# Scientific Briefing: Nanaimo Summer Chinook Risk Assessment & Life Cycle Model Updates to Inform a Stock Rebuilding Plan

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# Scientific Briefing: Nanaimo Summer Chinook Risk Assessment & Life Cycle Model Updates to Inform a Stock Rebuilding Plan

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# Table of Contents

**ABSTRACT** .......... iv

**RÉSUMÉ** .......... v

**Introduction** .......... 1

**The Requirements for a Place-Based Approach to Rebuilding** .......... 1

**The Requirements of a Data-Driven Approach to Rebuilding** .......... 2

**Overview** .......... 3

**Interactive Dashboard and Stock Distribution Map** .......... 4

Nanaimo River Chinook Dashboard .......... 5

Bottlenecks Interactive Microtroll Distribution Map .......... 5

**Key Updates to Risk Assessment** .......... 6

Summary of Major Changes .......... 6

**Life Cycle Model Updates** .......... 6

- Egg to Smolt survival estimates need clarification: .......... 6
- Early Rearing: .......... 7
- Estuary to spawning areas: .......... 7
- Estuary to ocean marine mortality: .......... 8

**Data Transparency and Catalog for Rebuilding Models** .......... 8

**Summary** .......... 8

**Next Steps** .......... 10

**References** .......... 11

**Appendix A: Limiting Factors and Risk Assessments for Salmon Survival - Suggested Updates** .......... 13

**Appendix B: Data Catalog** .......... 24

## ABSTRACT

The Nanaimo River summer Chinook population has experienced severe declines, with adult returns consistently below 1,000 since 2014. These declines prompted a COSEWIC review, leading to the listing of both the Nanaimo River spring and summer Chinook populations in 2018 and 2020, respectively. As part of the Recovery Potential Assessment (RPA), the Bottlenecks to Survival Project was engaged by DFO and Snuneymuxw First Nation to assist the assessment with local knowledge and data. The Bottlenecks Project is a large-scale scientific PIT tagging initiative that began in 2020 to address data gaps critical for managing salmon populations. As a local project working directly with the listed populations, we advocate for a place-based, data-driven, adaptive management approach. This briefing presents key data from the project relevant to the RPA, including survival estimates, migration timing, and interactions with hatchery-origin fish, predators, and fisheries. An interactive data dashboard was created, which allows users to explore data collected by the Bottlenecks Project on Nanaimo Chinook populations.

Preliminary data show very low marine survival (<1%), highlight broad outmigration and return windows, and provide preliminary evidence of the substantial variability in survival across habitats and life stages. These results were used to update previous qualitative assessments of limiting factors and life cycle model inputs. Bottlenecks Project data are now integrated into tools such as the RAMS limiting factors spreadsheet and the CEMPRA model to support recovery planning. The project also developed a catalog of datasets to promote transparency and inform ongoing management. Findings underscore the need for locally grounded, data-driven, and adaptive strategies that incorporate Indigenous knowledge and respond to evolving ecological conditions to support the rebuilding of Nanaimo's summer Chinook.

# RÉSUMÉ

La population de saumons Chinook d'été de la Nanaimo River a connu des déclins majeurs, avec des retours d'adultes, constamment inférieurs à 1 000, depuis 2014. À la suite de ces déclins, le COSEPAC a procédé à une évaluation, ayant mené à l'inscription, en 2018 et 2020, des populations de saumons Chinook de printemps et d'été de la Nanaimo River. Dans le cadre de l'Évaluation du potentiel de rétablissement (EPR), le projet « Bottlenecks to Survival » a été mandaté par le MPO et la Première Nation Snuneymuxw, afin de contribuer à l'évaluation, en mobilisant les connaissances et les données locales. Le projet Bottlenecks est une initiative scientifique à grande échelle de marquage PIT, lancée en 2020, afin de combler des lacunes de données essentielles à la gestion des populations de saumons. En tant que projet local travaillant directement avec les populations inscrites, nous préconisons une approche de gestion adaptative, fondée sur les données et ancrée dans le contexte local. Ce rapport présente des données clés du projet, pertinentes dans le cadre de l'EPR, telles que des estimations de survie, les périodes de migration et les interactions avec les poissons d'écloserie, les prédateurs et les pêches. Un tableau de bord interactif de données a été créé. Il permet aux utilisateurs d'explorer les données recueillies par le projet Bottlenecks, sur les populations de saumons Chinook de la Nanaimo River.

Les données préliminaires révèlent une survie marine très faible (< 1 %), mettent en évidence l'ampleur des périodes de dévalaison et de retour et fournissent des éléments de preuve préliminaires, d'une variabilité importante de la survie, selon les habitats et les stades de vie. Ces résultats ont servi à mettre à jour les évaluations qualitatives antérieures des facteurs limitants, ainsi que les données d'entrée des modèles de cycle de vie. Les données du projet Bottlenecks sont maintenant intégrées dans des outils, tels que la feuille de calcul RAMS sur les facteurs limitants et le modèle CEMPRA, pour appuyer la planification du rétablissement. Le projet a également élaboré un catalogue de jeux de données, afin de favoriser la transparence et d'appuyer la gestion en cours. Les conclusions soulignent la nécessité de stratégies de gestion adaptative, fondées sur les données et ancrées dans le contexte local, qui intègrent les connaissances Autochtones et tiennent compte de l'évolution des conditions écologiques, afin de soutenir le rétablissement des saumons Chinook d'été de Nanaimo.

