmon populations.

Phytoplankton, zooplankton, and water quality:

- Improve integration across datasets to understand how these are interrelated and affect the greater food web and salmon survival.
- Management should model zooplankton variability with time and temperature, including determining if vertical migration patterns are happening.
- Correlations or modeled relationships should be explored between and among water quality, plankton, and fish communities by looking across existing datasets.
- There is interest in using remote sensing, specifically Polarized Light satellites, to model plankton seasonality, abundance, and distribution.
- Research should determine if there are changes in the phytoplankton community that could be affecting the food web, and if zooplankton vertical migration is increasing in some parts of the lake, what the impact is on the food web.
- Chlorophyll declines raise questions about shifts in phytoplankton composition and downstream effects on zooplankton and fish.
- Plankton should be measured to model fish presence probability, noting that PACE and NASA launched a satellite that measures polarized light which can be used to measure plankton.

Neomysis (Mysids) in the Food Web

- General information is needed on neomysid abundance and population trends, as no long-term mysid monitoring exists.
- A better understanding of related trophic interactions and fish competition is required, as neomysid abundance could be related to competition between longfin smelt and salmonids.
- Longfin smelt eat approximately 80% neomysis when available, reducing pressure on daphnia since mysids eat daphnia, meaning smelt predation on mysids could indirectly benefit sockeye by freeing up daphnia since sockeye prefer daphnia but may shift to neomysis as they grow.
- It is unclear whether boom-bust mysid cycles correspond with longfin smelt populations.
- Longfin smelt experience even/odd year boom/bust cycles, with smaller size classes in one year feeding on daphnia and larger size classes the next year feeding on neomysis.
- There is limited longfin smelt data in Lake Washington, they are not known to exist in Lake Sammamish, and more information is needed on the longfin smelt population size in Lake Washington.
- Kokanee interactions with mysid–smelt–sockeye dynamics remain uncertain and it is unknown if they are the same or different than sockeye.

Predation related to invasive species: Resident shad

- Invasive resident shad have recently come into Lake Washington and have established landlocked populations, requiring a focus on their population-level impacts on the lake ecosystem before connecting those impacts to sockeye and other salmonids.
- The potential for a shad fishery should be considered if implemented by the Muckleshoot Indian Tribe.
- Many unknowns exist for shad, including their spawning locations, juvenile distribution, and potential competition with salmon.
- Shad distribution in the water column and their overlap with neomysis is unknown, and a major concern is zooplankton depletion and food-web disruption if populations get big enough.
- The landlocked shad population in Lake Washington may alter seasonal energy pathways.
- Longfin smelt population estimates and locations need to be related to invasive shad to see how this would buffer predation on salmon.

Unknowns related to other invasive species:

- Research should investigate unknowns surrounding Asian clams.
- Monitoring is needed for rock bass, which are established in Lake Washington and could potentially spread to Lake Sammamish.

Piscivorous Predators on Salmon (Non-Pinniped)

- Chinook interact with both littoral and pelagic zones, making them a prey item for many piscivorous species.
- The major predators of juvenile Chinook are yellow perch, smallmouth bass, cutthroat trout, rock bass, and crappie.
- Perch populations are extremely large, with group hunting observed, and small-bodied predators like yellow perch, bass, and crappie can heavily impact fry.
- Predator population-level estimates must be expanded, focusing on habitat and predation hotspots.
- Research should determine what is driving predation hotspots, such as physical restrictions, light, and temperature.
- Forced perturbations, such as studying the impact of predator removals, should be conducted to study the impact in a specified area like hotspots or lake segments that are distinctly different.
- Removal efficacy studies should consider if removals affect predator population shifts.

- Predators on juvenile sockeye and kokanee include cutthroat trout, Northern Pikeminnow, and maybe smallmouth bass once sockeye disperse offshore, though cutthroat and black crappie seem to be more significant.
- A better sense of major juvenile sockeye predators is needed, noting that while research may focus on hotspots like the lower river and its confluence with the lake, sockeye are more widely distributed in the lake, which presents a monitoring challenge.
- The Northern Pikeminnow population number is highly debated, but it seems to be less than previously assumed, indicating a need to reassess population numbers.
- A gap exists regarding Northern Pikeminnow habitat use, movement, and where they go when cleared out of an area.
- If Northern Pikeminnow are not the main predator, research needs to identify what is eating juvenile sockeye.
- Juvenile predation is a major bottleneck, and the residualization of other salmon may play a role.
- Better abundance indices are needed for predators.
- Larger kokanee released are returning double the amount of smaller kokanee released, which could be a gape-size override or could reinforce that predation is an issue, though it could also be natural mortality.

