# BUILDING A MORE PRODUCTIVE SALISH SEA

## FOR CHINOOK SALMON, COHO SALMON AND STEELHEAD

Photo © Eiko Jones

*Findings of the*

SALISH SEA MARINE SURVIVAL PROJECT

LONG LIVE THE KINGS

PACIFIC SALMON FOUNDATION

# Primary Funders

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“Without thriving salmon populations, our Pacific Northwest culture, economy and ecosystems are in danger. Declining salmon runs also threaten to breach the obligations made to our region’s original inhabitants — First Nation and Native American peoples — and could push Southern Resident killer whales toward extinction.”

—Jacques White, Executive Director, Long Live the Kings

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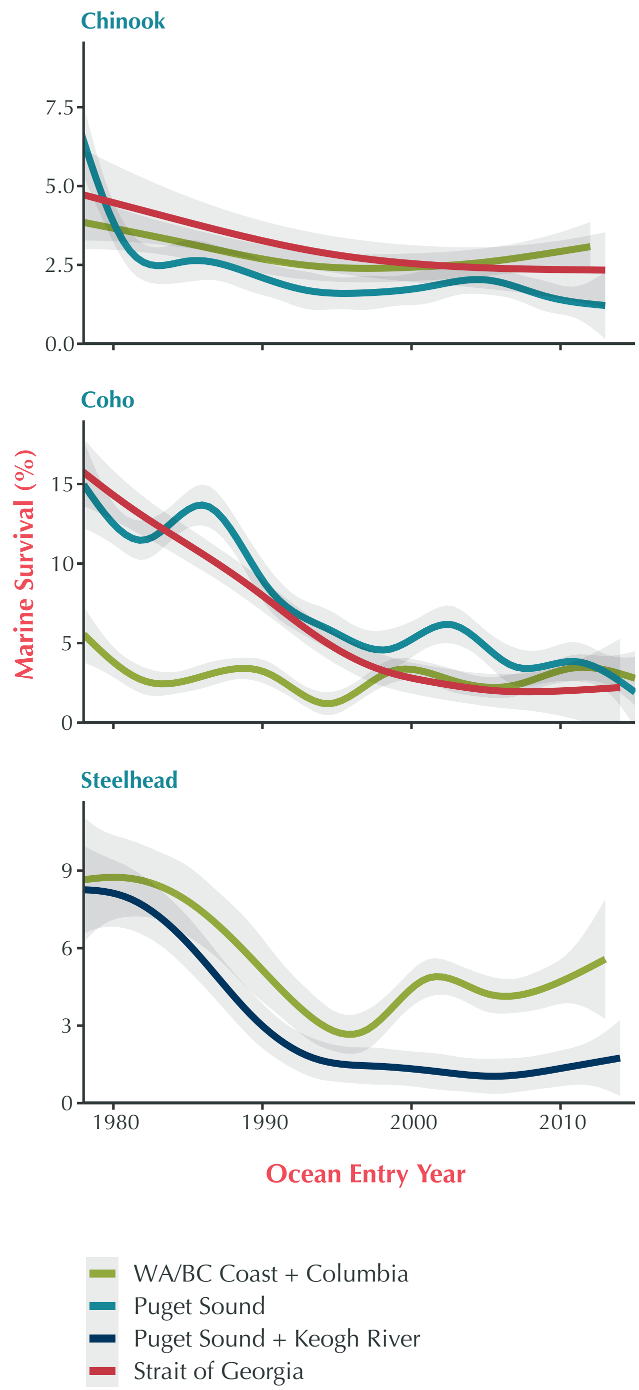
# Overview

## Salmon in the Salish Sea are in serious danger.

Despite hundreds of millions of dollars invested in stream restoration and hatchery production, despite improved management of fisheries and fish hatcheries, many salmon populations have failed to rebound in this region that includes Puget Sound and the Strait of Georgia.

One extraordinarily critical question has remained unanswered: Why are so many young Chinook salmon, Coho salmon and steelhead dying as they leave their natal streams and confront what appears to be an increasingly hazardous world in the Salish Sea marine environment?

The Salish Sea was once a highly productive place for Chinook, Coho, and steelhead. However, things began to change abruptly through the late 1970s and 1980s, when marine survival rates plummeted in ways not seen in other populations along the Pacific Coast. This trend was seen in both wild and hatchery fish. Southern Strait of Georgia steelhead are not represented due to limited data but are also depressed.



Evidence suggests that for a short time after entering seawater, juvenile salmon must survive a critical period that plays a major role in dictating the overall number of adults that later return to spawn. For this reason, experts have suspected that ongoing ecological changes in the Salish Sea may be largely to blame for the overall decline in Chinook, Coho, and steelhead in our local streams.

In 2014, Long Live the Kings in the U.S. and the Pacific Salmon Foundation in Canada initiated the **Salish Sea Marine Survival Project (SSMSP)**. This collaborative, international research endeavor was unprecedented in scale. More than 200 scientists from 60 federal, state, tribal, nonprofit, academic, and private institutions collaborated in more than 90 studies to investigate the relationship between salmon, steelhead, and the Salish Sea ecosystem.

While researchers realize that many factors can affect salmon survival, the challenge has been to figure out which conditions are driving some populations toward extinction. With the bulk of the SSMSP research completed from 2014 to 2018, a "Synthesis Committee" made up of the lead U.S. and Canadian scientists met to review the findings to date and to provide their perspective regarding which factors contribute most to the reduced survival of our salmon and steelhead in the Salish Sea.