## Introduction

This briefing outlines the foundational principles necessary for an effective salmon stock rebuilding plan, emphasizing a science-driven, inclusive, adaptive approach to stock rebuilding. It presents key recommendations for a rebuilding framework, followed by updates to Marine Risk Assessment Limiting Factors and the Life Cycle Model.

The analysis integrates contemporary data from the Bottlenecks to Survival Project alongside findings from additional local research and monitoring projects. These data sources help refine our understanding of limiting factors and shape the evidence-based management recommendations. By incorporating the latest research, this briefing provides contemporary data-driven updates to help inform the Nanaimo summer Chinook rebuilding plan.

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## The Requirements for a Place-Based Approach to Rebuilding

Current salmon management strategies often apply broad, generalized models that may not capture local ecological and socio-economic realities. A place-based approach, which recognizes the unique adaptation of each population to its natal system, as well as the unique environmental, cultural, and economic conditions of the watershed itself, is critical for effective salmon recovery (Gayeski et al. 2018; Rahr et al. 2025).

**Key Considerations for a Place-Based Strategy:**

- **Localized data collection:** Generalized models often overlook regional variations in habitat conditions, life history and migratory patterns, and threats. Long-term, site-specific data is essential for an adaptive management approach.
- **Integration of Indigenous knowledge:** First Nations have deep historical and contemporary knowledge of salmon populations and their ecosystems. Collaborative management incorporating Indigenous expertise will enhance rebuilding efforts.
- **Community engagement:** Salmon management should reflect the interests, knowledge, and needs of local stakeholders, including fishing communities and conservation groups.
- **Adaptive management frameworks:** Given the impacts of climate change and habitat degradation, management must be flexible, allow for post-monitoring of salmon population status, incorporate new data, and adjust strategies over time accordingly.

- **Hydrographic and biological considerations:** An ecohydrological (the study of how water shapes ecosystems and how living organisms influence the movement and quality of water in natural environments) watershed-specific management framework should be prioritized.

A place-based approach aligns with the principles of the Wild Salmon Policy (DFO 2005). It ensures that conservation and rebuilding efforts address the unique challenges individual salmon populations face while promoting evidence-based, sustainable watershed recovery (Rahr et al. 2025).

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## The Requirements of a Data-Driven Approach to Rebuilding

The Precautionary Approach guides the Federal Government's Wild Salmon Policy (DFO 2005) and the Province of British Columbia's Framework for Steelhead Management (MFLNRO 2016). Both policies outline the importance of genetic diversity, healthy ecosystem functions, inclusivity of decision making, and the need for sound scientific information (DFO 2005).

The Precautionary Approach requires having adequate data when developing restoration and rebuilding plans for fisheries. Developing rebuilding plans based on sparse and out-of-date information has been repeatedly shown to lead to unsuccessful results. For example, Lackey (2015) described the failure of costly recovery programs that lack robust scientific foundations. Hood et al. (2021) demonstrated that habitat restoration projects have failed to enhance juvenile survival due to the lack of comprehensive datasets on salmon ecology. Similarly, Ellings et al. (2016) showed that habitat shifts over time affect salmon bioenergetics, underscoring the need for long-term monitoring to assess the effectiveness of restoration efforts. Further, Munsch et al. (2020) warned that ignoring long-term fisheries and habitat interdependencies results in incomplete recovery strategies.

These cases demonstrate that salmon recovery efforts must be grounded in local, long-term ecological studies that not only allow for better informed plans but also provide results on management decisions that allow for an adaptive management framework. Informing the successes or failures of implemented restoration/conservation efforts, whether they are enhancement, habitat, or regulations-based, is critical (Hood et al. 2021). Relying on short-term data or borrowing data from other regions risks misallocation of resources, ineffective interventions, and the inability to adapt due to a lack of knowledge.

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## Overview

Based on reconstructed escapement estimates, the Nanaimo River spring and summer Chinook populations have been highly variable since the 1980s and under 1,000 adult returns since 2014 (DFO 2025). In response to the 2018 and 2020 COSEWIC designations of Nanaimo River spring and summer Chinook (CK-83) as an endangered species, Fisheries and Oceans Canada (DFO) initiated the Risk Assessment Method for Salmon (RAMS) process in 2018 and 2020. In 2019, Nanaimo spring (Conservation unit CK-23/Designatable Unit 19) was assessed and deprecated and is now included in the Nanaimo summer management units (Conservation Unit CK-83/Designatable Unit 20). The RAMS process aimed to identify and prioritize key threats to the population, but a lack of long-term ecological datasets hinders a comprehensive, well-informed analysis.