Pinniped Predation

- Pinniped predation rates must be quantified to determine how many adults and juvenile salmon are consumed, and how many salmon are wounded, which leads to stress, poor health, and potentially eventual mortality.
- Abundance estimates are needed for the pinniped population proximate to the Ship Canal when fish are present.
- Good abundance estimates regarding the number of individual seals using the locks are needed to help support evaluating potential removal efforts.
- Research should determine how many individuals are consuming the majority of the salmon, and spot patterning of seals can help with identifying these primary individuals.
- If protected terminal area management or other protection actions are implemented, ways to support targeted approaches and study the impact to target prey species of concern should be explored.
- Research should identify what type of habitat is helping pinnipeds thrive.
- Behavioral unknowns include whether seals are teaching pups to eat salmon as their main foraging strategy.

Bird Predation

- Bird predators include mergansers, cormorants, mallards which cause redd disturbance, and herons, especially under artificial lighting.

- There are lots of tags found under the heron rookery just downstream of the Locks.
- High uncertainty exists around bird predation on salmonids in the river, locks, and in the lake regarding which species are preying, to what extent, and where.
- Studies could isolate the potential role of specific habitat or human infrastructure in facilitating bird predation.
- Piscivorous birds should be mapped using a combination of surveys and citizen science e-bird data, and then paired with scat to look at which birds are eating what salmonids by considering Audubon data and using the WDFW approach for marine mammal scat analysis.
- A better assessment of bird predation on juvenile Chinook is needed using maps of piscivorous birds around Lake Washington, pairing eDNA of scat with citizen science e-bird counts of significant bird populations.
- Research should determine what fraction of predation is attributed to birds compared to non-native fish predators.
- Further investigation is needed on Great Blue Heron predation and its relationships with dock lighting and hunting.

River Predation

- River predation is often overlooked relative to lake predation.
- Low river flows increase salmon vulnerability to predation.
- New river predators include perch, coho, bass, and sculpin.

Kokanee-Specific Notes

- Extended rearing strategies for kokanee show higher adult returns.
- A key question for kokanee is whether removals can target predators at sizes that meaningfully reduce fry mortality, noting that most gillnetting has mesh sizes that only catch very large predators, which is not helpful for smaller fish that are consuming large numbers of fry.
- There is no clear ecological response to predator removals yet.

Predator population & consumption uncertainties

- Uncertainties in predator populations and consumption include total sculpin abundance.
- Reliable population estimates are needed for all predators.
- Consumption rates across species remain an unknown gap.
- Seasonal habitat overlap needs to be understood, especially between perch and juvenile Chinook.
- Habitat complexity, including weeds and temperature preferences, shapes predator distribution and timing, which creates a need for more data.

Predation management

- Predation management should focus removals at hotspots like tributary mouths, such as the lower Cedar River, where velocity shifts concentrate predators.
- Sockeye should be allowed to disperse into the lake to reduce nearshore predation risk.
- Microcosm experiments are needed to get a better handle on adaptive management strategies for sockeye, such as the rearing and release size needed to override predation.
- Perch removal studies and ongoing tribal work may inform Lake Washington strategies.
- Past removals shifted predator composition, such as an increase in largemouth bass after smallmouth bass removal in Lake Sammamish.
- Monitoring must coincide with mitigation efforts to assess ecological response and efficacy.
- Winter mid-lake predation on sockeye is low, meaning predation likely occurs earlier seasonally.
- It is essential to quantify the survival benefits resulting from mitigation efforts like predator removals or hotspot management.

Climate & urbanization interactions

- Key climate and urbanization variables to monitor include the length and intensity of warm seasons, the timing of storm seasons and lake turnover, and spring bloom timing relative to zooplankton and fish phenology.
- Integrated, cross-pillar modeling is needed to link phytoplankton, zooplankton, fish, water quality, vegetation, temperature, disease, and invasive species.
- Invasive-species monitoring must better understand relationships with climate change impacts like heat, storms, seasonal variability, and the timing and degree of lake turnover.
- Modeling to synthesize physical data with biological data could help us better understand potential linkages.
- Investigating the relationship between increasing temperatures and changes to related habitat and supported fish species assemblages is needed, including bioenergetic work to estimate changes in predation on salmonids with warming.
- Environmental factors like flow rates and depth throughout the lake should be investigated to see what areas are going to be most susceptible to climate changes, noting that background fish at the locks will wait out high temperature seasons and become easy prey for pinnipeds.