The Committee's primary conclusion was that factors affecting food supply and predation are the largest contributors to the declines in marine survival of Chinook, Coho, and steelhead. Changes in environmental conditions have affected when, where, and how much food is available to juvenile Chinook and Coho, influencing their growth and survival. Food is not as significant an issue for steelhead, which enter the Salish Sea in late spring and then swim quickly from their natal rivers to the Pacific Ocean in a few weeks. At the same time, the number of harbor seals has soared throughout the Salish Sea. Studies have found that, even though juvenile Chinook, Coho and steelhead make up a small portion of a seal's diet, the sheer abundance of seals results in significant losses of these fish. But researchers note that other factors also impact juvenile salmon survival; factors that include estuary habitat loss, low river flows, chemicals in the water, and diseases. Any or all of these impacts can impair salmon growth or health, affecting their behavior and critical abilities to forage for food and avoid predators.

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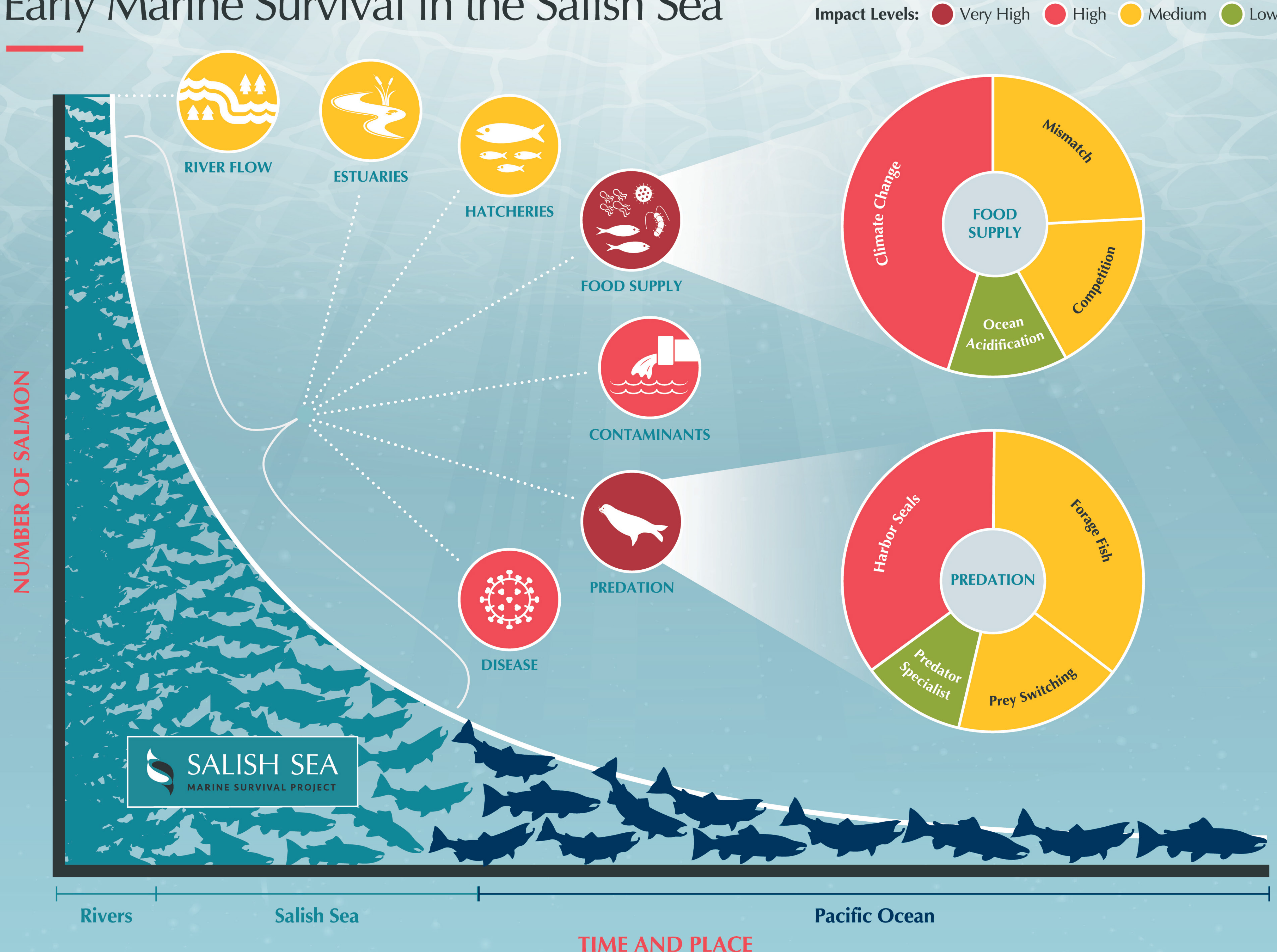
| **PARTICIPANTS** | **ENTITIES** | **MILLION** | **YEARS** | **COUNTRIES** | **QUESTION** |

## What affects the survival of young Chinook, Coho & steelhead in the Salish Sea?

# Early Marine Survival in the Salish Sea




**INFOGRAPHIC ILLUSTRATES THE RAPID DECLINE** in number of juvenile salmon as they migrate downstream and through the Salish Sea. Impacts shown are those that were assessed as part of the Salish Sea Marine Survival Project. Impact levels were established by the project's lead scientists.

## Legend

**RIVER FLOW –** Low river flows can expose young salmon migrating downstream to higher predation.

**HATCHERIES –** More hatchery Chinook are released at the same time now versus spread out over the spring as they were in the past. Pulses of hatchery fish can increase predation risk, potentially increase competition for food, or reduce chances of the fish entering the saltwater when prey is plentiful.

**CONTAMINANTS –** Young Chinook are contaminated with PBDEs or PCBs in many urban watersheds. PCBs continue to accumulate in Chinook that stay in Puget Sound to adult age.