This work is part of a collaborative initiative between Snuneymuxw First Nation, the Nanaimo River Watershed Stewardship Society and DFO, under the Pacific Salmon Strategy Initiative (PSSI) and the Integrated Rebuilding Unit (IRU), which includes habitat restoration, harvest management, hatchery planning, and Indigenous stewardship into a holistic conservation strategy. In 2024, Snuneymuxw First Nation engaged the Bottlenecks to Survival Project (https://www.survivalbottlenecks.ca/) to provide local insights into the rebuilding planning process. The Bottlenecks to Survival Project is an extensive PIT-tagging project across the east coast of Vancouver Island, led by the Pacific Salmon Foundation and British Columbia Conservation Foundation, funded through the BC Salmon Restoration and Innovation Fund. Members of the Bottlenecks to Survival Project were asked to help address the significant data gaps by providing critical stock-specific information on survival rates (freshwater, marine, terminal), migration timing (juvenile and adult), marine distribution, and hatchery-wild interactions. Data from the project will be provided and utilized to help inform the CEMPRA model (Cumulative Effect Model for the Prioritization of Recovery Action), a tool for evaluating and prioritizing freshwater restoration actions, and several marine-based limiting factors. The objective is to support the development of an inclusive, evidence-based, defensible Rebuilding Plan to increase the resilience of the Nanaimo River summer Chinook.

Specifically, we are providing the following deliverables to assist in the rebuilding planning process:

1. An interactive, online data dashboard for Nanaimo summer Chinook based on Bottlenecks Project data.
2. Comments on the limiting factors based on observations and data from the Bottlenecks and other projects.

3. Updated life cycle profile inputs for CEMPRA modelling (where applicable).
4. A catalogue of available datasets relevant to the limiting factors table.

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## Interactive Dashboard and Stock Distribution Map

The Bottlenecks Project began deploying PIT tags in young-of-year Nanaimo summer Chinook in the Strait of Georgia in August 2020, with the first hatchery and juvenile outmigration tagging in the spring of 2021. Thus, 2024 was the first return year where PIT-tagged 4-year-old Nanaimo summer Chinook returned. The data presented in the dashboard are preliminary and will be updated as new data become available (i.e., genetic results, outmigration timing, survival, and adult return). PIT-tagging under our current BCSRIF funding will continue until March of 2026. Therefore, PIT-tagged adult returns will continue to be detected until winter 2030.

The **Nanaimo Chinook Data Dashboard**, developed by the Bottlenecks to Survival Project in partnership with Snuneymuxw First Nation and DFO, serves as a tool for visualizing key metrics relevant to both the Nanaimo summer and fall Chinook populations. This platform provides:

- **Tagging summary:** Number of PIT tags deployed in hatchery and wild, summer and fall Chinook by stage (i.e., hatchery, river, estuary, microtroll) and outmigration year.
- **Outmigration timing:** Freshwater outmigration timing of wild Chinook captured in the river and estuary, as well as hatchery release groups.
- **Stage-specific survival:** A preliminary look at the differences in survival, i.e., proportion of returns, between fall and summer Chinook tagged at different stages in their first year of life.
- **Hatchery interaction data:** Providing a first look at spatial and temporal overlap between hatchery and wild Chinook at different life stages.
- **Adult escapement timing:** Interactive escapement curves with weekly detections.
- **Marine distribution during first and second winter:** Data collected during microtrolling provide a preview of the first marine winter stock distribution in the Strait of Georgia.

The following are a few early impressions from the data dashboard.

1. Hatchery juvenile summer Chinook exhibit a much wider outmigration window than their fall counterparts; with significant proportions leaving soon after release in late-May/early June. Most summer juveniles are detected leaving in June, varying from early to late June between years, while the fall hatchery Chinook tend to migrate out quickly (within roughly the first 10 days). Additionally, detections of outmigrating summer Chinook continue through the end of July, with a small number rearing throughout the fall and leaving in late winter/early spring.
2. Analysis is underway to model freshwater survival from multiple release groups during outmigration years 2022, 2023, and 2024.
3. When capturing juvenile summers in their first winter at sea, our catch averages 64% wild, which is directly inverse to falls, which average 26% wild.
4. From hatchery release to adult return, preliminary survival rates are likely well below 1%. This is a markedly lower rate than that of fall Chinook. Like the juvenile outmigration, the adult returns exhibit a wide return window, with returns detected as early as March 4 and as late as October 26.
5. The data collected during microtroll sampling in the Strait of Georgia to date indicate a broad distribution of Nanaimo summer Chinook throughout the Strait of Georgia during their first and second winters at sea. While catches are low, they are present in most PFMA's in most months.

The dashboards enable **real-time data visualization and filtering**, providing stakeholders with critical insights to support conservation efforts. Follow the hyperlinks below to view the dashboards:

Nanaimo River Chinook Dashboard

Bottlenecks Interactive Microtroll Distribution Map

## Key Updates to Risk Assessment

The Bottlenecks Project managers reassessed the Marine Limiting Factors. Below is a brief overview of the key suggested changes to current and future risk scores. Adjustments to current scores were based on a combination of Bottlenecks to Survival Project data, other research results, and/or expert opinion using ongoing research and preliminary results.

### Summary of Major Changes

- **Predation Risk (LF1, LF34, LF43, LF44):** Multiple scale factors increase or decrease due to new findings on pinniped impacts in estuarine and marine environments.
- **Hatchery Competition (LF28):** Multiple scale factors and risk scores increase due to wild-hatchery overlap across multiple life stages.
- **Estuarine and Marine Habitat Degradation (LF37a-c, LF38, LF46):** Increased risk scores due to ongoing habitat loss and water quality concerns.
- **Marine Survival (LF40, LF41, LF42):** High biological risk likely due to climate change, competition, and food availability.
- **Human Impacts (LF50):** Comments with references were added to acknowledge concerns with current scores and to ensure the inclusion of recent findings on Fisheries-Related Incident Mortality in all exploitation estimates.