C. Exacerbating Factors of Predation (e.g., artificial light levels)

General Gaps and Challenges

- There is a general lack of existing research regarding the exacerbating factors of predation.
- The use of different types of sensors makes it hard to compare results across studies.
- Current research is very site-specific and is not scaled to the watershed.

Environmental Conditions and Impacts on Predation

- More research is needed on whether shadowed areas and shadow lines created by structures serve as ambush sites for predators.
- Empirical in situ predation studies are needed in shallow environments to determine if they function as hotspots for predation or as refuges, and to study how manipulating lighting impacts predation outcomes.
- The effect of shoreline softening on predation rates needs to be evaluated.
- Research should determine the characteristics of predation hotspots, such as temperature, structures, and light levels, including temperature-mediated hotspots like the mouth of the Cedar River and thermal barriers.
- The threshold of light reduction needed in the Ship Canal to significantly improve salmon survival related to predation associated with artificial light at night (ALAN) must be determined.

Research on Predators

- Primary predator species abundance in Lake Washington needs to be established alongside research on their diets, the timing of diet composition, size distribution, and predator population modeling, particularly for yellow perch.
- Nighttime predation rates need to be quantified.

Research on ALAN and Zooplankton

- The effects of ALAN on zooplankton must be researched, including whether it affects the vertical migration and depth distribution of zooplankton.
- The effect of shad preying on zooplankton needs to be integrated into these light and predation studies.

Invasive Aquatic Vegetation in Lake Sammamish.

- A better understanding of invasive aquatic vegetation impacts from key species in Lake Sammamish, such as milfoil, elodea, water lilies, watercress, and canary grass, is needed to minimize them with management actions.
- The dissolved oxygen squeeze in Lake Sammamish is worsening with warming temperatures and higher fish biomass.
- Hydroacoustic surveys should be used to determine fish distributions.

Docks & Light Attenuation

- Research is interested in how docks create ambush habitat for predators by reducing light penetration, and whether docks or ALAN increase otter predation opportunities, creating a need for more data linking dock shading to predator behavior.
- The Washington administrative code requires new docks to allow 60% light penetration.

Sammamish Slough

- There is a knowledge gap on predation rates at the Sammamish Slough, which is a shallow, warm, and bright site with little riparian cover, making it necessary to determine if predation is high here as part of the larger question of where fish are dying in the watershed.
- Restored versus unrestored reaches of the slough should be compared.
- The slough requires salmon population monitoring alongside data collection on temperature, survivorship, predator counts, GIS land-use, MK9 data, toxins, disease, parasites, and phytoplankton.

Management

- Management must determine whether resources should target diffuse residential light or high-impact hotspots like Boeing, noting that centralized actors like SDOT may be easier to influence than thousands of homeowners.
- There is a lack of literature on the ecological impacts of property owner weed removal, noting that patchy removal may worsen ecological conditions and that achieving moderate vegetation densities via broad mitigation efforts may be preferable.

Compensatory Predation

- Management should evaluate compensation and density-dependent effects to determine where and how compensatory predation exists.

D. Water Quality Monitoring, Contaminants, Disease and Parasites

WATER QUALITY

- Research must address how climate change affects the temperature of the surface water entering the Ship Canal from Lake Washington, potentially using a forecasting projection model.

Temperature

- Temperature effects on the Chinook recycling rate in the Ship Canal should be investigated to see if there is a temperature threshold where fish turn around,

considering existing research on thermal migration barriers and thresholds by Tom Quinn and Kurt Fresh.
- Research is needed on how fish behavior, including recycling behavior, is impacted by changes in temperature and other aspects of water quality.

Ship Canal and Ballard Locks

- Salinity dynamics need study to determine how saltwater intrusion affects the Ship Canal and Lake Union.
- The impact of withdrawing cold water for the Ship Canal must be evaluated to see if there are long-term effects of removing cold water from Lake Washington.
- Research should determine how Locks operations affect water quality in Lake Washington.

Management and Restoration Effectiveness

- Management needs to better understand which restoration and management strategies have been effective at improving water quality and what the underlying mechanisms are.

CONTAMINANTS

6PPDQ

- Investigating how 6PPD-quinone and other stormwater contaminants alter disease susceptibility in fish is required.
- There is a need for research on sublethal endpoints because fish are migrating back in urban streams and reside in contaminated streams before migration.
- Research is needed on stormwater Best Management Practices (BMP) effectiveness regarding the removal of 6PPD-q to see if existing BMPs are effective.
- Unknowns in detecting 6PPD-q exposure include identifying the metabolites and determining which of them could serve as biomarkers or the cause of toxicity.

