SALISH SEA

MARINE SURVIVAL PROJECT

SYMPOSIUM REPORT 2025

MARCH 11-13

WA-BC CHAPTER AFS MEETING :: VANCOUVER, B.C., CANADA

LONG LIVE THE KINGS

PACIFIC SALMON FOUNDATION

Symposium Organizers & Moderators

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Symposium Abstract

This symposium will focus on cross-border marine connections for salmon in local Salish Sea waters and across the Pacific (and Atlantic) Rims. It serves as both the 24th Salmon Ocean Ecology gathering and the 2nd Post-Salish Sea Marine Survival Project (SSMSP) gathering. With increasingly frequent marine heat waves and stronger El Niño and La Niña events, some salmon populations have flourished while others floundered.

As a result of this "no analog future," management agencies increasingly struggle to predict the number of salmon that will return each year using ecological relationships and environmental indicators that worked in the past. The SSMSP identified climate-driven changes in the food web – both the availability of food for salmon, and the increasing impacts of salmon predators – as the largest contributors to declining marine survival, with habitat loss, pollution, and disease also having negative impacts.

A better understanding of how salmon interact with complex marine ecosystems, and how those interactions change in response to extreme environmental conditions, is necessary to ensure the sustainability of salmon fisheries and inform salmon recovery. This workshop-style symposium will feature themes on all aspects of salmon marine ecology, including growth; changing habitat use; winter ecology; movement and migratory behavior; ecology, predation, and food webs; and survival, stress, and health. We encourage presentations focused on advances made in the science and implementation of SSMSP findings, as well as presentations identifying opportunities for further research, action, and transboundary collaboration.

Acknowledgements

- WA-BC AFS Chapter: Many thanks to the chapter leadership and organizers of this annual meeting for hosting a fantastic event and supporting our symposium and related activities.
- The Pacific Salmon Foundation: Many thanks to PSF for hosting a SSMSP-related social and networking opportunity at the meeting for speaker and audience participants. PSF also provided funding to support note-taking and reporting out on the symposium.

Background

The Salish Sea Marine Survival Project (SSMSP), initiated and coordinated by Long Live the Kings (LLTK) and the Pacific Salmon Foundation (PSF), was a seven-year collaborative, international research effort focused on identifying factors affecting early marine survival of Chinook and coho salmon and steelhead in the Salish Sea. As part of this effort involving 200+ participants and 60+ entities, transboundary teams collaborated on more than 90 studies, culminating in the 2021 publication of a final synthesis report, related reports, and management recommendations (https://marinesurvivalproject.com/research-findings/).

One of the most valuable but intangible outcomes of this effort was that it established a vibrant transboundary network whose regular communication fostered the success of this work. Between 2014 and 2020, participants met in person at least annually and had regular online communication. Recognizing the continued value of this transboundary network, LLTK and PSF continued to prioritize opportunities to support transboundary collaboration toward implementing SSMSP findings and recommendations. In May 2023, LLTK and PSF hosted a SSMSP Transboundary Workshop geared towards participants that had either been involved in the technical work of the SSMSP or were leading research originating from the SSMSP. The workshop was well received and in addition to the immediate outcomes, the next workshop was planned for 2025 in British Columbia.

As it happened, the 2025 American Fisheries Society's Washington-British Columbia chapter meeting was being held in Vancouver, BC, and presented an ideal venue to host another SSMSP gathering. PSF and LLTK joined efforts with organizers of the annual Salmon Ocean Ecology Meeting (who had the same idea) to co-host a symposium titled **Salmon Ocean Ecology: Cross-Border Connections in the Salish Sea and Beyond**, This symposium served as both the 2nd post-Salish Sea Marine Survival Project gathering and the 24th Salmon Ocean Ecology Meeting (SOEM). Many thanks to the WA-BC AFS chapter leadership and organizers of this annual meeting for hosting us at this great event. Thanks also to PSF for providing funding to support the planning, execution, and collaboration opportunities at this symposium. The goals of the symposium were to:

1. **Share knowledge about the current state of salmon marine ecosystems,**
2. **Highlight advances in the science and implementation of SSMSP findings, and**
3. **Identify gaps and opportunities for research, action, and transboundary collaboration.**

This workshop-style symposium featured themes on all aspects of salmon marine ecology, including models, tools and data; climate and oceanography; food webs and predation; movement and migratory behavior; growth, stress, health and survival; and survival trends and forecasts. The symposium was held on March 11-13, 2025.

TUESDAY, MARCH 11

Day 1

Salmon Marine Ecology Working Group Lunch

The WA-BC AFS chapter has recently established "Working Groups" set up by members who are passionate about their area of fisheries. The primary purpose of working groups is to plan symposia, workshops and other activities for the annual conferences. Given the popularity of the SOEM-SSMSP symposium at the 2025 WA-BC AFS meeting, we hosted a gathering during the Working Group lunch session to discuss whether there was interest from members in forming a Salmon Marine Ecology working group. This would help establish a more formal and long-term group that is focused on organizing salmon marine ecology-themed gatherings at the annual WA-BC AFS chapter meetings which could serve as an option for future SOEM and/or SSMSP symposia.

Around one dozen people attended the lunch, including those who affiliated with SSMSP or SOEM, and some who considered themselves part of both. Attendees introduced themselves and had a discussion that focused on the future of SSMSP and SOEM meetings, the current challenges around hosting and attending scientific meetings in general, and their thoughts on forming a Salmon Marine Ecology Working Group as part of the WA-BC AFS chapter. Overall, there were a lot of mixed feelings and a sense that we need to continue this discussion among the broader SSMSP and Salmon Ocean Ecology network. It was noted that we would be revisiting this topic in the final discussion of the symposium as well as over email after the symposium. Some initial takeaways were:

- It's become more difficult, especially for federal employees, to host and attend meetings, and even staff at state/provincial and other government agencies are also more limited in their participation.
- It has become more challenging for many government employees to get international travel approved.
- It may be easier to get approval to attend informal gatherings, like workshops or meetings that don't have registration fees (don't call it a conference).
- Non-profits (like PSF and LLTK) may be best suited to host these gatherings in the near term but would still need to get support/funding to host these events.
- To have the best chance of getting good participation, it helps to give at least 6-9 months notice before future meetings.
- It's important to make sure these gatherings are accessible to students and those earlier in their careers.
- While people generally prefer the camaraderie and focus of smaller, stand-alone meetings, they recognized that combining these themed gatherings with a bigger conference might be the best way to guarantee attendance.
- There is interest in a salmon marine ecology Working Group but uncertainty as to who would be take the lead.