All suggested changes to risk values are presented in Appendix A, with the justification for changes and references. All suggested updates have been included in the attached Marine Limiting Factors Excel file.

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## Life Cycle Model Updates

Following the above updates to the Marine Limiting Factors, suggested changes to the life cycle model are presented below. Changes have also been included in the Marine Limiting Factors Excel file in the life cycle tab. Changes were directly made to both the simple and more detailed models.

- Egg to Smolt survival estimates need clarification:
  A recent egg-to-emergence survival study was conducted on the Englishman River over two winters, 2023 – 2025. The average survival across three control locations with eight incubation standpipes (n = 28) was 67.2% (± 5.71% standard error).

Survival was determined from the eyed egg stage to emergence using Big Qualicum fall Chinook (Swainson et al. in prep).

- Early Rearing:
  Two contemporary hatchery fall Chinook freshwater release studies have shown relatively lower rates of survival. Balfour et al. 2025 conducted multiple releases of hatchery fall Chinook in the Toquaht River on the west coast of Vancouver Island. Survival results from all releases averaged 35% (95% HPDI = 0.02, 0.81) with highly variable survival between release locations and dates.

  The second study conducted on the Cowichan River with hatchery fall Chinook, found that survival varied significantly through space and time. These data are currently being utilized in a larger East Coast Vancouver Island Chinook freshwater outmigration survival and timing analysis. Additionally, the results showed that, on average, the hatchery cohort had a lower rate of survival than their wild counterparts (**Juvenile Salmon Studies - Salish Sea Marine Survival Project**).

- Fishing-related mortality:
  In collaboration with DFO, the Bottlenecks to Survival Project created four enhanced fisheries monitoring tables. These are traditional cleaning tables for fishers to clean their catch, but are equipped with PIT antennas, built into the tables, and overhead cameras to provide data on species, clip rates, and head-submission rates. Preliminary results from the Bottlenecks to Survival Project's enhanced fishery monitoring tables suggest that current harvest estimates for recreational fisheries in the Strait of Georgia could be underestimates, and refinements in the current harvest rate analysis may be required.

  We suggest that the inclusion of Fisheries Related Incidental Mortality (FRIM), which is currently estimated to be 5-25% of catch, into exploitation calculations (during both openings and closures) could improve fisheries management and our understanding of the risks posed by fisheries on summer Chinook. In addition, accounting for exploitation rates on non-legal Chinook could also improve our understanding of fisheries impacts (Johnston, S. UBC-PhD Candidate, Pers. Comm. 2025) (Hinch et al. 2024).

- Estuary to spawning areas:
  A recent study on Cowichan River fall Chinook terminal survival from estuary staging to in-river escapement estimated 20% to 80% mortality when the river exhibited high

and low flow conditions, respectively (Atkinson et al. 2024). While the Nanaimo River differs from the Cowichan River, there are many similarities, including log booms in the estuary/bay, pinnipeds, low flow concerns, river temperatures, and dams. As climate change decreases snowpack and increases spring and summer droughts, terminal survival rates are expected to decrease.

- Estuary to ocean marine mortality:
  The Bottlenecks to Survival Project's first survival estimate of hatchery Nanaimo summer Chinook for the 2020 brood year (outmigration year 2021) is 0.25% (0.22 - 0.28).

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## Data Transparency and Catalog for Rebuilding Models

Appendix B provides a comprehensive data catalog developed from the Bottlenecks Project's datasets utilized in the CEMPRA model, Life Cycle Profile, and Limiting Factors Analysis. It also includes a complete list of references to additional studies and expert opinions used to inform the changes outlined in this briefing.

The Bottlenecks Project's data system consists of a Postgres data warehouse and a front-end web-based interface through which team members can interact with the database. Cloud infrastructure was provided to the team through the Pacific Salmon Foundation's Marine Data Centre's established partnership with UBC's Institute of Oceans & Fisheries. Through this partnership, a remote Ubuntu server was set up to host the system. On this server, the various software components were orchestrated using Docker Compose, a solution for managing containerized applications.

Through the web-based interface, team members can perform ad hoc queries to search for data from the database, generate advanced data visualizations, build interactive dashboards, etc. Data will become publicly available once it is fully QA/QC'd. At this time, access to the data system can be provided upon request.

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## Summary

The Bottlenecks to Survival Project began in 2020, with tagging ongoing until 2026. Due to the life history of Nanaimo River Chinook, complete adult return data are not expected until 2030. The Bottlenecks Project has collected critical life history information and tagged Chinook at multiple life stages. This provides a contemporary dataset to help inform the Nanaimo summer Chinook rebuilding plan quantitatively and to advise limiting factors and Recovery Potential Assessment. This ecological Chinook dataset will be essential in helping inform management and stock rebuilding plans. Updates will be provided as new data is collated.

Analysis is currently underway to assess freshwater outmigration timing and survival of hatchery summer Chinook. In particular, in partnership with the University of Northern British Columbia, a post-doc has been contracted to continue the development of the Bayesian-informed freshwater recapture model developed by Balfour et al. 2024. The project "Modeling the Survival of Outmigrating Pacific Salmon Smolts" aims to assess East Coast Vancouver Island hatchery Chinook freshwater outmigration survival for all Bottlenecks Project hatchery releases, while also including data from previous years of work on the Cowichan River on both hatchery and wild Chinook.