Contaminants of Emerging Concern

- Additional research is needed on how contaminants of emerging concern, including pharmaceuticals, cosmetics, and microplastics, impact native fish, referencing the prioritization publication by James et al. (2023).

Other Contaminant Research Gaps

- Primary contaminants in native fish in the Lake Washington Basin must be identified to see if they vary by region and to determine the overall extent of contamination.
- Chemical concentration thresholds must be investigated for both sublethal effects and mortality in native fish populations.

- Research should determine if the effects of chemicals change under different water quality conditions, such as different temperatures or dissolved oxygen levels, and if there are synergistic impacts of contaminants, elevated temperatures, and other stressors like disease.
- A Chinook life cycle model should be utilized to see how contaminants affect the recovery of salmonids.
- The extent of exposure, accumulation, primary types, and population-level impacts of contaminants on juvenile Chinook must be evaluated.

DISEASE

Sources, Environmental Reservoirs and Intermediate Hosts

- The primary environmental reservoirs of fish disease in the Lake Washington Basin must be identified, including finding the definitive hosts for myxozoans to understand where infections are happening.
- An improved understanding of the types and distribution of intermediate hosts is needed to manage fish diseases.

Fish Health and Disease Vulnerability

- Research should determine if different environmental conditions predispose salmonids to disease.
- The ability to perform rapid fish health assessments is needed.
- Mortality throughout the spawning season and indices of disease severity for conditions like Columnaris, furunculosis, and copepods represent clear data gaps.

Bacterial Pathogens

- The location of bacterial pathogens in the ecosystem must be determined.
- Research needs to track how bacterial presence and severity increase with rising water temperatures, specifically for Columnaris.

Ceratonova shasta

- The distribution and source of different *Ceratonova shasta* genotypes remain unknown, which would be helpful to know for management.

Sockeye Specific Sampling

- Sockeye sampling should be expanded to determine hotspots of where fish are exposed to infections, distinguishing between the Ship Canal and the Cedar River.
- Water sampling is needed deeper in the water column where sockeye are located to inform release locations and overall management strategies.

- Research should determine if sockeye salmon are able to shed infections as smolts, or if smolts are just not affected and return as uninfected adults, and whether infection affects smoltification.

Overarching Disease and Management Approaches

- Wider surveys of the lakes and rivers in the Basin are needed across all salmonid species to capture all pathogens and improve management strategies.
- Research gaps exist regarding the best strategies for the management of diseases in native fish.

APPENDIX F: WRIA 8 Chinook Research and Data Needs and Monitoring and Assessment Priorities

The following research and data needs are taken from the *Lake Washington/Cedar/ Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan 10-year Update* (2017). In 2015, WRIA 8 hosted a technical forum assembling fisheries scientists and technical experts on salmon recovery in the watershed. Participants proposed the following priority level rankings of limiting factors to recovery. These constitute an outline for a prioritized list of research and data needs to advance recovery and support implementation of the 2017 Plan

First-tier priorities:

1. Ballard Locks and Ship Canal operations –What are feasible solutions to improve conditions related to high temperature, low dissolved oxygen, and concomitant decreased resistance of salmonids to disease/parasites?
2. Rearing and refuge – What are the effects of a lack of woody debris and floodplain connectivity (levees, revetments) and other features of adequate instream rearing habitat?
3. Lake survival – What are the effects of artificial light and predation in Lake Washington, Lake Sammamish, and the Ship Canal (predation in Ship Canal may be a key limiting factor)?
4. High water temperature – What are the effects of high water temperature in the Ship Canal and Sammamish River?

Other important priorities:

5. Water quality – What are the effects of stormwater on Chinook salmon, including toxic loading of chemicals and contaminants? Are current stormwater regulations and treatment standards adequate? How can the pace of retrofits be increased?
6. Streamflow – What are the effects of low summer flows and “flashy” winter flows?
7. Invasive aquatic vegetation – What are the effects of invasive aquatic vegetation on salmon migration and survival?

Other limiting factors with potentially large impacts:

8. Piers and docks – What are the effects of overwater structures on salmon migration and survival?
9. Genetic introgression or other issues related to hatchery operations – What are the effects of hatcheries on the genetic fitness of natural origin salmon?

In addition, the WRIA 8 TC identified the following critical monitoring needs to track indicators associated with key recovery goals. Juvenile outmigrant trapping and adult spawner surveys are currently funded in part by competitive grants; other critical monitoring needs are unfunded.