Participant Presentations

One of the primary objectives of this symposium was to share updates on projects that had their origin in the Salish Sea Marine Survival Project (SSMSP) and/or research that addressed the marine ecology of salmon throughout their range. With the addition of the Salmon Ocean Ecology Meeting (SOEM) community, the presentations provided for a more comprehensive look at the full marine life history of salmonids throughout their range in the Pacific (and sometimes Atlantic) Ocean. This perspective highlighted both high-level similarities driven by global forces (e.g., climate change) and more localized regional forces that are impacting salmon today.

Opening Session

The symposium opened with a plenary presentation focused on the role of ecosystem models and other complex tools in advancing science and management (Table 1). The organizers chose to open the symposium with the big picture topics – the models, databases, and tools that are the end goal of much of our work. The goal was to set the stage with some reflection on how we transform our research into knowledge and how we use that knowledge to inform management and guide our next steps. Topics ranged from large food web-based ecosystem models to the value of shared data portals and long-term monitoring programs on the high seas to the importance of large scale collaborations (Table 1). The final talk of the afternoon was an overview of the current state of the SSMSP and a discussion on the future of transboundary collaboration around salmon marine ecology topics.

TABLE 1. Opening day presentations focused on models, data, and tools for understanding the marine ecology of salmon in the Salish Sea and beyond. Presenters are listed in bold.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Vivitskaia Tulloch, Hem Nalini Morzaria-Luna, Greig Oldford, & Isobel Pearsall	A time of change: can we move SSMSP forward with marine ecosystem model ensembles?	Several Salish Sea salmon-focused ecosystem models were developed by SSMSP researchers (Oldford, Morzaria-Luna) and externally (e.g. Tulloch, Couture) to ask questions (run scenarios) about the impacts of harvest, climate change, and alterations in the food web on marine survival of salmon. Ensemble methods that run the same scenarios through multiple models improve the reliability of predictions and better manage risk in management decisions. This approach helps us better understand future scenarios and guide actions that can build salmon and ecosystem resilience to climate change.
Ben Skinner	The PSF Marine Data Centre: Marine Information for Southwest British Columbia	The PSF Marine Data Centre is a centralized repository (1-stop shop) for ecological, environmental, and human use information for the Strait of Georgia. It allows open access to marine data, with guiding principles of sharing, informing, and promoting learning, and provides data visualization like interactive maps. The Marine Data Centre strives to ensure that users have the information they need to protect salmon and their marine habitat.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Brian Riddell	Future Collaborations	The collaboration required to design, fund, and execute the SSMSP was critical to its accomplishments and can be used to justify future studies in large marine ecosystems. Informed by the SSMSP, PSF built their Marine Science Program to expand their science and research efforts. Today with increasing effects of climate change and the declining abundance of Pacific salmon in North America, we need to build on these successes. Under the UN Decade for Ocean Sciences a new program is being developed: Basin-scale Events and Coastal Impacts (BECI). Building collaborations to conduct BECI will be our biggest challenge yet.
Kathryn Berry	Plans for a North Pacific Ocean Climate Knowledge Network	Through an integrated approach, the Basin-scale Events and Coastal Impacts (BECI) project aims to bridge the gap between innovative ocean science and practical climate adaptation strategies. By fostering unprecedented collaboration and knowledge sharing across the Pacific, BECI will transform how we collectively build climate resilience, moving from siloed research toward coordinated, evidence-based action that strengthens our shared marine ecosystems. BECI is currently in its planning phase.
Skip McKinnell	The data legacy of sampling salmon in the ocean; current state of the IPSDL	The International Pacific Salmon Data Legacy (IPSDL), compiled by Skip, contains 75 years of high seas salmon tag recovery data. This includes historical catches by 51,415 salmon fishing operations, by about ~140 research vessels from Canada, Japan, and USA, and some by USSR/ Russia. Of those caught, there are currently biological data for 1,170,207 individuals, but mostly from the North American side. The NPAFC has agreed to host the IPSDL.
Nicole Christiansen	Greening the Salish Sea: Decision Support Tools for Successful Pacific Salmon Habitat Recovery	With funding from DFO's Aquatic Ecosystem Research Fund (AERF), the Pacific Salmon Foundation is leading a project that will create a Restoration Resource Hub of open-access informative resources, as well as decision-support tools to guide and help coordinate adaptive nearshore habitat restoration approaches and strategies. By fostering multi-disciplinary approaches and enhancing education, awareness, and skills, this project will improve conservation efforts and protect valued fish species and habitats.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
David Willis and Chrys Neville	An Update on Release Timing Experiments in Salish Sea Hatchery Chinook and Coho Populations	During the SSMSP, DFO Canada's Salmonid Enhancement Program initiated a series of release timing experiments for Chinook and Coho salmon at hatcheries in the Strait of Georgia to understand how release timing impacts marine survival. Overall, later releases have had greater survival, leading to changes in release strategies. They are looking to offshore marine trawl sampling of juvenile salmon to better understand links between release timing and differential mortality.
Liz Duffy	The Salish Sea Marine Survival Project: Putting Recommendations to Work (Discussion)	The SSMSP generated many recommendations to improve prospects for salmon survival and stimulated a groundswell of action. Though the official project wrapped up in 2021, LLTK and PSF continue to support its legacy. After an overview of how recommendations from the SSMSP are being advanced and implemented, we will discuss opportunities for further research, action, and transboundary collaboration.