Our project has also generated a unique dataset on fisheries interactions through the enhanced fisheries monitoring table project in partnership with DFO Stock Assessment. To date, four public fish cleaning tables located on Vancouver Island at Brechin Hill, French Creek (2), and Pacific Playgrounds have been enhanced to include an integrated PIT tag antenna paired with an overhead motion-activated camera system. This system allows each fish cleaned on the table to be automatically scanned for a PIT tag, inspected for species and origin (hatchery/wild), and assessed for participation in the head recovery program. Data are still being processed. Results from this project will help inform current creel estimates and could potentially provide stand-alone harvest rates of target stocks.

Predation can be a significant source of mortality throughout the salmon life cycle. The Bottlenecks Project is collecting valuable data on heron predation and developing a model to estimate predation rates. In addition, we are collaborating with First Nations to create a novel baseline of pinniped abundance in the estuary and lower river habitats on the Cowichan, Nanaimo, and Campbell rivers. This project will collect a year and a half of monitoring data, which will provide information on abundance, freshwater habitat utilization, and the spatial and temporal overlap between salmon and pinnipeds.

The methodologies applied by the Bottlenecks Project can be utilized to collect information on the successes and/or failures of prescribed restoration efforts, whether they are enrichment, habitat, or policy-based. Continued monitoring and data collection allow researchers and managers the ability to address the biological and ecological data gaps, which are of critical importance for an adaptive management approach (Munsch et al. 2020; Hood et al. 2021).

## Next Steps

The Bottlenecks Project continues to refine assessments and data collection to support its primary objectives of developing stage-specific survival estimates for multiple ECVI Chinook stocks. However, the data collected will continue to be used to help evidence-based recovery planning. Ongoing studies on the Nanaimo River Chinook stocks include (with deadlines):

- **Freshwater outmigration survival and timing analysis (March 2026).**
- **Estuary and lower river pinniped monitoring program (March 2026).**
- **Heron rookery predation analysis (March 2026).**
- **Stage-specific survival estimates (March 2026).**
- **Reporting on enhanced fisheries monitoring tables (August 2025).**

We are committed to continuing to support the Snuneymuxw First Nation and DFO in the rebuilding process and will provide updates on these efforts as they are completed. Our aim is for these efforts to inform management recommendations to improve the survival and productivity of Nanaimo River summer Chinook.

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# Appendix A: Limiting Factors and Risk Assessments for Salmon Survival - Suggested Updates

## LF1: Predation of adults in the estuary and lower river by pinnipeds

- **Stressor:** Habitat Loss
- **Life History Stage:** Terminal adult migration and spawning.
- **Spatial Scale:** 5 *(change from 4) - The entire population must pass through the pinniped haul-outs in the estuary to reach the spawning grounds.*
- **Temporal Scale:** 5 *(change from 4) - Pinnipeds are intelligent and time their presence with salmon returns, waiting at river mouths annually.*
- **Impact:** *Variable impact, ranging from 10-70%*
- **Current Trend:** 4 *(change from 3).*
- **Comments:**
  - Driven by drought: Extended estuary staging due to low flows increases exposure to predation and mortality. Annual terminal survival varied from 24% - 65% in the Cowichan River.
  - *Lower River and Estuary Pinniped Monitoring Project* (co-led with Snuneymuxw First Nation) will provide by March 2026:
    1. Updated estimates of pinniped populations in estuary/lower river (year-round counts fill summer data gaps).
    2. Seasonal abundance fluctuations and overlap with salmon returns (species-specific).
  - Scanning of otter latrines on Cowichan River found over 200 confirmed otter crossings over an antenna but no PIT tags, suggesting otters are not a significant predation source.
- **References:**
  - Trzcinski et al. 2024.
  - Atkinson et al. 2024.

## LF28: Absence of competition with other species or hatchery fry

- **Stressor:** Habitat Loss / Estuary Competition
- **Life History Stage:** Freshwater rearing, fry to smolt.
- **Location:** Updated to River, Estuary, and Marine.
- **Spatial Scale:** 3 *(change from 1) - Bottlenecks data shows overlap between hatchery and wild Chinook at all tagging stages, likely affecting resource availability.*
- **Temporal Scale:** 4 *(change from 1) - This occurs annually; exact overlap of habitat/resources is still being studied.*
- **Confidence:** Medium *(change from low)*
- **Current Risk:** Low *(change from very low)*
- **Future Risk:** Low *(change from none/unknown)*
- **Comments:**

- Bottlenecks data will inform overlap in freshwater, estuary, and marine habitats.
- Three years of freshwater outmigration and survival studies directly inform hatchery Chinook behavior.
  - Fall-run Chinook: Majority outmigrate within days; some linger for weeks.
  - Summer-released Chinook (lake/upper river): Some remain in the river for up to three months.
- Consensus from "Salish Sea Salmon and Estuaries Workshop" in Bellingham on February 26 and 27th, 2025, was that assessing these impacts without long-term datasets is challenging.
- Doherty et al. 2023 – found significant positive relationship between hatchery releases per wild smolt by CU (suggesting positive density dependence in freshwater habitats) and productivity, but also found significant negative effects of cumulative release sites on Chinook productivity.