10. Juvenile outmigrant trapping
11. Adult spawner surveys
12. Wood volume surveys on all Tier 1 and Tier 2 streams
13. Lakeshore surveys: length of natural bank profile, bulkheads, overwater structures
14. Remote sensing: high-resolution land cover mapping of forest cover and impervious surfaces
15. Assessment of accessibility and habitat quality of pocket estuaries and coastal streams entering Puget Sound Monitoring needs are outlined in more detail in the Monitoring and Assessment Plan, Appendix A.

2026 Monitoring and Assessment Priorities

In addition to Research and Data Gaps from 2017, WRIA 8 annually updates Monitoring and Assessment Priorities for the King County Flood Control District's Cooperative Watershed Management (CWM) grant program and other funding opportunities focused on monitoring priorities, noted below.

A. Salmon Population Status, Habitat Use, and Survival

Evaluate Chinook populations over time and in priority systems, including assessments of survival bottlenecks. Monitoring needs include:

1. Spawner surveys on Chinook bearing systems, prioritizing the Cedar River.
2. Expand or improve the network of PIT tagging and tag detection antennas to improve annual estimates of freshwater survival and help identify locations of high juvenile mortality during outmigration.
3. Enhance monitoring of juvenile passage (e.g. using acoustic tagging technology) in and around the Ballard Locks and smolt passage flumes. Assess potential delayed juvenile mortality following outmigration through the Ballard Locks.
4. Investigate the discrepancy between adult Chinook counts at the Ballard Locks and spawner counts to improve monitoring practices and our understanding of adult freshwater survival.
5. Develop a life cycle model for WRIA 8 Chinook to evaluate which stages and habitats are most limiting and weigh the effects of restoration and management actions on recovery.

B. Impacts and Mitigation of Poor Water Quality and Disease on Salmon Health and Survival

Evaluate impacts from and interactions between high temperatures, low dissolved oxygen, disease, and contaminants. Evaluation should inform potential mitigation of the impacts identified. Monitoring needs include:

1. Build off ongoing work of the Lake Washington Ship Canal Roundtable to identify and evaluate solutions that reduce impacts of high temperatures and low dissolved oxygen conditions on salmon in the Lake Washington Ship Canal.

2. Evaluate salmon behavioral response to warm temperatures in the Ship Canal and response to potential solutions to mediate temperature impacts.
3. Evaluate opportunities in the Sammamish River to reduce or eliminate thermal barriers, create cool water refugia, and enhance or protect existing groundwater resources.
4. Evaluate the thermal influence and migration impacts of invasive aquatic vegetation in the Sammamish River to inform management strategies.
5. Assess parasite-related disease magnitude and extent in WRIA 8 Chinook populations.

C. Impacts and Mitigation of Predation Risk

Develop, evaluate, and monitor mitigation strategies to reduce impacts of predators on juvenile salmon in priority areas, including south Lake Washington, south Lake Sammamish, and the Lake Washington Ship Canal. Monitoring needs include:

1. Evaluate the magnitude of impact native and non-native piscivores have on juvenile Chinook survival. Improve understanding of how predators are distributed and where impacts are greatest, particularly where limited information is available, for example the lower Cedar River, lower Issaquah Creek, and Sammamish River.
2. Evaluate effectiveness of fish removal efforts at reducing predation rates and increasing juvenile survival.
3. Investigate the role of lake nearshore habitat conditions on predator assemblages or predation efficiency to inform management strategies, such as removal of invasive aquatic vegetation, shoreline habitat restoration, and predator suppression.
4. Evaluate strategies to reduce artificial light at night (ALAN) impacts on salmon behavior, health, and predation risk. This could include alternative lighting technologies or approaches to encourage public behavior change.
5. Evaluate strategies to reduce impacts of pinniped predation on adult and juvenile salmon at the Ballard Locks focusing on actions recommended at the 2023 Technical Workshop on Pinniped Predation on Salmon at the Ballard Locks.

D. Project Effectiveness and Monitoring to Support WRIA 8 Habitat Goals

Evaluate whether restoration projects or approaches achieve their intended outcomes for salmon and their habitats, especially when a novel approach is used or when outcomes are uncertain or not well understood. Monitoring needs include:

1. Conduct an opportunity analysis to support the WRIA 8 goal to increase natural lake edge habitats south of Interstate 90 (I-90) in Lake Washington and throughout Lake Sammamish to support juvenile Chinook rearing and migration.
2. Test the effects of different restoration techniques on water temperature and dissolved oxygen to identify effective practices and advance efforts to mitigate poor water quality.
3. Evaluate use of constructed large wood features by juvenile Chinook salmon and other juvenile salmonids. Do certain types of large wood structures provide better salmonid rearing habitat than others?