Key Takeaways Included:

- Models are crucial for informing ecosystem-based management, and we need to run all models with the same questions and standardized inputs to see where they are agreeing and disagreeing. By using this ensemble model approach to quantify the uncertainty in models, we can better manage risk.
- The PSF Marine Data Centre is a valuable collaborative data hub that allows for public access to input and download data and communicate data through interactive and visual tools.
- PSF is seeking data submissions to the Marine Data Centre from SSMSP-related projects so the work can be de-siloed and accessed in a central hub. If interested, please submit your data or reach out with questions at https://marinedata.psf.ca/.
- The transboundary collaboration fostered by the SSMSP was very valuable and should be continued to support implementation of recommendations and offshoots of this work.
- Large-scale collaboration is essential but also very challenging. Common challenges are competing priorities, scheduling, funding, and trust between agencies; we need to break those silos to make progress in recovering salmon under a changing climate.
- BECI's vision is for individual researchers focusing on local issues to interact in a similar fashion as in the SSMSP, through international working groups. Collaboration on the smaller-scale work is just as important as at the high levels.
- Skip has made heroic strides in compiling the vast (75+ year-old) dataset of ocean salmon sampling data in the International Pacific Salmon Data Legacy (IPSDL) but there is more work to do. Skip is looking for help and a successor in compiling the next version and fixing any errors – is looking to the NPAFC. There is additional data (e.g., parasites and scale data) that should also be added to the database.
- PSF has four products under development addressing habitat restoration knowledge and data gaps: tools and maps, reports and handbooks, estuary report cards, and symposiums and workshops.

Key Takeaways, Continued:

- Based on results of hatchery release timing experiments in BC that showed higher survival of late releases (at some hatcheries), the Big Qualicum hatchery has moved to include late release Chinook as a larger portion of their hatchery releases, while the Quinsam River hatchery has incorporated both late release Chinook and coho as part of their ongoing hatchery operations.
- When evaluating hatchery release strategies, DFO is investigating early indications of differential success through marine monitoring of juvenile salmon. This would allow for quicker adaptative management than the typical timeline which relies on evaluating adult returns (3-7 years).
- Collaboration between research and management is critical. To facilitate this, we need ways to share and advance knowledge, tools like data hubs, decision support tools, and collaborative assessments.
- Keep pursuing large-scale collaborations – they are worth it. Steps to take along the way include: building your networks, having patience, embracing challenges, and communicating your successes

Group Discussion

At the end of the session, participants were invited to share about the SSMSP specifically or about any of the talks in this first afternoon. Participants pointed out changing trends, new publications and findings, and the continued need to understand drivers of marine population trends in a rapidly changing and more variable climate and ocean ecosystem.

One observation was that Chinook in the Strait of Georgia has seen some recent positive trends - specifically the recovery of South Thompson Chinook in 2023 and 2024. Another participant pointed out that the importance of long-term marine datasets (like the high seas tagging dataset and the DFO midwater trawl survey for juvenile salmon) for identifying trends and uncovering mechanisms – and that we need to do more of this work.

There was also support for the importance of collaboration and the recognition that large-scale and international collaboration efforts were facing additional challenges in recent times. To address that latest observation, we wrapped up and urged participants to continue their discussions in person at that evening's PSF-hosted social gathering.

TUESDAY, MARCH 12

Day 2

Participant Presentations: Updating the Science

After a fun evening social (hosted by PSF) where delicious food and beverages fueled rousing discussions and new and renewed connections, participants returned for another round of presentations and discussions. Day two sessions were focused on oceanography, food webs, and migratory behavior of salmonids in marine waters.

Session 1: Climate and Oceanography

After Day One focused on big picture goals and outcomes, DaTwo 2 allowed us to dig deeper into the biological and ecological details that are the critical building blocks of this work. Presentations and discussions included in this first session covered oceanographic conditions in the northern Salish Sea and Canadian waters, lower trophic level food web interactions in the eastern North Pacific Ocean, and demography of pink salmon (Table 2).

TABLE 2. Presentations focused on the physical and biological oceanographic links to salmon feeding and distribution. Presenters are listed in bold.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Genyffer Troina, Evgeny Pakhomov, Laurie Weitkamp, Aleksey Somov, Brian Hunt	Exploring the role of oceanographic conditions in shaping the structure of Pacific salmon food webs in the open ocean	Isotope functional indices are applied to describe and compare patterns in the trophic structure of pelagic food webs along the eastern North Pacific open ocean, across gradients of oceanographic conditions and zooplankton biomasses. Samples of pelagic invertebrates and fishes were obtained during the International Year of the Salmon expedition to the Gulf of Alaska in the winter of 2019. Spatial gradients in ocean conditions were followed by differences in the structure of the pelagic food webs and species biomass distributions. These differences in food web structure may be relevant for food web energy transfer efficiency. This is the first time that this type of study has been done in the eastern North Pacific Ocean.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Svetlana Esenkulova	Insights into Salmon Ecosystem Dynamics in the Strait of Georgia Using the Citizen Science Oceanography Program	As part of the SSMSP, PSF introduced a Citizen Science Oceanography Monitoring program in 2015 to collect oceanographic data in the Strait of Georgia at an unprecedented scale for this region, aiming to assist in identifying bottom-up factors influencing salmon survival. Data and analysis results are available through the PSF Marine Data Center. Using the dataset, the dynamics of the microalga *Heterosigma akashiwo* and its relationship with environmental factors are evaluated. Its potential to serve as an ecosystem indicator, as preliminary evidence suggests it could be linked to shifts in juvenile salmon catch per unit effort and biodiversity indices.
Karyn Suchy, **Susan Allen,** Akash Sastri, and Kelly Young	Impacts of marine heatwaves on model-based plankton in the Canadian waters of the Salish Sea	The Northeast Pacific Marine Heatwave (NEP-MHW) began to impact the Salish Sea in 2014 and continued to persist in the region until 2017. A three-dimensional coupled biophysical model, SalishSeaCast, was used to examine the impacts of the NEP-MHW on the physics and the plankton in the Salish Sea with a focus on the Canadian waters. Model results suggest multiple types of marine heatwaves affect the Salish Sea, each of which has unique regional impacts on the food web.
Rich Pawlowicz	Oceanographic climatology and interannual variations in the Strait of Georgia 2015-2024	Since 2015, oceanographic data has been collected in the Salish Sea by many groups. This data was combined to create a monthly climatology of the Strait of Georgia (SoG) and other areas within the Salish Sea, illustrating how oceanographic conditions in the upper water column (temperature, salinity, dissolved oxygen, and phytoplankton biomass) change with time and location. Conditions below the surface layer in the SoG are largely driven by the seasonally changing characteristics of inflow water from the Pacific Ocean, modified by atmospheric conditions in the Haro Strait/Boundary Pass area. Conditions in the SoG may be linked to various climate indices that have been proposed for the NE Pacific.
Neala Kendall	Range-expanding and invading pink salmon: they're everywhere you want to be	Recent research suggests that pink salmon are a climate change winner – outcompeting other salmon in their native range and beyond. Beyond the Pacific Ocean, pink salmon are expanding their range to the Arctic Ocean and are invasive in the Atlantic Ocean, where they are interacting with other species. The Northern Hemisphere Pink Salmon Working Group first met in 2022 to review pink salmon in the marine environment and released an NPAFC report in 2023 informing management actions for this species on the move.