**ESTUARIES –** Degraded estuaries and nearshore reduce shelter and prey for young salmon, in particular Chinook that use these habitats for some time.

**DISEASE –** More infectious agents are found in young Chinook and Coho in the Strait of Georgia compared to the open coastline.

**FOOD SUPPLY –** Zooplankton and forage fish, especially herring, have declined when young salmon need energy-rich food to grow and survive.

**CLIMATE CHANGE –** More days of sun, less wind, earlier spring river flows, and increasing water temperatures all can affect when, where and how much food is available for young salmon.

**MISMATCH –** Alterations in climate can change the timing of spring phytoplankton blooms, cascading through the food web so that zooplankton and herring are not available to young salmon in the size and quantities they need when they enter the Salish Sea.

**COMPETITION –** Competition for food between young salmon or between salmon and herring may occur when food supplies or habitat is limited.

**OCEAN ACIDIFICATION AND HARMFUL ALGAE –** Ocean acidification and harmful algae pose concerns as climate change continues to affect our waters.

**PREDATION / HARBOR SEALS –** A massive increase in harbor seal abundance results in high predation rates of young salmon and steelhead.

**FORAGE FISH –** A primary food source for salmon predators, forage fish like herring are less abundant.

**PREY SWITCHING –** Prey switching may occur and hatchery fish targeted when they enter the Salish Sea en masse.

**PREDATOR SPECIALISTS –** At fish migration barriers and other bottlenecks, seals are specializing in eating young steelhead and salmon.

The Committee strongly believes that no one factor is acting alone to cause the decline in marine survival in the Salish Sea. Existing models suggest complex interrelationships among many factors. Future modeling with additional data — such as the key role of plankton — offers hope for a better understanding of the complete picture and for predicting future shifts with climate change.

The SSMSP has made a significant contribution to our understanding of Chinook, Coho, and steelhead, and our findings have resulted in several recommendations to improve the prospects for salmon survival. Ultimately, we believe that research results and subsequent management actions may also benefit other marine life in the Salish Sea, including the Southern Resident killer whales.

**Key recommendations include:**

- Protect and restore estuary and nearshore habitat
- Recover herring populations and evaluate herring distribution and movement
- Build resilience in salmon by protecting and increasing their diversity
- Continue to assess seal predation, including foraging hotspots, seal diets, and responses to hatchery releases. Implement multiple strategies to reduce seal predation
- Identify toxic contaminant hotspots and sources and focus efforts to reduce the contaminants
- Optimize the health and survival of hatchery-reared salmon
- Protect and manage river flows
- Improve adult salmon return forecasting and guide other ecosystem recovery actions with the new data compiled via the SSMSP.
- Assess disease in young salmon, especially in the face of climate change.
- Continue to assess juvenile Chinook and Coho growth and survival, including survival through winter life-stages, especially as climate change continues to affect our region
- Maintain and improve upon ecosystem monitoring of the Salish Sea
- Continue to test new and novel research techniques and strategies

The SSMSP has already stimulated a groundswell of action. PSF's Strategic Salmon Health Initiative has enormously improved our understanding of pathogens in BC salmon (wild, hatchery, and aquaculture), and resulted in the development of tools that can be used to monitor the health and condition of our salmon. LLTK's Hood Canal

*Photo © Mitch Miller*

Bridge Ecosystem Assessment identified structural solutions for improving fish passage at the bridge where nearly 50 percent of the juvenile steelhead that make it there die. These bridge projects, now funded, are scheduled to be in the water in 2022. Further, new predator deterrent technology is being tested with collaborators in Puget Sound; temperature-resilient kelp strains are being identified in the Strait of Georgia; new Chinook and Coho hatchery-release strategies are being tested throughout the Salish Sea; and actions to recover herring are being implemented on both sides of the border.

The SSMSP also provided a foundation for long-term monitoring of the Salish Sea and salmon health, including a community science program for oceanographic and forage fish monitoring in Canada, expanded zooplankton monitoring programs on both sides of the border, and more extensive monitoring of marine mammals, marine debris, and nearshore habitat. Finally, the science of the SSMSP has been incorporated into recovery plans for Puget Sound steelhead, Chinook, and Southern Resident killer whales.

*Photo © Matt Hagen, LLTK*

One of the greatest achievements of the SSMSP has been the development of a broad community of researchers across disciplines, borders, and authorities. Professional and community-based researchers were convened to address a historically fragmented approach to ecosystem science and implement the most comprehensive study of the Salish Sea to date. This great collaboration was only achieved through strategic funding and facilitation. We must maintain this style of science to continue to evolve our relationship with our precious Salish Sea ecosystem. **Therefore, we strongly recommend that the region establish and sustain a formal transboundary support structure for ecosystem science.** This Salish Sea Science Council would sustain collaboration and advise resource management. This could be achieved via the recently created Salish Sea Institute at Western Washington University.

This document briefly describes the findings of the SSMSP, its outcomes, and recommendations for next steps in management and research. Please go to **www.marinesurvivalproject.com** for the full synthesis report, including references to the studies discussed in this document.

KEY FINDINGS

# Food Supply

## As young salmon grow, they consume larger and larger prey. The key to growth and survival is to find sufficient quantities of the right food at the right time.

This is mainly a concern for young Chinook and Coho salmon that enter the Salish Sea in the spring and rear there through the summer before migrating to the ocean. Some even stay in the Salish Sea their entire lives. On the other hand, foraging and food is likely not as significant an issue for steelhead, which enter the Salish Sea in late spring and then swim quickly from their natal rivers to the Pacific Ocean in two to three weeks.