- **References:**
  - Bottleneck Projects: Estuary and Microtroll data.
  - Greene et al. 2020.
  - Andrew Bateman may be able to provide disease-related data (consult him).
  - McMillan et al. 2023.
  - Ohlberger et al. 2018.
  - Doherty et al. 2023.

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## LF33: Low early marine survival of Chinook fry and smolts

- **Stressor:** Food, Habitat Loss
- **Life History Stage:** Estuary Rearing
- **Concerns:** Lack of food supply (first 4 months) and reduced water quality.
- **Comments:**
  - Juvenile Chinook diets are sampled through the Bottlenecks Project in their first marine fall/winter—an overlooked stage in the current table of limiting factors.
  - Preliminary diets suggest food limitation but not starvation (Innes et al. 2025 in prep).
  - Consensus from "Salish Sea Salmon and Estuaries Workshop" in Bellingham on February 26 and 27th, 2025, was that there was a lack of diet data for juvenile Chinook in estuaries. Where there are data, these are limited to a site, month, or season, and additional collections are required to develop a holistic understanding. System specific and seasonal specific differences are the primary concerns.
- **Ongoing Research:**
  - Mike Lemoine – Director Research and Recovery - Skagit River System Cooperative
  - Joshua Chamberline – Research Biologist - NOAA
  - Corriegh Greene – Research Biologist - NOAA
  - Dave Scott – Salmon Biologist/PhD Student – Raincoast/UBC
  - Phoebe Gross - Salmon Watersheds Lab/Nature Trust Estuary Work - SFU
  - Pelagic Ecosystems Lab – UBC.
- **References:**
  - Innes et al. 2025 (in prep).
  - Greene et al. 2020.

    - Bottlenecks Survival data.
    - Salish Sea Salmon and Estuaries Workshop – Notes and references will be provided once compiled.
    - Hakai Institute's Juvenile Salmon Program.

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## LF34: Predation of smolts in the lower river and estuary

- **Stressor:** Predation
- **Life History Stage:** Estuary
- **Spatial Scale:** 4 *(change from 2)*
- **Confidence:** Medium *(change from low)*
- **Future Trend:** *Increased variability in river conditions due to climate change may heighten in-river predation risk through increased low flow periods and ambient temperatures.*
- **Comments:**
    - *Heron predation:* PIT tag scanning at Cowichan, Beacon Hill, and Nanaimo's Old Victoria Road rookeries (July 2024) found 245 tags with 14.8% being Nanaimo summer Chinook.
    - *Pinniped predation:* Lower River and Estuary Monitoring Project began surveys on the Nanaimo River in October 2024; outmigration data will be available after Spring 2025.
    - *Log booms:* Significant issue due to habitat destruction and providing foraging platforms for seals.
    - Bottlenecks pinniped program will have preliminary year-round pinniped abundance data for Campbell River spring of 2025, and more complete data for other systems by spring 2026.
    - Harbour seal densities in areas of marine entry found to be the largest driver of decreases in Chinook productivity in models evaluating hatchery, harbour seal, and SST impacts (Doherty et al. 2023)
- **References**
    - Doherty et al. 2023.
    - Sherker et al. 2021.
    - Thomas et al. 2017.
    - Thomas et al. 2022.
    - Conwell et al. 2024.
    - Salish Sea Marine Survival Project. 2024.
    - Furey et al. 2016.
    - Duffy and Beauchamp 2006.

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## LF37: Loss of marine, intertidal, and subtidal habitat

### LF37a: Loss of good-quality marine riparian habitat

- **Stressor:** Habitat Loss

- **Life History Stage:** Estuary
- **Current Trend:** 4 *(change from 3)*
- **Future Trend:** 5 *(change from 4) - Habitat is critical for rearing amid climate change and declining populations.*
- **Comments:**
    - Importance of salt marshes for habitat, carbon sequestration, and flood risk reduction.
    - West side of the estuary is the key migration corridor for Chinook and primary restoration site.
    - Log booms negatively impact physical habitat, water quality, and benthic invertebrates.
- **Ongoing Research:**
    - Nicole Christiansen - Salt Marsh Symposium & PSF Restoration Playbook (to be released in the next year) - PSF
    - Nicole Christiansen - Eelgrass Symposium & PSF Restoration Playbook (to be released in the next year) - PSF
- **References:**
    - Kussin-Bordo et al. 2024.

**LF37b: Loss of good-quality intertidal habitat**

- **Stressor:** Habitat Loss
- **Life History Stage:** Estuary
- **Future Trend:** 4 *(change from 3)*
- **Comments:**
    - Stability in benthic communities does not imply health.
    - Log booms increase non-target species and anoxic conditions (Atkinson et al. 2022 – *Log Boom Literature Review*).
    - Log booming directly affects eelgrass through smothering and increased sedimentation.
    - Debarking creates oxygen depletion and toxin release (terpenes, sulfides), requiring habitat restoration.
- **Ongoing Research:**
    - Nicole Christiansen - Salt Marsh Symposium & PSF Restoration Playbook (to be released in the next year).
    - Nicole Christiansen - Eelgrass Symposium & PSF Restoration Playbook (to be released in the next year).
- **References:**
    - Kussin-Bordo et al. 2024.