Key Takeaways Included:

- The southeast Gulf of Alaska (GoA) region has more complex food webs, with a higher degree of trophic richness, trophic diversity, and less trophic redundancy. In the northwest GoA, ocean conditions seem to benefit the large zooplankton groups, resulting in food webs with lower overall trophic diversity and high trophic redundancy.
- Oceanographic conditions in the Strait of Georgia (SoG) changed over the last 23 years, with waters warming, and the presence of *Heterosigma* could serve as an indicator to reflect ecosystem health.
- Multiple types of marine heatwaves impact different regions of the Salish Sea, and each has a unique impact on the food web.
- Dissolved oxygen (DO) levels below 6 mg/L have impacts on growth rate and health. In the SoG, DO levels have declined by 1 mg/L since 1968, corresponding to around a 10% reduction in potential salmon growth.
- In the SoG, reduced DO conditions are primarily widespread in late summer but also occur as early as June in certain areas and depths, especially below 15m. These conditions are expected to worsen with climate change resulting in salmon experiencing DO levels and water temperatures that impact their growth and health.
- Pink salmon are thriving due to their unique life history traits: they have low spawning site fidelity (high stray rates), can tolerate wide temperature ranges (though juveniles are vulnerable to very low temperatures), have flexible diets, and have short (2 year) life cycles.
- To coordinate actions and better inform responses, management strategies need to take into account differing population trends among marine regions and ocean basins. The scale of change we are seeing requires a similar scale of collaboration.

Session 2: Food Webs and Predation (I)

This session was the first of two sessions focused on food webs and predation. Presentations and discussions in this session covered current and historical availability of Chinook in Southern and Northern Resident Killer Whale habitats, food web interactions of salmon sharks in the open subarctic Pacific, and the importance of Pacific herring in salmon recovery efforts in the southern Salish Sea (Table 3).

TABLE 3. Presentations focused on salmon food webs and predation. Presenters are listed in bold.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Tess M. McRae	Beyond the Salish Sea: Century-old changes in Chinook salmon availability for resident killer whales	Historic run sizes of Chinook salmon were estimated based on salmon cannery records (from the late 1800s) and tabulated current run sizes (2010-2020) from reported catches and escapements for river systems between SE Alaska and S California. Current Chinook salmon returns are 4 times larger in southern resident killer whale habitat compared to northern resident habitat, and historic Chinook salmon returns were 3 times higher than current returns in southern resident killer whale habitat. These data suggest that the low carrying capacity of southern residents was set before the 1960s and could be explained by the collapse of Chinook salmon populations that occurred over a century ago in California and Oregon.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Szymon Surma	Modelling the ecological impacts of salmon sharks in the open subarctic Pacific	Catch per unit effort in Japanese pelagic driftnet surveys indicates salmon shark biomass increased in the early 1990s and again in the early 2000s, with an overall increase between 1990 and 2012. It has thus been suggested that predation by salmon sharks could exert notable top-down impacts on Pacific salmon, which raises the further possibility of cascading effects on ecosystem dynamics. This study uses a mass-balance model of the oceanic ecosystem in the eastern subarctic Pacific, showing direct top-down impacts of salmon sharks to sockeye, and indirect positive impacts on coho and Chinook.
Jayde Essex	Herring in the spotlight: a food-web approach to salmon recovery in south Puget Sound	Healthy herring populations are important for salmon recovery as they are both an important food source and a buffer to predation. The Nisqually Indian Tribe and LLTK discovered that some adult herring caught in the Nisqually Reach, south Puget Sound, are a genetically distinct local population that spawns later than other known spawning populations. They are studying food web interactions, contaminant exposure, and exploring recovery techniques for this local herring population, including experimenting with adapting traditional Indigenous harvesting techniques to supplement herring spawning habitat.

Key Takeaways Included:

- Comparing the current and historic abundances of Chinook salmon provides timely insights into what is hindering the recovery of southern resident killer whales and suggests potential strategies to ensure their survival and Chinook salmon recovery.
- Chinook are more abundant in southern resident killer whale habitat than in northern, despite the whale population being 4x higher in northern habitats. Return estimates alone do not show available fish in these habitats. Additional work is needed on the seasonality of these estimates.
- There is limited long-term data on salmon sharks and their diets, however recent research shows that salmon sharks consume substantial amounts of salmon and can have indirect impacts on other species due to loss of prey availability in the food web.
- The SSMSP found that Pacific herring are important for salmon recovery in the Salish Sea. This has led to considerable overlap in herring and salmon-related research being conducted in both WA (Puget Sound) and B.C. (SoG) and presents a promising opportunity for continued transboundary collaboration.
- A previously undescribed and genetically distinct population of Pacific herring has been found in south Puget Sound. This population spawns later than most known herring populations and may have important implications for herring management and salmon recovery.
- Herring and zooplankton in south Puget Sound were found to be heavily contaminated with PCBs, indicating a food web pathway to legacy contaminants.