SSMSP studies have confirmed a connection between the availability of zooplankton and the survival of Coho and Chinook salmon, but the dynamics — including what drives plankton availability — is not entirely clear. For example, biologists have learned that tiny free-swimming crabs and amphipods make up significant parts of Chinook and Coho diets, but the important factor seems to be the total abundance of zooplankton, not just the tiny fraction represented by crabs and amphipods.

The key question becomes: What is driving overall zooplankton abundance? The answer seems to lie within the water itself. Winds, light, water temperatures, and the timing and magnitude of spring river flows — all related to weather — have been changing through the years, leading to the conclusion that **climate change** may be affecting phytoplankton productivity at the base of the food web. Phytoplankton feed zooplankton, and zooplankton feed salmon. Nutrients, primarily nitrogen from sewage,

**EXPERTS ARE FINDING** that there are also more jellyfish in our Salish Sea waters. This could be due to warmer and more nutrient rich waters. Jellyfish are voracious eaters but have little nutritional value themselves. They are considered food-web "dead ends" in ecology. The main concern is whether they are consuming a lot of the phytoplankton and zooplankton, reducing the overall productivity of the food web and affecting Chinook and Coho in the process. *Photo © Christopher Krembs, Washington Dept. of Ecology*

**SSMSP STUDIES FOUND** a relationship between the size of young herring available to juvenile Chinook and the amount of herring in their stomachs. This could suggest many herring are growing larger earlier and are too big for juvenile Chinook to eat. *Photo © Will Duguid, University of Victoria*

agriculture, and stormwater have also increased and could be affecting phytoplankton.

Here again, the science is murky, compromising our ability to make strong links between climate change or nutrient inputs and changes to phytoplankton, zooplankton, and thusly salmon growth and survival. For example, SSMSP experts found conflicting evidence as to whether the annual quantity of phytoplankton has changed: Samples of dead plankton in the seafloor suggest no, whereas growth rings of geoducks over 50 years old suggest yes. However, even if the annual quantity of phytoplankton hasn't changed, the type of phytoplankton or their seasonal availability may have been altered, thus affecting the overall food web.

Increasing evidence supports the notion that weather — **notably changes in winds and sunlight from winter to spring** — may be affecting the timing or size of the spring phytoplankton bloom. While variable yearly, some findings suggest that the timing of the spring bloom has become earlier on average since 1990.

This spring bloom sets the course for when and how much zooplankton will be available to our Chinook and Coho, and to the herring these salmon eat later in life. If a **mismatch** occurs and the right type of food is not available either at the right time or the right size for salmon and herring to eat, they may not grow the way they need to survive. For example, experts found that if the start of the larval crab life cycle began as little as two weeks earlier, then the crabs could be too big to eat for young Chinook entering the Salish Sea. Meanwhile, releases of hatchery Chinook have become more consolidated — with more fish released at the same time. This practice may exacerbate a misalignment between the time hatchery Chinook enter the Salish Sea and what food is available when they arrive.

As young Chinook and Coho live through the summer, they must consume increasingly energy-rich food to grow fast enough to avoid predators and fat enough to survive the coming winter. Forage fish — in particular fish like Pacific herring, Pacific sandlance, anchovy and eulachon

— become extremely important to Chinook and Coho once the salmon are large enough to eat them. Experts have found strong positive relationships between Chinook growth and the quantity of forage fish in their diet.

**Herring**, the most abundant of Salish Sea forage fish, are of primary concern, because SSMSP scientists have found strong positive relationships between herring abundance in the Salish Sea and Chinook and Coho growth and survival. To the detriment of the salmon, herring populations have declined in many parts of the Salish Sea, and there is less diversity in spawning locations as well as spawn timing. Diet studies suggest that juvenile Chinook are eating fewer herring compared to the 1970s, when Chinook survival rates were higher. Since herring are less diverse and are on average spawning earlier in spring, young Chinook and Coho may not be able to find herring of the right size when they get large enough to eat fish. Similar to zooplankton, this may be another **mismatch** problem in the food supply.

While there is not strong evidence that **competition** is a primary cause of the identified declines in Chinook and Coho survival, competition for food could contribute to low survival in some situations, particularly in years when food supplies are low or in locations where habitat is limited. Evidence of competition was found among hatchery Coho, and potentially among Chinook in some years.

Finally, the Synthesis Committee looked briefly at **harmful algae and ocean acidification**. While harmful algae can kill salmon outright, the greater concern is that increasing water temperatures will increase the abundance of harmful algae that will reduce the productivity of the food web.

Similarly, ocean acidification can affect a salmon's sense of smell and increase the risk of being eaten, but the greater risk may be to the prey side of the ledger. Acidification has been shown to limit the growth of — or even dissolve — the shells of important zooplankton species, leading to a less productive food web for salmon.

Ultimately, the Synthesis Committee concluded that changes in harmful algae or increased ocean acidification were not significant enough to explain the decline in marine survival since the late 1970s. Nevertheless, these issues pose significant concerns for the future, as climate change continues to affect our waters.

Climate Change and Ocean Acidification pose significant concerns for the future, as climate change continues to affect our waters.