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## LF38: Reduced survival due to decreased water quality

- **Stressor:** Water Quality
- **Life History Stage:** Estuary
- **Key Concerns:** Industrial runoff, fertilizers, bark deposition from log booms.
- **Comments:**

  - Agree with scales and current and future biological risk rankings.
  - This is a major data gap. A significant monitoring program is required.
- **Ongoing Research:**
  - Erik Krogh & Haley Tomlin - VIU & BCCF.
  - Jake Dingwall – MSc student UVic – Water Quality & Herring Spawning Study.
  - Kimberly Lagimodiere – MSc student - Water Quality in the Cowichan River - Cowichan Tribes.
- **References:**
  - Pearsall et al. 2021.

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## LF40: Low marine survival due to inadequate food supply (abundance or value)

- **Stressor:** Temperature Adult
- **Life History Stage:** Ocean
- **Spatial Scale:** 3 *(change from 5)*
- **Temporal Scale:** 3 *(change from 5)*
- **Current Risk:** Moderate
- **Future Trend:** High
- **Comments:**
  - Bottlenecks first marine winter Chinook diet and condition data indicate that lack of food availability, may exist but is unlikely to be a driver of mortality in all years.
    - This is a critical period, in addition to estuary diets and adult marine diets, that should be considered in the limiting factors list.
    - Will Duguid has first marine year (incl summer) Chinook diets for 2017.
  - Adult Salmon Diet Program can help inform (2020).
  - Impacts are cumulative, therefore food availability in the Strait will influence subsequent survival, and conditions in the Strait are variable year to year.
- **Ongoing Research:**
  - Will Duguid – PSF
- **References**
  - Innes et al. 2025 (in prep).

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## LF41: Low marine survival due to low marine productivity, poor water quality, increase mean water temperature

- **Stressor:** Temperature Adult
- **Life History Stage:** Ocean
- **Comments:**
  - Marine Science Program's Citizen Science data - regular collections of water quality data; we have monthly CTD casts throughout SOG through fall and winter since 2020
- **Ongoing Research:**
  - Nicole Fredrickson - IMAWG

  - Svetlana Esenkulova - PSF

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## LF42: Low marine survival as a result of competition for food

- **Stressor:** Food, Habitat Loss
- **Life History Stage:** Ocean
- **Comments:**
  - Bottlenecks data show anecdotal evidence of Chinook and coho habitat partitioning, but no diet data is associated.
  - Concerns with competition in the Pacific Ocean due to Pink Salmon Production (although more information needed on marine distributions of Chinook salmon to understand spatial/temporal overlap).
  - Bottlenecks data suggests Nanaimo summer Chinook reside throughout the Strait.
- **References**
  - Bottlenecks Stock Distribution Map.
  - Bottlenecks Nanaimo Chinook Data Dashboard.
  - Bottlenecks Microtroll Capture Data.
  - Ruggerone et al. 2023.
  - Kendall et al. 2020.

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## LF43-44: Low marine survival due to predation by orcas/pinnipeds

- **Stressor:** Predation
- **Life History Stage:** Ocean
- **Confidence:** Medium *(change from High)*
- **Comments:**
  - Bottlenecks data does *not* suggest that summer Chinook are further north in the SOG (see interactive map) - they are found throughout the SOG.
    - In-situ pinniped haul-out monitoring and mobile haul-out monitoring can inform this.
  - Pinniped diet studies show salmon consumption varies greatly spatially and temporally; chum salmon are more affected than Chinook.
  - Newly developed genetic baselines and markers now identify individual seals and new prey items. Once these results are published risk scores should be revisited.
    - This recent research has shown that previous research may have biased scat sampling programs (i.e., sampling the same individuals multiple times) and updates to results will be required.
    - Seals are shown to be highly specialized in diets.
  - Recent research by Cam Freshwater found variations in Chinook mortality rates more strongly correlated with harvest than with predation (presented at AFS 2025 conference)
  - As noted in the Standing Committee on Fisheries and Oceans (2023):

        - “Many variables are not being considered, such as migratory patterns, changes in water temperature, and even the effects on predated fish species and other species that are available for predation.”
        - “Disentangling the role of pinnipeds in the ecosystem means a thorough appreciation of diets and distribution across the entire year, and not just within short snapshots.”
        - “Our current understanding is heavily restricted both spatially and temporally, creating severe biases in interpretation.”
- **Ongoing Research:**
    - Erin D’Agnese - Researcher Wild Ecohealth
    - Casey Clark - WDFW – Marine Mammal Researcher
    - Cameron Freshwater - DFO
- **References**
    - Trzcinski et al. 2024.
    - Ecosystem Impacts and Management of Pinniped Populations: Report of the Standing Committee on Fisheries and Oceans, 44th Parliament, 1st session, December 2023.
    - Bottlenecks Stock Distribution Map.