Session 3: Movement and Migratory Behavior

This session focused on movement and migratory behavior of salmon in the Salish Sea. Presentations and discussions covered the use of eDNA to detect salmonid presence in different habitats, life history diversity of coastal winter steelhead in the Hoh River, movement patterns of anadromous cutthroat trout, the marine migratory diversity of juvenile Chinook in the Strait of Georgia, and juvenile life histories of successful returning natural origin Chinook (Table 4).

TABLE 4. Presentations focused on salmonid movements and migratory behaviors. Presenters are listed in bold.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Christoph M. Deeg	Ecosystem wide insights into salmon habitats from spawning grounds to the open ocean via environmental DNA	eDNA is becoming a standard tool for surveying salmon ecosystems from the freshwater habitats to the open ocean, revealing insights into the ecological interactions salmon rely upon. Through eDNA surveys in a Vancouver Island watershed, unexpected detections of exotic species were observed associated with aquaculture. Salmonids with coastal resident life histories are associated with areas of high biological activity, including aquaculture sites, potentially exposing themselves to pathogens.
Andrew Claiborne	Life history diversity of wild coastal winter steelhead (Oncorhynchus mykiss) returning to the Hoh River, WA based on three decades of scale analysis	Winter steelhead age information derived from scale analysis was examined to describe the age structure, trends in iteroparity and life history diversity from 1994-2023 for wild coastal winter steelhead from the Hoh River. 35 unique life histories were observed and over half of the life histories observed were repeat spawners. The survival of repeat spawners has decreased since the 1980s. Life history diversity of repeat spawning steelhead was positively related to kelt survival. The results of this study are particularly important given the crucial role life history diversity plays in population stability, and the recent declines in abundance of most steelhead populations along the west coast of North America.
James P. Losee	Movement Patterns of Anadromous Cutthroat Trout in the Marine Environment	The ecology and movement patterns of cutthroat trout as they transition from periods of residency at nearshore beaches to spawning activity in freshwater is poorly understood. A large collection of acoustic telemetry tagged trout in South Puget Sound showed no evidence of large-scale migrations, with some staying at the same location for months. Seasonal thermal patterns in this tagging effort showed fish over-summering in thermal refuge areas in freshwater. Further studies will involve setting up receiver stations at multiple beaches (at least 3) to triangulate where the same fish moves when holding at the same beach (within a meter).

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Wesley Greentree, Will Duguid, Nick Bohlender, Lucia Ferreira, Katie Innes, Bridget Maher, Jamieson Atkinson, Francis Juanes	Marine migratory diversity of juvenile Chinook salmon from the Strait of Georgia: testing relationships with early marine traits	An abundant population of juvenile Chinook were tagged with acoustic transmitters during their first fall and winter at sea in 2022 and 2023 to determine when migrants leave the SoG, if early marine phenotypes predict migratory strategy, and what vertical habitat residents use. Overwinter residency in the Strait of Georgia was common. Emigration was concentrated in the second ocean spring and summer through Queen Charlotte Strait, though some individuals emigrated through Juan de Fuca Strait in the first ocean fall in one year. Inter-annual temperature differences made comparisons difficult for these years.
Wade D. Smith, *(presented on behalf of Lance Campbell)*	Successful juvenile life history strategies of returning natural origin adult Chinook in western Washington	To examine the consequences of individual early migration strategies on reproductive success, otolith chemistry and microstructural analyses were applied to reconstruct the life history strategies of Chinook salmon from 9 river systems within the Salish Sea, Hood Canal, Strait of Juan de Fuca, and Washington coast. Juvenile life history contributions were compared to adult returns across watersheds, examined inter-annual life history expression by brood year, and evaluated the influence of habitat and environmental factors on the success of juvenile migration strategies. Four juvenile out-migration types were detected. Evidence of interannual variation in the size at juvenile outmigration in returning adults and the relative success of early migratory strategies was found. “Alternate” life history strategies, such as fry and late parr, represented sizable contributions to Chinook returns in western Washington, comprising up to 43% of the returning adults in some years and systems.

Key Takeaways Included:

- eDNA can be used to characterize salmon distribution and detect invasives.
- Atlantic salmon farms have been linked to pathogens and exotic species associated with terrestrial feeds that can be detected through eDNA.
- Atlantic salmon farms in the SoG and on the west coast of Vancouver Island predicted the presence of some species of salmonids (and other fish) suggesting that these species are attracted to the high biomass of aquaculture farms which is likely increasing their exposure to pathogens.
- An eDNA-based co-occurrence analysis in the Pacific Ocean (based on 2019-2020 high seas surveys as part of the International Year of the Salmon) revealed a negative association between Chrysaora (sea nettle) and chum salmon.
- eDNA analyses in the open ocean also revealed the presence of oceanic biomes, eddies, and temporal shifts in species assemblages including spring blooms.
- Life history diversity for wild winter steelhead in the Hoh River has decreased significantly over the last 30 years, primarily related to a decline in repeat spawner life histories.
- Life history diversity of repeat spawning steelhead was positively related to kelt survival, highlighting the importance of protecting kelts and their contributions to population diversity.
- Tagged anadromous cutthroat trout in South Puget Sound revealed high site fidelity in nearshore marine waters, with a maximum migration of 39km (although cutthroat have been found to migrate up to 70km).
- Tagged cutthroat in South Puget Sound spawned and over-summered in freshwater thermal refuge areas.
- Refined understanding of marine migrations through acoustic telemetry tagging will support ongoing work to estimate stage-specific survival rates of Strait of Georgia Chinook salmon.
- The functional surface area for estuarine habitats within different river systems show higher proportions of early fry outmigrants contributing to adult returns (Skagit River vs. Green River systems).
- Recognizing, identifying, and managing for life history diversity can enhance population resilience and improve conservation and restoration efforts.

Session 4: Food Webs and Predation (II)

This session was the second of two sessions focused on food webs and predation. Presentations and discussions in this session focused on trophic interactions between Chinook salmon and forage fish, availability of juvenile Pacific herring in the Strait of Georgia, offshore monitoring of juvenile salmon and herring in Puget Sound, and competitive food web interactions between pink salmon and other salmon and forage fish in the open subarctic Pacific (Table 5).