4. Evaluate the influence of Cedar River main-channel and off-channel habitat types on invertebrate prey availability and juvenile Chinook growth potential to inform salmon habitat restoration planning and design.

APPENDIX G: Contact List

Name	Email	Current Focal Areas	Instrumentation Expertise	Topics of Interest for Future Collaborations
Alison Agness	aagness@kingcounty.gov	Population Monitoring, Communications, Urban Landscape Influences, Conservation Hatchery		salmon recovery strategies that benefit multiple species / address common limiting factors
Andrea Carey	andrea.carey@dfw.wa.gov	Water Quality		
Arielle Tonus Ellis	ate89@uw.edu	Food Web Interactions, Climate Change Impacts, Predation, Zooplankton, Invasives	The Clark Bumpus!	Zooplankton trophic interactions (fish and non fish) maybe a project pairing fish catch and zoops specifically. Impacts of nonnative fish (e.g. American shad) Neomysis in the Lake Washington basin. Role in the food web. Diel migration of zoops and ALAN. (They may or may not depending on site) Connectivity of Lake Sammamish with Lake Washington. (Biological.Fish inverts etc or chemistry etc) Parasites (C.shata/p.mini) and their distribution/trophic interactions/if related to epibenthic animals. (I just find it fascinating) Toxins (e.g. 6pptq) and if there is transfer via zooplankton in the basin? Zooplankton in Chester moris reservoir (when was the last study
Arni H Litt	arni@uw.edu	Water Quality, Food Web Interactions, Zooplankton, Invasives		
Ava Fuller	ava.fuller@muckleshoot.nsn.us			
Bethany Scoggins	Bethany.Scoggins@dfw.wa.gov	Riparian Habitats		
Bosworth Aaron	Aaron.bosworth@dfw.wa.gov	Population Monitoring, Predation		
Brianna Pierce	Bpierce@bellevuewa.gov	Population Monitoring, Water Quality, Urban		Stream health monitoring, data integration/visualization

		Landscape Influences, Riparian Habitats		
Candice Powers	cpowers@contractor.usgs.gov	Food Web Interactions, Predation, Zooplankton, Life History Strategies	light meter knowledge (C-OPS, SQM, Mk9), gillnetting, fish husbandry	
Carol Volk	carol.volk@seattle.gov	Parasitism and Disease, Population Monitoring, Water Quality, Urban Landscape Influences, Riparian Habitats, Lake Washington, Cedar River		sockeye population dynamics, disease monitoring, changes/conditions in Lake Washington, artificial lighting at night, habitat restoration opportunities
Chelsea Mitchell	chemitchell@kingcounty.gov	Water Quality, Urban Landscape Influences, ecotoxicology		6PPDQ monitoring
Chloe Pak	chloeepak@gmail.com	Population Monitoring, Communications, Food Web Interactions, Predation, Zooplankton, Urban Landscape Influences, Artificial Light at Night	zooplankton/insect quantification/ID/measuring, zooplankton (daphnia) culturing, scale mounting/pressing for age analysis, zooplankton field sampling, boat- and land-based light measurement (ALAN), certified boat driver	Visual + movement ecology, anthropogenic impacts to the lake(s) and intersections with local (human) communities, fish/invert taxonomy, trophic interactions, disease, also interested in graphic design/illustration/science communication opportunities!
Christa Heller	christa.heller@seattle.gov			
Cleo Neculae	Cleo.neculae@ecy.wa.gov	Water Quality, Food Web Interactions, Climate Change Impacts, Urban Landscape Influences, Riparian Habitats		Lake Washington Ship Canal water temperature, toxics in Lake Washington and the Ship Canal
Daniel Nidzgoraki	daniel.nidzgorski@kingcounty.gov	Water Quality, Urban Landscape Influences		
Daniel Schindler	deschind@uw.edu	Population Monitoring, Water Quality, Food Web Interactions, Climate Change		