KEY FINDINGS

# Predation

## Young salmon may be threatened at any moment by predators as they migrate through the Salish Sea.

**STEELHEAD MAY BENEFIT** indirectly from warmer water temperatures, according to studies on steelhead predation. When waters are warmer, anchovies have been known to appear in increased numbers, corresponding to an increase in steelhead survival. A likely explanation is that predators, such as harbor seals, are eating more anchovies while letting more steelhead escape. *Photo © Ryan Miller Media*

Studies have shown that harbor seals, in particular, may be eating an inordinate number of juvenile Chinook and Coho. The Salish Sea harbor seal population increased at least seven-fold since seals received protection via Canada's Marine Mammal Regulations and under the U.S. Marine Mammal Protection Act in 1972. Today, it's estimated that between 5 and 39 percent of juvenile Chinook are consumed by seals in Puget Sound, whereas the estimated consumption is between 37 and 43 percent in the Strait of Georgia. Further, the consumption of juvenile Coho by seals is estimated at 3 to 9 percent in Puget Sound and 47 to 59 percent in the Strait of Georgia. Some questions have been raised regarding the certainty of these estimates and whether the health of our young salmon is contributing to these high mortality rates. However, it is clear that seals are having a big impact.

Juvenile steelhead also appear to be threatened by high rates of seal predation. While difficult to quantify, studies show that when juvenile steelhead mortality is high in Puget Sound (up to 96 percent die in some years), more dead steelhead are found in areas where seals are known to haulout and forage.

Overall, juvenile salmon and steelhead are a small component of the seal diet. Further, **specialization** — by which some seals learn to target young salmon and steelhead specifically — does not seem to be significant. Exceptions are in places like the Hood Canal Bridge, which slows the fish migration, allowing seals to hunt down steelhead trying to find their way past. For the most part, **the sheer abundance of harbor seals** is the main issue, with a lot of seals each consuming a few juvenile salmon and steelhead while foraging for other fish.

Nevertheless, forage fish, like herring, do make up a large portion of seal diets, so **declines in the overall abundance of forage fish** may indirectly contribute to a greater consumption of young salmon and steelhead. One study showed how more steelhead were able to survive when large numbers of schooling anchovy were present in Puget Sound.

Finally, there is conflicting evidence as to whether **releasing hatchery fish in pulses** attracts predators. One SSMSP study found that seals respond to Coho entering the Strait of Georgia after release from a hatchery, but the same was not true for Chinook. This could be because Coho are larger than Chinook at the time of release, as newly released Coho are of suitable size for seals to eat.

Of course, seals are not the only animals that eat juvenile salmon. SSMSP scientists documented increased predation in the Cowichan River by raccoons, herons, and other animals at times when stream-flows were extremely low. This could be a significant concern as climate change alters flow patterns and causes more of these low-flow events.

# Salmon and Steelhead Behavior

## Salmon must make choices when they migrate through the Salish Sea. Where should they rear in the Salish Sea, and how long should they stay there?

These decisions affect their growth and survival.

Some Chinook and Coho, called **residents**, stay in the Salish Sea most of their lives, spending little to no time in the open ocean. A study of this behavior found no consistent patterns between the portion of a Chinook population deciding to stay resident and that population's rate of survival.

SSMSP research found that Chinook showed greater variation in marine survival trends between populations when compared to Coho populations which all showed very similar trends over time. Sampling juvenile Chinook and Coho salmon in the Strait of Georgia provided a likely explanation. Chinook salmon populations consistently used different areas of the Strait of Georgia to rear through the summer, but Coho salmon populations mixed without any preference for specific rearing areas.

Coho also appear to be spending more time in the Strait of Georgia in recent years compared to years past. Some researchers speculate that an increase in prey close to home may be responsible for this change in behavior.

Juvenile steelhead spend only a couple weeks in the Salish Sea during their migration from their natal streams to the ocean, but their survival can be influenced by the path they take or distance they must travel to get to the ocean.

**FOR SOME TIME,** we've known that hatchery salmon don't survive at the same rates as wild salmon. SSMSP studies suggest hatchery Chinook survive at about one-third to one-half the rate of wild Chinook. Scientists believe the greater loss of hatchery fish may occur over the first winter at sea. New research using PIT tags (passive integrated transponders) in the Strait of Georgia is focused on determining the reasons why. *Photo © PSF*

KEY FINDINGS

# Physical Habitat

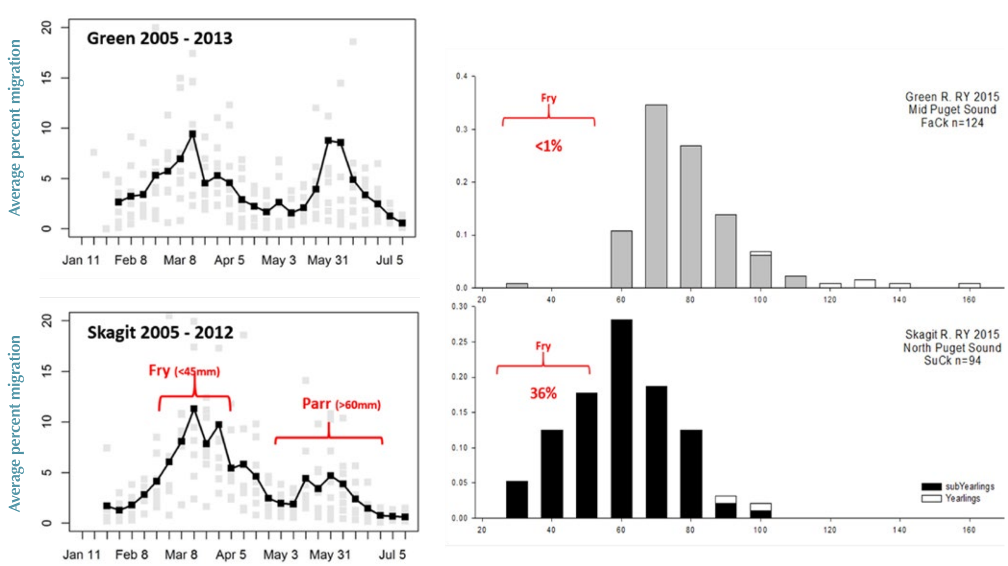
## Habitat degradation began long before the late 1970s when salmon and steelhead marine survival began to decline.