TABLE 5. Presentations focused on food web interactions between salmon and forage fish. Presenters are listed in bold.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Nathanael Tabert	Chinook salmon diets reveal historical trends in forage fish distribution and availability	Chinook salmon diets from PSF's adult salmon program were used to characterize recent trends in the distribution and availability of forage fish in southern British Columbia and compared to historical datasets to highlight major trends over the past century. Herring have been consistently important in Chinook salmon diets across years in most regions and seasons. Sand lance have been important across years in certain regions and seasons. Anchovy are currently important in small regions but historically were not observed. Sardine were important in the early 1940s but have been rare in diets since. This research provides novel insights into Chinook salmon diets and forage fish community dynamics providing an indicator for monitoring changing pelagic food webs.
Mike Crewson, Liz Duffy, and Dave Beauchamp	Understanding Marine Survival of Puget Sound Salmon in a Changing Climate	To fill the critical gap of long-term monitoring data on the food web of Puget Sound, the Tulalip Tribes, the U.S. Geological Survey, and Long Live the Kings have established a collaborative Puget Sound Juvenile Salmon and Herring Offshore Monitoring Program following protocols from an offshore purse seine survey refined under the SSMSP that sampled water, zooplankton, juvenile salmon and herring. Since 2021, annual summer surveys spanning Puget Sound and northern Washington waters have been conducted building a dataset that can be used to determine mechanisms in early marine life that are impacting survival.
Madeleine Thomson, Will Duguid, Kate Innes,Jessica Qualley, Avril Maher, Jake Dingwall, Francis Juanes	Regional availability of age-0 Pacific Herring to first ocean year Chinook and Coho Salmon in the Strait of Georgia	Juvenile Chinook and Coho Salmon diets were sampled throughout their first ocean summer in the Strait of Georgia from May to October 2024. Currently, 59 sampling days have been completed in 2024 and will be repeated in 2025. Initial results suggest that Chinook start eating herring a month later in the southern Gulf Islands than in the northern Strait. This may be due to a size mismatch as the Chinook in the S Gulf Islands are smaller in the early summer months than in other areas and may not yet be large enough to eat the available herring.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Szymon Surma	Chasing competition among salmonids in the open subarctic Pacific, with an emphasis on pink salmon	Pink salmon could be particularly important competitors and drivers of a trophic cascade affecting zooplankton and phytoplankton in the east-central subarctic Pacific. For most prey groups, salmonid predation is a small fraction of total mortality. This study employed network analysis and dynamic simulations in a mass-balance ecosystem model of the open eastern subarctic Pacific to resolve this apparent paradox. While prey niche overlap among salmonids was substantial, it failed to explain their powerful, mutually negative trophic impacts, including those of pink salmon on other salmonids. The substantial omnivory of salmonids could explain these impacts. By consuming zooplankton, salmonids (notably pink salmon) reduce prey availability for their congeners and micronekton. This indirect trophic pathway amplifies the direct negative impacts of predation on zooplankton.

Key Takeaways Included:

- Sardines were more important diet items for Chinook in the early 1940s and are rarely seen today; herring have increased in importance in Chinook diets in the Strait of Georgia.
- Fishery closures from April-July limit inferences that can be made for different species in the diets of Chinook (e.g., likelihood of sand lance in diets when closure is happening), hopefully this can be addressed in spatio-temporal modeling.
- There is a need for a long-term offshore monitoring program in Puget Sound, as established for other coastal areas and the Strait of Georgia; The Tulalip Tribes and LLTK have been building this collaborative regional monitoring program which will be conducting its 5th year of sampling in July 2025. Secure, long-term funding is needed to continue this important program.
- There has been a reduction in the temporal distribution of herring spawning in the SoG, and there appears to be a reduction in the spatial distribution as well.
- Understanding the factors controlling juvenile salmon access to age-0 Pacific Herring is likely crucial to understanding changes in salmon population productivity and developing strategies for recovery.
- Food web modeling in the N Pacific Ocean showed that pink salmon have a direct negative impact on certain salmon species (e.g., sockeye and steelhead), and indirect negative impacts on marine mammals (e.g., northern fur seals, dolphins, and porpoises). Pink salmon had positive impacts on coho and Chinook, likely by reducing competition from sockeye and steelhead.

THURSDAY, MARCH 13

Day 3

Participant Presentations

Session 1: Growth, Stress, Health, and Survival

This session focused on Pacific salmon growth, stress, health, and survival studies. Presentations and discussions covered a new analysis linking juvenile coho salmon growth and survival in the northern California Current to sardine abundance, winter survival of juvenile Chinook in the Strait of Georgia, mapping nearshore hotspots for habitat suitability for juvenile salmon in Puget Sound, modeling the population-level impacts of Chinook contaminant exposures in Puget Sound, and Tenacibaculum maritimum detections and exposure to Chinook on the west coast of Vancouver Island (Table 6).