		Impacts, Predation, Zooplankton, Life History Strategies		
Danielle Devier	danielle.devier@seattle.gov	Urban Landscape Influences, Riparian Habitats, Lakeshore restoration		Shoreline restoration projects
David Kyle	Dkyle@tu.org	Parasitism and Disease, Population Monitoring, Water Quality, Communications, Predation, Zooplankton, Invasives		Aquatic weeds and Disease
Emily Jameson	ejameson@uw.edu	Population Monitoring, Communications, Food Web Interactions, Predation, Invasives		Quantifying impacts of nonnative predators on juvenile salmonids
Eric Warner	Eric.Warner@Muckleshoot.nsn.us	Population Monitoring, Food Web Interactions, Predation, Invasives, Urban Landscape Influences		
Evan Russell	evan.russell@co.snohomish.wa.us	Riparian Habitats, River and Stream morphology, Hydraulics & Hydrology		
Frieda B. Taub	taub@uw.edu	Water Quality, Food Web Interactions, Predation, Zooplankton	Closed Ecological Systems including Space Life Support Systems	Nutrient Phytoplankton Grazer interactions and Predation
Ian Anderson	ian.anderson@dfw.wa.gov	Population Monitoring, Life History Strategies	PIT telemetry and antenna technology	Juvenile salmonid outmigration timing and survival and its connection to salmon predators in lake, hatchery release strategies
Jason Toft	tofty@uw.edu	Food Web Interactions, Predation, Urban Landscape Influences		
Jeff Duda	Jduda@usgs.gov	Food Web Interactions, Predation, Restoration monitoring	eDNA	Quantifying the extent and levels of bird predation on juvenile salmon using eDNA
Jeffrey S. Jensen	jsjensen@uw.edu	Population Monitoring, Life History Strategies,	Drone surveys; starting to use machine learning	Population structure of nerka; salmon supplementation and restoration,

		Genetic population structure		particularly in North Lake Washington and Sammamish tribs.
Jennifer Schulien	jennifer@schulcon.com	Water Quality, Food Web Interactions, Climate Change Impacts, Predation, Zooplankton, Urban Landscape Influences		
Jesse Dykstra	Jesse.dykstra@dfw.wa.gov	Parasitism and Disease, Population Monitoring, Water Quality, Communications, Climate Change Impacts, Predation, Invasives, Riparian Habitats		What can be done about the ship canal?? Seems to be the problem for every salmon population in this watershed.
Jillian Howard	jillian.howard@muckleshoot.nsn.us	Parasitism and Disease, Population Monitoring, Predation, Invasives	PIT tags for capture-recapture	Invasive piscivore population monitoring and ecology, parasite communities of largemouth bass
Jim Bower	james.bower@kingcounty.gov	Parasitism and Disease, Population Monitoring, Water Quality, Food Web Interactions, Predation, Zooplankton, Life History Strategies, Invasives		
John Hansen	jhansen@usgs.gov	Parasitism and Disease, Water Quality	Salmonid in vitro screening platform for contaminants of concern	Water quality, contaminants
Joseph P Short	joseph.short@dfw.wa.gov	Parasitism and Disease, Population Monitoring, Predation, Invasives	Ops planning. Netting projects. boats. Fishing gear.	Monitoring and predation
Kaelie Spencer	Kspencer@lltk.org	Communications, Climate Change Impacts, Predation		
Katey Queen	katey.queen@tu.org	Water Quality, Food Web Interactions, Climate Change Impacts, Zooplankton, Riparian Habitats		

Kerry Accola	kaccola@uw.edu	Predation, Urban Landscape Influences	DIDSON (acoustic camera)	Predation, ALAN, bioenergetics
Kirsten Vacura	kirsten.vacura@muckleshoot.nsn.us	Population Monitoring, Predation, Invasives		
Lisa Wetzel	lwetzel@usgs.gov	Population Monitoring, Food Web Interactions, Zooplankton, Life History Strategies, Invasives		Monitoring of shad, mysids and zooplankton
Liz Allyn	liz@coastsalmonpartnership.org	Predation		Pinniped management & predation
Lucas Hall	Lhall@lltk.org	Water Quality, Communications, Climate Change Impacts, Predation, Urban Landscape Influences		
Luke Skowronek	Luke.Skowronek@dfw.wa.gov	Urban Landscape Influences, Riparian Habitats		Water quality, plankton, riparian areas
Madi Norton	Madisen.norton@seattle.gov	Communications		
Maria McNaughton	Maria.Mcnaughton@dfw.wa.gov	Riparian Habitats		
Mark Celedonia	mark.celedonia@celedoniaenv.com	Climate Change Impacts, Urban Landscape Influences, artificial light at night; Chinook smolt movement/habitat use in Lake WA & the ship Canal; overwater structures; passage behavior at Ballard Locks		artificial light at night; Chinook smolt movement/habitat use in Lake WA & the Ship Canal; overwater structures; passage behavior at Ballard Locks
Mark Scheuerell	scheuerl@uw.edu	Population Monitoring, Food Web Interactions, Climate Change Impacts, Predation, Life History Strategies, Invasives, Urban Landscape Influences	Data analysis/synthesis	