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## LF46: Mortality due to impacts related to offshore habitat destruction

- **Stressor:** Habitat Fragmentation
- **Life History Stage:** Ocean
- **Current Risk:** Moderate *(change from Very Low)*
- **Future Risk:** Moderate *(change from low/unknown)*
- **Comments:**
    - Increases in marine underwater noise are of significant concern
        - Change animal behaviour
        - Predator prey dynamics
    - Shipping traffic has significantly increased in the last decade, likely continue to increase.
    - Need to continue to consider the impacts of log booms
- **Ongoing Research:**
    - Kelsie Murchy – UVIC

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## LF47: Mortality or sub-lethal effects as a result of pollutants / data deficient

- **Stressor:** Water Quality
- **Life History Stage:** Ocean
- **Comments:**
    - Need to continue to consider the impacts of log booms

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## LF48: Mortality or fitness impacts as a result of disease

- **Stressor:** Disease
- **Life History Stage:** Ocean
- **Comments:**
  - Bottlenecks will have genomic data for a subset of first winter Chinook.
  - There is ongoing research assessing the influence of disease and other environmental stressors on multiple life-stages of Chinook salmon.
- **Ongoing Research:**
  - Scott Hinch - UBC
  - Andrew Bateman - PSF
  - Arther Bass - DFO
  - Kristi Miller-Saunders - DFO

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## LF49: Mortality or fitness impacts as a result of HABS

- **Stressor:** Temperature Adult
- **Life History Stage:** Ocean
- **Comments:**
  - Discuss with Svetlana (PSF's Marine Science Program). She has studied HABS with the Citizen Science Program in the Strait of Georgia for the last 10 years.
- **Ongoing Research:**
  - Svetlana Esenkulova - PSF

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## LF50: Mortality due to fishing

- **Stressor:** Harvest (Predation)
- **Life History Stage:** Marine
- **Comments:**
  - Preliminary data from Brechin Hill cleaning tables suggest higher-than-estimated Chinook harvest rates.
  - Consider Fishing Related Incidental Mortality (FRIM) in exploitation rate estimates. While closures in the harvest fishery occur, Chinook are exploited at a considerable rate in the Strait of Georgia. Through social media posts and work with the Avid Angler Program, guided vessels can capture >70 adult Chinook on a given outing, regularly, during this period. A better understanding of the exploitation (both direct and FRIM) during closures is required. Recent work measured FRIM to be between 5-25% of catch (Hinch et al. 2024)
  - Recent research by Cam Freshwater found variations in Chinook mortality rates more strongly correlated with harvest than with predation (presented at AFS 2025 conference).
- **Ongoing Research:**

- Phil Lemp - DFO
- Scott Hinch - UBC
- Steve Johnston - UBC
- Katie Zinn - UBC
- Wes Greentree - UVIC

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# Appendix B: Data Catalog

The following tables provide a structured overview of the key attributes from key data tables used to analyze Bottlenecks data. The tables outlined below are all_tagging, detections, genetics, and location datasets, which are available in the Bottlenecks data system:

**All Tagging Data (ods.all_tagging)**

| **Attribute** | **Description** |
|---|---|
| source | Origin of dataset or contributing research program. |
| pit_tray | Identifier for PIT tag trays used in sample collection. |
| river | The river system where sampling occurred. |
| species | The salmon species sampled. |
| cohort | The cohort year of the sampled fish. |
| year | Year of data collection. |
| tag_id_long | Long-form PIT tag identifier. |
| fork_length_mm | Measured fork length of fish (mm). |
| origin | Wild or hatchery-origin classification. |
| updated_stock | Updated stock classification (e.g., Nanaimo Summer, Nanaimo Fall). |
| outmigration_year | Year in which the fish outmigrated. |
| vial | Identifier for genetic sample vials. |

**Detection Data (ods.detections)**

| Attribute | Description |
|---|---|
| location | Location of PIT tag detection site. |
| antenna | Antenna where PIT tag was recorded. |
| detection_date | Date of PIT tag detection. |
| detection_time | Time of detection event. |
| tag_id | Unique PIT tag identifier matching fish records. |
| loc_code | Code identifying the detection site (e.g., estuary, upstream). |
| mv | Movement status recorded at detection. |

**Genetic Data (ods.genetics)**

| Attribute | Description |
|---|---|
| indiv | Individual fish identifier from genetic analysis. |
| vial | Vial identifier linking genetics to tagging data. |
| id_source | Source of the genetic data. |
| pbt_brood_year | Parent-based tagging (PBT) brood year. |
| species_updated | Genetically confirmed species identification. |
| stock | Stock classification based on genetic analysis. |
| stock_group | Broader stock grouping for comparison. |
| prob | Probability assignment to primary stock classification. |
| stock_2 | Secondary stock classification if applicable. |
| prob_2 | Probability of secondary stock assignment. |
| source_table | Origin dataset of genetic information. |

**Location Data (ods.location)**

| Attribute | Description |
|---|---|
| site_name | Name of the monitoring site. |
| nearest_town | Closest town or landmark. |
| watershed | Watershed in which the site is located. |
| site_description | Brief description of the site. |
| mc | Site classification code. |
| is1001 | Indicator for site-specific metrics. |
| subloc | Sub-location within a broader monitoring site. |
| loc_code | Unique location code identifier. |
| latitude | Latitude coordinates for site location. |
| longitude | Longitude coordinates for site location. |
| utm_easting | UTM easting coordinate. |
| utm_northing | UTM northing coordinate. |
| antennas | Number of antennas installed at the site. |
| installation | Date of antenna installation. |
| removal | Date of antenna removal (if applicable). |
| location_type | Type of monitoring site (e.g., estuary, mainstem, tributary). |
| sitenotes | Additional notes related to site operation. |
| othernotes | Any other relevant information. |
| jamiesonnotes | Specific site details noted during data collection. |
| upstream_downstream | Identifies if the site is upstream or downstream of a key passage. |