TABLE 6. Presentations on the final morning of the symposium focused on factors affecting survival of Pacific salmonids. Presenters are listed in bold.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Brian Beckman, Meredith Journey, Cheryl Morgan, and Brian Burke	Decadal scale variation in growth of coho salmon in the Northern California Current: some familiar data, some new data and perhaps a paradigm shift.	IGF1 levels (an indicator of growth) of juvenile coho salmon in the N California current differed significantly over succeeding decadal intervals (2000–2009 higher than 2011–2022). Across the time series, IGF1 levels were correlated with a zooplankton abundance index for juvenile salmon, though there is little to no correlation of IGF1 levels to coho survival. There are no apparent correlations between juvenile salmon growth and basin-scale oceanographic indictors. These data don't easily fit with current paradigms. Additionally, an index of sardine abundance is highly correlated with both the zooplankton index and IGF1. These findings are new and could suggest variation in juvenile coho salmon growth may be the result of competition with sardine for food.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Will Duguid, J. Atkinson, W. Greentree, K. Innes, S. James, E. Rondeau, M. Thomson, and F. Juanes	Is winter a survival bottleneck for juvenile Chinook Salmon in the Canadian Salish Sea	As part of a PIT tag-based study to investigate stage-specific survival of ocean-type Chinook Salmon (the Bottlenecks Program), juvenile Chinook from 7 focal ocean-type populations have been sampled and tagged over 5 winters (2020-2025) throughout the Strait of Georgia. A subset of effort has focused on investigating the ecology, growth, and health of these fish during winter. Results to date indicate that size, condition, and growth of juvenile Chinook salmon differ by year and stock group. Preliminary analyses of scale circulus-based growth trajectories suggest that slow growing fish selectively disappeared from the sampled population for one stock group through the winter of 2022-23, but not in other years.
Catalina Burch *(presented on behalf of Correigh Greene)*	Mapping nearshore hotspots for juvenile Chinook salmon in Puget Sound	A seascape approach was used to develop a spatial model of habitat suitability in Puget Sound for juvenile Chinook salmon, by combining three sources of information: 1) predictions from a diffusion model of spatial spread from natal sources, 2) predictions from models of occurrence linked to hydrodynamic model outputs, and 3) spatial distributions of shoreline features known to provide refuge, cover, and material recruitment. The resulting product is a visualization of Puget Sound that incorporates the cumulative effects of migration, hydrodynamic suitability, and habitat attributes of local shoreline reaches. This information will help define habitat value when considering shoreline mitigation and restoration, but also can be used to better investigate ecological hotspots for juvenile salmon in the nearshore.
Sandra M. O'Neill, Maya Faber, John Best	Evaluation of the Population-level impacts of Chemical Exposures on Chinook Salmon in Puget Sound, Washington	Using existing life-cycle models and empirical life-stage specific PCB contaminant data for both the Puyallup/White River and the Stillaguamish River systems, the potential, population-level impacts of PCB exposure was quantified. The results indicated a significant impact on the population from chemical exposures, likely limiting the success of recovery and restoration activities. This finding highlights the need to improve our management of anthropogenic chemicals in Puget Sound to enhance recovery of Chinook salmon.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Christoph M. Deeg *(presented on behalf of Arthur Bass)*	*Tenacibaculum maritimum* detections in Pacific salmon from the West Coast of Vancouver Island, British Columbia	*T. maritimum* is an opportunistic bacterium known to cause disease and high rates of mortality in salmon worldwide, and is primarily associated with marine aquaculture. A new monitoring effort focused on West Coast Vancouver Island Chinook revealed high prevalence of *T. maritimum* in Chinook collected in Barkley Sound during the summer months of 2022, a period during which molecular evidence of thermal stress was observed. It's hypothesized this period of high prevalence was indicative of an outbreak of *T. maritimum*.

Key Takeaways Included:

- Reduced abundance of the west coast population of California sardine was correlated with increased zooplankton abundance, and consequently increased coho salmon growth in the northern California Current. This correlation suggests that variation in juvenile coho salmon growth is due to competition with sardines for food
- Looking at the fullness of PIT tagged Chinook stomachs captured in the winter, more than 80% of stomachs had food in the winter months, and Fulton's K (fatness, condition factor) showed no signs of low condition in winter.
- PIT tag adult returns from PSF's bottlenecks program will help us gain an unprecedented understanding of if and how growth, size and food availability interact to regulate winter survival and overall productivity of Strait of Georgia Chinook Salmon.
- The heatmap of habitat suitability of Puget Sound will help choose monitoring sites of salmon outmigration locations and help conservation actions for habitat features, by showing salmon need larger buffers from natal streams and other areas they use for prolonged periods. Data is currently from Hatchery CWT Chinook from Skagit Bay, hatchery origin and wild origin fish migrate differently and this should be considered in the development of this map.
- A median 26.5% increase in Chinook spawners was observed if PCBs were removed in the Puyallup River System model, and a 1% increase in the Stillaguamish (less developed system). PCBs have a significant impact on the population of Chinook in the developed Puyallup River System. Future work will evaluate the impacts of PBDEs on Chinook.
- An abundance of data and direct links to mortality of a contaminant are needed to run contaminant modeling efforts.
- Using information from eDNA investigations, *Tenacibaculum maritimum* is most likely to be present and associated with aquaculture in B.C. waters. Chinook and other salmonids may be at increased risk of exposure when migrating near aquaculture farms.

Session 2

This session focused on survival trends and forecasting of Pacific salmon. Presentations and discussions covered the abundance of pink salmon in the North Pacific Ocean, late-stage marine survival rates for Chinook and sockeye populations on their return migrations in B.C. waters, chum salmon declines, and standardization efforts for salmon forecasting methodologies (Table 7).

TABLE 7. Presentations in the final session focused on survival trends and forecasting for Pacific salmon. Presenters are listed in bold.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Brendan Connors	Adapting management of Pacific salmon to a warming ocean that is more crowded with pink salmon	The increase in Pacific salmon abundance in the North Pacific Ocean is in large part due to warming-related changes in marine ecosystems at northern latitudes that primarily benefit pink salmon, and industrial-scale hatchery production to support commercial fisheries. These shifts provide increased harvest opportunities in some regions and exacerbated conservation concerns in others. North Pacific salmon nations should consider limiting further increases in hatchery salmon production until there is a better scientific understanding of hatchery and wild salmon distribution at sea, how they interact, and how the consequences of these interactions are influenced by broader climate and ecosystem conditions.
Cameron Freshwater	Extreme variability in adult Pacific salmon marine mortality rates: the importance of geographic context and empirical observations	A growing body of evidence suggests that late-stage marine mortality during the final year of ocean residence may be higher than commonly assumed and ultimately contribute to declines in population productivity and age-at-maturity. Two case studies were reviewed using acoustic telemetry to estimate late-stage marine survival rates for populations of Chinook and sockeye migrating through B.C. waters. Results suggest high survival of Chinook salmon and poor survival of sockeye salmon, despite very different interactions with marine fisheries. Spatiotemporal variability in predator communities may create strongly divergent patterns in marine survival and scaling data up for stock assessments can inaccurately inform management decisions.