Marshal Hoy	Mhoy@usgs.gov	Food Web Interactions, Invasives, eDNA	eDNA sampling and analysis	
Mary Ramirez	Mramirez@kingcounty.gov	Population Monitoring, Technical coordination throughout the watershed		Technical coordination throughout the watershed (facilitate and manage the W8 Technical Committee)
Michelle Green	Migreen@kingcounty.gov			
Mickey Agha	mickey.agha@dfw.wa.gov	Population Monitoring, Predation	Hydroacoustic Monitoring	Juvenile fry to smolt survival
Mike Mahovlich	mike@muckleshoot.nsn.us	Parasitism and Disease, Population Monitoring, Predation		
Nandita Kohli	nkohli@usgs.gov	Communications	Photography equipment	communications related, data visualizations
Neala Kendall	neala.kendall1@dfw.wa.gov	Population Monitoring, Life History Strategies	life-cycle models, integrated population models	life-cycle models
Nicole Doran	ncdoran@uw.edu	Climate Change Impacts, Predation, Invasives		Lake Sammamish kokanee, and predation by invasive piscivores
Piper Hanson	Piper@midsoundfisheries.org	Communications, Invasives, Urban Landscape Influences, Riparian Habitats, Artificial Light at Night		Residential involvement in improving lake health through outreach, communications, community science
Rachael Gravon	rachael.gravon@kingcounty.gov	Water Quality, Food Web Interactions, Climate Change Impacts, Zooplankton, Urban Landscape Influences		
Rebekah Stiling	rstiling@kingcounty.gov	Water Quality, Urban Landscape Influences, Riparian Habitats	Benthic Index of Biological Integrity (B-IBI)	
Regan McNatt	regan_mcnatt@fws.gov	Food Web Interactions, Predation, Life History Strategies, Invasives, Urban Landscape Influences	predation event recorders	Chinook survival through the basin and the Ship Canal, predation risk in lower Cedar and Sammamish Rivers

Rich Sheibley	sheibley@usgs.gov	Water Quality		6ppd-q and other water quality monitoring
Robert (Wes) Flynn	RobertWesley.Flynn@dfw.wa.gov	Water Quality, Food Web Interactions, Urban Landscape Influences, Environmental Contaminants		
Robert Plotnikoff	robert.plotnikoff@snoco.org	Population Monitoring, Water Quality, Invasives, Urban Landscape Influences, Riparian Habitats		
Ryan Lewis	ryan.lewis@snoqualmietribe.us	Population Monitoring, Predation, Invasives, Urban Landscape Influences, Riparian Habitats	Amphibian monitoring techniques	
Sandra O'Neill	sandra.o'neill@dfw.wa.gov	Water Quality, Parasitism and Disease, Population Monitoring, Food Web Interactions, Life History Strategies, Urban Landscape Influences, Contaminants		
Sarah Converse	sconver@uw.edu	Population Modeling		
Shelley Johnson	rachellejohnson@usgs.gov	Food Web Interactions, Predation	Field: Hydroacoustic equipment, mid-water trawling, gillnetting, lampara and beach seining; Lab: wetlab with experimental capacity and temperature control, bomb calorimeter, fish age and growth analysis, bioenergetics analysis	Predation, lake food web, juvenile salmon survival, bioenergetics, climate change, invasive species

Tessa Code	Tcode@usgs.gov	Food Web Interactions, Predation, Urban Landscape Influences, Artificial Light at Night	Light sensors, hydroacoustic equipment, mid water trawling	Lake phase survivorship, predation, migration success/predation in the ship canal
Tiffany Armstrong	tiffany.armstrong@muckleshoot.nsn.us	Population Monitoring, Predation, Life History Strategies, Invasives		
Tim Kuzan	timothy.kuzan@dfw.wa.gov	Parasitism and Disease	Sample collection for diagnostic techniques, pathogen identification and clinical sign	Causes of mortality, survey of pathogens, investigations of abnormal mortality
Tom Hardy	twhardy@redmond.gov	Water Quality, Communications, Climate Change Impacts, Invasives, Urban Landscape Influences, Riparian Habitats, Restoration project implementation		Project effectiveness monitoring, thermal refuge, predatory fish