Still, the Synthesis Committee concluded that the quality of habitat is likely a contributing factor, with the largest concern for young Chinook entering degraded estuary habitats.

**Estuaries and the nearshore** can be among the most productive marine habitats, providing food and shelter to young salmon as well as critical prey species, such as herring, sand lance, and crab. However, in many areas throughout the Salish Sea, estuary habitat has been replaced by urban development and farms. Throughout the nearshore regions, eelgrass has declined and eelgrass beds are more fragmented. Also, kelp has declined as much as 62 percent since 1900. This nearshore degradation has likely been caused by coastal development, rising water temperatures, and other changes to our local waters. For kelp, heavy grazing by sea urchins may also be blamed for habitat losses.

While many young Chinook rear for some time upstream in their natal rivers, over half of them migrate quickly downstream to estuaries soon after hatching. This behavior was rewarded over thousands of generations by historically rich habitats that provided shelter and food to grow before transitioning to the marine environment. SSMSP studies found that within the Salish Sea, small Chinook rearing in healthy estuaries have a much greater chance of surviving to adulthood compared to those that rear in degraded estuaries. Only 1 percent of the adult returning population were composed of fry that reared in degraded estuaries, whereas 36 percent of the adult returning population were composed of fry that reared in healthy estuaries. This was the most direct evidence of habitat impacts, emphasizing the need for increased investments in estuary restoration.

**CHINOOK SMOLTS LEAVE BOTH THE GREEN AND SKAGIT RIVERS** early as small fry and later as larger parr. However, returning adults to the urbanized, developed Green River are only derived from those smolts that left as larger parr. The fry component did not appear to survive. Similar results were apparent in a number of other degraded estuaries. *Source: L. Campbell, WDFW*



KEY FINDINGS

# Disease

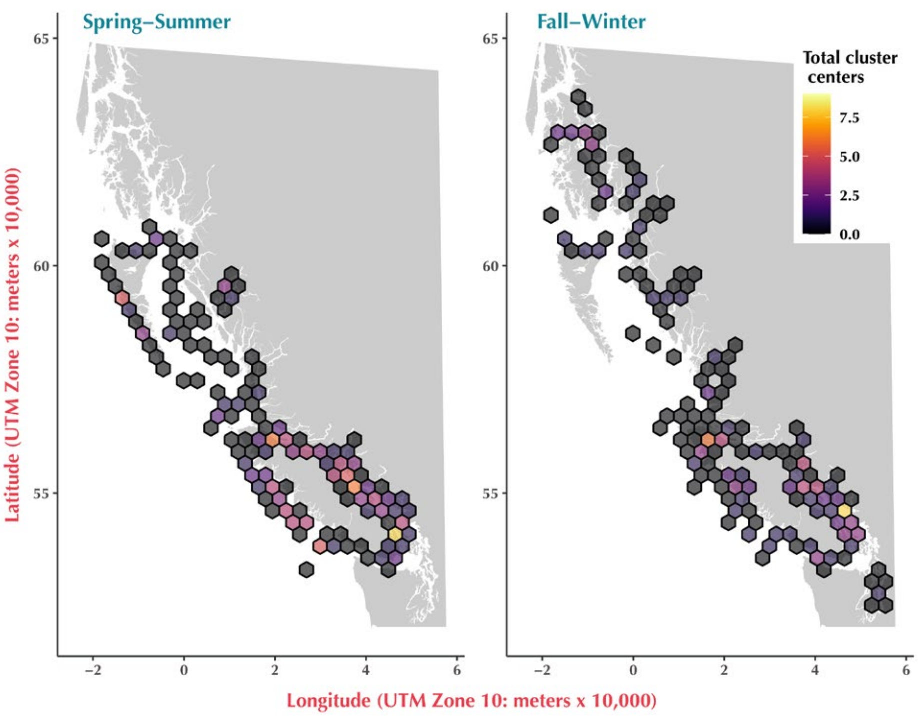
## Studies of disease in Chinook salmon have led researchers to conclude that pathogens could be playing a substantial role in the survival of Chinook and probably Coho and Sockeye as well.

Although there is no historic information to determine whether disease contributed to marine survival declines, experts say there is cause for concern because of known relationships between increasing water temperatures and higher disease susceptibility. Recent findings about relationships between pathogens and Chinook salmon survival raise issues to be considered.

The southern Strait of Georgia has been identified as an infection hotspot in summer months. In fact, recent studies show a greater number of infectious agents in Chinook in the Strait of Georgia compared to Chinook along the outer Pacific Coast. SSMSP scientists concluded that the length and intensity of exposure to disease agents have a direct effect on infection loads, with the highest susceptibility among Chinook residing in the southern Strait of Georgia.

Most of the disease work has been conducted in the Strait of Georgia under the Strategic Salmon Health Initiative, launched in 2013 by the Pacific Salmon Foundation in partnership with Genome BC and Fisheries and Oceans Canada. Less is known about diseases among Chinook and Coho salmon in Puget Sound.

In Puget Sound, a review by experts concluded that few diseases could result in the early marine mortality patterns exhibited among steelhead populations. The most likely suspect was the parasite *Nanophyetus salmincola*. While SSMSP studies did find very heavy infestation of steelhead in some streams — high enough to kill them — experiments concluded that these infestations were not contributing to higher early marine mortality once these fish migrated downriver and through Puget Sound.