PRESENTER(S)	PRESENTATION TITLE	DESCRIPTION
Chrys Neville and Richard Beamish *(recorded)*	Collapsing chum salmon populations in British Columbia and around the Sub-Arctic Pacific	Commercial catches of chum salmon in B.C. have collapsed and escapements to major chum producing rivers have seen major declines; commercial catches of chum by all countries have declined by about 40%. Despite these declines, juvenile chum abundance in the Strait of Georgia during September surveys have remained relatively constant over the past 20 years. This indicates that the declining abundance of chum is occurring during their open ocean residence. The persistent basin-wide trend indicates that climate-related changes are a major reason for the declines. There is evidence that the declining ocean survival may be a consequence of reduced winter survival.
Matthew R. Siskey and Gabe M. Madel	Standardization of Chinook salmon (*Oncorhynchus tshawytscha*) extreme terminal run-size forecasts and performance of survival-based forecasting methodologies	WDFW has developed a standardized method for calculating Pacific salmon extreme terminal run size (ETRS) across southern Puget Sound river systems that ensures reproducibility, employs forecast model selection via Akaike's information criterion, and incorporates non-linear relationships between ETRS and covariates in the suite of candidate models. Forecast accuracy was calculated annually to compare observed returns to both historically forecasted ETRS and newly forecasted ETRS based on model selection. Model selection resulted in more accurate forecasts when compared to observed returns, non-linear models were most useful for age-3 forecasts, and the most common predictor of survival was sibling survival. This work should influence further standardization efforts for salmon forecasting methodologies across Puget Sound, as gains in forecast accuracy could also benefit regional population dynamics model performance and thus management success.

Key Takeaways Included:

- Improved communication and collaboration among North Pacific salmon research and management agencies will be key to balancing the benefits and risks of a warming and more crowded ocean. A shift in hatchery management focus from maximizing harvest to increasing resilience to climate-induced impacts is recommended.
- Coordinated research to overcome knowledge gaps and develop strategies to reduce unintended interactions between hatchery and wild salmon could potentially be partially funded by a tax placed on industrial-scale hatchery salmon releases.
- There was no evidence of pinniped predation observed in acoustic tagged adult Fraser River sockeye passing through a pinniped predation hotspot in 2024. Instead, mortality is more likely due to predation by salmon sharks based on observed changes in temperature and pressure recorded by the tags.
- Different species and stocks of salmon can experience a wide range of marine mortality during their return migrations for spawning. This is likely due to spatiotemporal variability in predator communities.
- There is evidence that the declining abundance of chum salmon in B.C. is occurring during their open ocean residence during or after their first winter.
- In 2022, during the International Year of the Salmon (IYS) winter open ocean surveys, researchers caught 7 1st ocean winter chum salmon close together in a gill net. These fish were from 3 geographically distinct regions (BC to Central Alaska) spread over a distance of 1,800 km. This suggests that chum salmon display schooling behavior and same-age cohorts have similar distributions in the open ocean.
- We need to rethink the scientific relationships that regulate chum abundance and better understand their ocean ecology, especially over the winter.
- Salmon forecasting methodologies should be standardized across Puget Sound.
- Gains in accuracy of salmon forecasts could also benefit the performance of regional population dynamics models. Both are outcomes that should improve management success.

Final Group Discussion: The Future of the Salish Sea Marine Survival Project and Salmon Ocean Ecology Meetings

In our final discussion of the symposium, we continued to discuss the future of SSMSP and SOEM gatherings and the idea of forming a WA-BC AFS chapter Salmon Marine Ecology working group. As in the working group lunch at the start of the meeting, there were a lot of mixed feelings and a sense that we need to continue this discussion among the broader SSMSP and Salmon Ocean Ecology network. Some initial reactions and topics for ongoing discussion were:

- Mixed feelings around having stand-alone meetings vs having a gathering (workshop, symposium, etc.) as part of a larger conference
    - Separate meetings seem to be largely preferred for the focus and easier socializing and collaborating.
    - BUT, it is increasingly difficult for people to attend meetings due to cost and agency restrictions. It may be more realistic for people to attend a meeting that's part of a larger conference

Final Group Discussion, continued

- Should SOEM and SSMSP stay as separate meetings or should they continue to be combined?
    - There is a lot of overlap in these groups but the SSMSP is a lot more geographically constrained.
    - Would SSMSP folks travel to SOEM meetings in WA, OR, or CA?
- WA-BC AFS chapter Salmon Marine Ecology working group thoughts:
    - There is a lot of interest in putting one together so that Salmon Marine Ecology is a recurring part of annual meetings
    - Need to identify Working Group leads
    - Nice that it could be an option for hosting SOEM and/or SSMSP gatherings, but it wouldn't need to.
    - It's a central and relatively easy hosting region for the Salmon Ocean Ecology community but it may mean limited participation from AK, OR, CA.
    - Makes a lot of sense for SSMSP gatherings.
- Options for larger meetings that could host a SOEM and/or SSMSP symposium:
    - WA/BC in Wenatchee, WA – April 2026
    - Western Division AFS in Portland, OR – 2026 dates TBD
    - W Coast AFS chapters (Oregon, WA/BC, Alaska)
- If part of a larger meeting, it may be better to have the SSMSP/SOEM portion as an add-on so that people can also attend the regular conference presentations
    - Could be offered as a workshop on day 1 of a WA-BC AFS chapter meeting
- Both are outcomes that should improve management success.

Wrap-Up and Next Steps

Overall, this symposium was the largest and most well-attended at the WA-BC AFS Chapter meeting which shows the importance of this topic and community. We are grateful to all the presenters for their excellent talks and for everyone for participating in discussions both in and outside of sessions. We are grateful for this vibrant collaborative community.

Next Steps:

- LLTK and PSF will work to foster continued opportunities for collaboration and communication around SSMSP and Salmon Ocean Ecology topics.
- LLTK and PSF will explore options for hosting future gatherings including participating in a WA-BC AFS chapter Salmon Marine Ecology working group.
- LLTK and PSF will share this summary with participants and the broader community through the SSMSP website (https://marinesurvivalproject.com/).

Thank you to all participants, symposium organizers, and the WA-BC chapter of AFS for a productive and enjoyable gathering!