**THE SOUTHERN STRAIT OF GEORGIA** is a hotspot for infection, based on an infection hot spot analysis done in spring/summer (left) and fall/winter (right). This image shows where there are the highest quantities of infectious agents in Chinook, Coho, and Sockeye. *Source: K. Miller-Saunders, DFO*

# Contaminants

## Toxic chemicals are known to affect a large number of marine species, from plankton to the killer whales that feast on salmon.

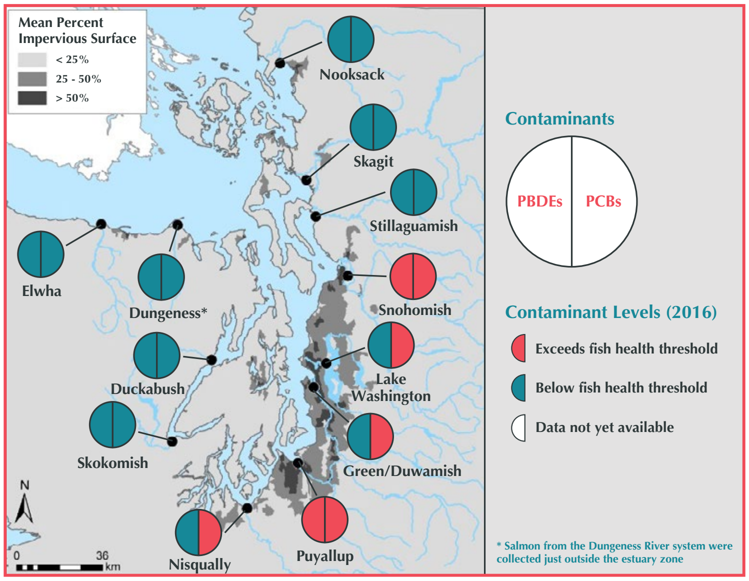
It's not clear whether toxic chemicals played a primary role in the decline of marine survival for Chinook, Coho and steelhead in the Salish Sea. However, the Synthesis Committee believes that, at a minimum, contaminants are limiting the recovery of many Chinook populations, especially those that come from urbanized watersheds in Central and South Puget Sound and likely the Fraser River in the Southern Strait of Georgia.

SSMSP studies focused on contaminants in Puget Sound with less attention paid to the Strait of Georgia. Two contaminants known to persist in the environment and negatively affect salmon growth and survival were broadly assessed in young and resident Chinook. They are PCBs (polychlorinated biphenyls), a group of oily compounds used in many commercial applications before being banned in the 1970s, and PBDEs (polybrominated diphenyl ethers), a group of chemicals used as flame retardants.

Juvenile Chinook captured in all urbanized rivers of Puget Sound contained PCBs at levels known to cause adverse health effects. Researchers found that the longer Chinook stay in Puget Sound, the more they accumulate PCBs. Impacts appeared greatest in the South and Central parts of the Sound. Although Chinook populations in general were less impacted by PBDEs, juvenile Chinook in the Snohomish River estuary and Puyallup River were found with very high levels of PBDEs, well above thresholds that cause adverse effects.

Less is known about the impacts of PCBs and PBDEs on juvenile Coho, which have not been studied as much as Chinook. Steelhead from several rivers were assessed, and PBDEs were found in steelhead in the Nisqually River at levels high enough to cause adverse effects.

A recently identified threat is a chemical associated with automobile tires that can lead to sudden death of adult Coho salmon in urban streams. Still under investigation are sub-lethal effects of the deadly chemical, which could be impacting juvenile Coho, steelhead, and Chinook marine survival. Another threat attracting increased attention is known as Chemicals of Emerging Concern (CECs). This wide-ranging group of compounds with varying toxic effects includes household chemicals, pharmaceuticals, and personal-care products that can get into the Salish Sea through municipal sewage and stormwater.




**SYMBOLS ON THIS MAP** indicate sites where contaminants in juvenile Chinook salmon exceed (red) or remain below (green) adverse health effects thresholds. *Source: PSP 2021: https://vitalsigns.pugetsoundinfo.wa.gov/VitalSignIndicator/Detail/49*

# What Can We Do?

## Recovering our salmon is urgent business.

Guided by the findings of the SSMSP, we should continue scientific research to further address key questions about impacts to salmon marine survival, but we should also begin testing management actions in response to what we've learned to date. Following an adaptive management strategy we should assess the outcomes of our actions, learn from them, and hone our approaches over time.


*Photo © LLTK*

### TEST AND IMPLEMENT MANAGEMENT ACTIONS

The following are the highest priority management actions recommended by the Synthesis Committee. In some cases, work has already started.

**Protect and restore estuary and nearshore habitat** to benefit not only salmon but also their prey. This includes efforts to ensure connectivity within and among marsh, eelgrass, and kelp habitats and accounting for climate change. Critical elements are large-scale estuary restoration and residential soft-shore initiatives that reduce artificial shoreline armor. In Canada, PSF is supporting nearshore spatial planning and climate adaptation, piloting soft-shore initiatives, and supporting efforts to assess kelp resiliency. In addition, PSF and collaborators are building a biodiversity bank of thermos-tolerant macroalgae to be used for restoration in warming waters. In the U.S., LLTK has helped increase emphasis on estuary and nearshore restoration in recovery plans and funding initiatives for Chinook and Southern Resident orcas.

**Recover herring populations**, focusing on both abundance and diversity. LLTK, the Nisqually Indian Tribe and other partners are testing indigenous methods to recover and redistribute herring populations, including the use of evergreen trees as artificial spawning substrate.

**Build resilience in salmon by promoting diversity** in their migration behavior. This idea involves restoring habitat, introducing different varieties of Chinook (eg. spring, summer, and late fall run) to rivers they likely once inhabited, and experimenting with hatchery-rearing strategies that vary the timing for when fish are released into the environment. These actions could make salmon more resilient to mismatches with prey and help reduce competition, disease, and predation.

**Investigate strategies to reduce seal predation**, such as reducing barriers to salmon and steelhead migration that allow increased predation; removing log booms and obstructing the use of other seal resting areas (haulouts); using predator deterrents; and restoring estuary and nearshore habitat that provides protection for salmon. Carefully examine the ecological implications of each action. PSF is developing a project targeting the removal of log booms in the Strait of Georgia. In Puget Sound, LLTK is working with the nonprofit Oceans Initiative, along with tribal, federal, and state partners, to test a new acoustic deterrent to reduce seal predation at the Ballard Locks and other salmon-migration pinch points, such as narrow estuaries. LLTK and partners are also installing attachments at the Hood Canal Bridge to help young steelhead navigate through the migration barrier that currently results in nearly 50 percent mortality from seals and other predators.

Experimental removals of seals from specific locations could be considered. However, current studies suggest that 50 percent of the seal population would need to be removed for a notable increase in the marine survival of Chinook, Coho, and steelhead throughout the Salish Sea. This action would likely garner public opposition and could have significant unidentified impacts to the ecosystem.

**Reduce toxic contamination** in locations that have the greatest impact on salmon and steelhead, such as hotspots of PCBs and PBDEs. LLTK and state and local partners are focusing on ways to reduce the amount of PBDEs entering the Snohomish estuary from a wastewater treatment plant where Chinook are heavily impacted. State and tribal partners are also investigating the sources of PBDEs on the Puyallup and Nisqually Rivers.

**Optimize fish health in hatcheries.** PSF, the Department of Fisheries and Oceans and other partners of the Strategic Salmon Health Initiative have developed a salmon FIT-CHIP, a new genomic technology for rapidly assessing the health and physiology of young salmon to make real-time management decisions. This new technology should be broadly tested.

**Protect and manage river flows** to reduce predation of out-migrating salmon smolts. SSMSP studies focused on the Cowichan River, but this could also be a problem elsewhere.

**Improve adult salmon return forecasting and guide other ecosystem recovery actions** by using the new ecosystem data collected and models developed via the SSMSP.

*Photo © PSF*

## CONTINUE CRITICAL RESEARCH

Here are the most critical research needs to improve our understanding of impacts to salmon marine survival:

**Continue to assess juvenile Chinook and Coho growth and survival** at their various life stages during their first summer, and add winter assessments when these salmon appear to continue to experience high mortality. PSF has expanded their survival bottlenecks study from the Cowichan to many other Chinook and Coho populations throughout the Strait of Georgia. PSF and LLTK's federal, state, and tribal partners also **continue to assess the mortality patterns of young steelhead** in the Salish Sea.

**Add and improve upon the monitoring of Salish Sea** water properties, zooplankton, juvenile salmon and herring, and seal and sea lion demographics and diet. In addition to the need for new efforts, many programs were initiated during the SSMSP that must continue, including a Strait of Georgia community science oceanography program, a new Puget Sound zooplankton monitoring program, and an expanded Strait of Georgia zooplankton monitoring program. Also, as impacts due to climate change increase, further study of ocean acidification and harmful algae impacts to salmon will be needed.

**Evaluate herring distribution and movement** at different ages, including spawning locations and timing. Local tribal knowledge should be included. Also, support studies and monitoring of herring early life stages when young salmon prey on them.

**Examine the abundance and size of crab larvae** relative to Chinook and Coho size and migration timing. Assess the consumption of crab larvae by Pink salmon, Chum salmon and herring which may deplete this prey species before Chinook and Coho salmon arrive.

**Continue to assess seal predation**, including foraging hotspots, seal diets, and responses to pulses of migrating salmon. In Puget Sound, a predation hotspot study led by Washington Department of Fish and Wildlife and the University of Washington is underway. These data will help target management actions.

**Identify contaminant sources and hotspots** in the Strait of Georgia, particularly the lower Fraser River, and determine contaminant pathways for PCBs in Puget Sound. Also study the potential effects of CECs. Canada's Department of Fisheries and Oceans has resumed its contaminant efforts, so we are optimistic that our understanding of contaminant impacts in the Strait of Georgia will soon improve.

Use the new FIT-CHIP technology to further **assess disease in young salmon in the face of climate change**.

Continue to **test new and novel research techniques and strategies** to improve our understanding of salmon in the Salish Sea ecosystem. Extensive innovation occurred during the SSMSP, and it is imperative that this type of creative thinking continue!

**Establish a formal transboundary research structure to continue funding and facilitating these essential collaborative ecosystem science partnerships.** The SSMSP established a broad coalition of professional and community researchers across disciplines and borders. We must maintain this style of science to continue to evolve our relationship with our precious Salish Sea ecosystem. This could be achieved via the recently created Salish Sea Institute at Western Washington University.

# We Need Your Help!

## We need your help to again make the Salish Sea a healthy and productive place for salmon and steelhead.

There are many ways you can be involved:

**Support ongoing research and recovery actions** by making a financial contribution: Donate online at https://www.psf.ca/support/donate in Canada and https://lltk.org/donate/ in the U.S.

Photo © LLTK

**Let local and regional leaders know** that investing in salmon recovery is vital for a healthy, prosperous, and sustainable Salish Sea.

**Volunteer** with a habitat-restoration project, join a community science team, and choose salmon-safe products for your home and yard.

**Join the conversation** by sharing our story with friends and family, and follow Long Live the Kings and the Pacific Salmon Foundation online as we continue to learn and apply new science for salmon recovery.

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# Partners

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