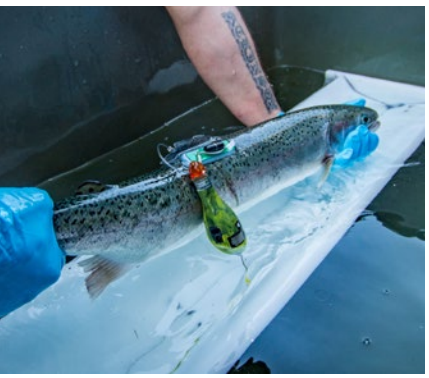
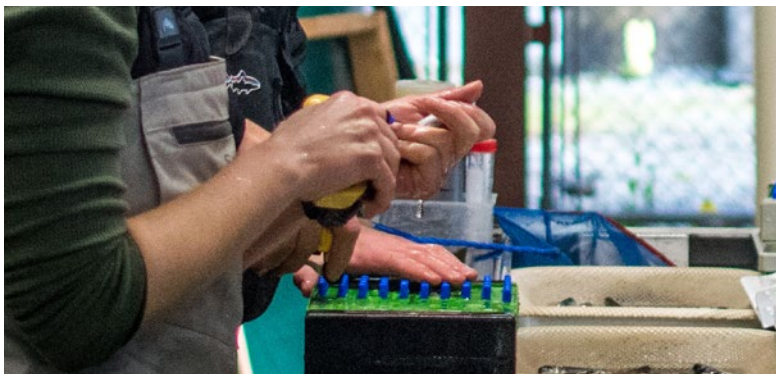
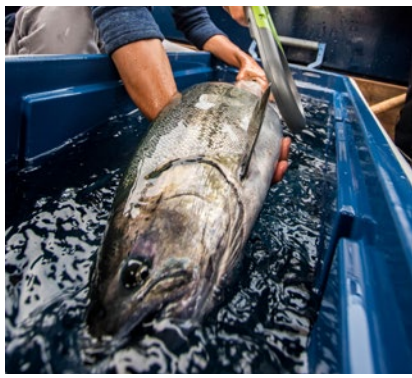
PACIFIC SALMON FOUNDATION







SALMON MIGRATION STUDIES

BOTTLENECKS TO SURVIVAL

Marine Science Program Newsletter

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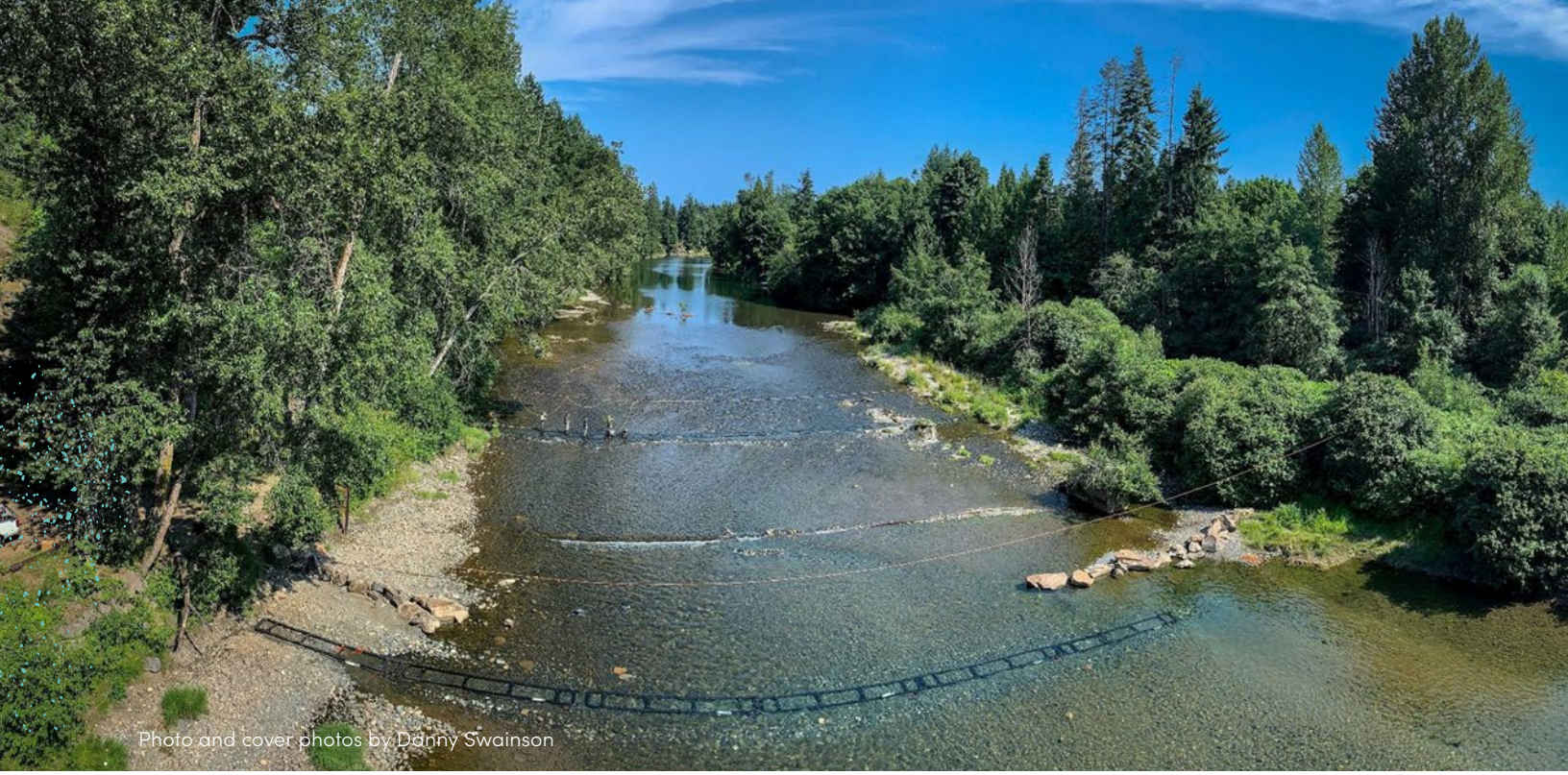


Photo and cover photos by Danny Swainson

Initiated in the fall of 2020, the Bottlenecks to Survival Project was an ambitious undertaking led by the PSF and BCCF with a broad network of First Nations, government, academic, and community partners. Thanks to funding from the BC Salmon Restoration and Innovation Fund (BCSRIF) the project ran for four years to investigate where and when Chinook, coho, and steelhead are experiencing survival "bottlenecks", or periods of elevated mortality, throughout the early stages of their life cycle. This newsletter looks back at what we've found over those four years. We've achieved an astonishing amount of work and learned a great deal.

Spoiler — while the initial 4-year project has come to an end, the Bottlenecks Project is continuing! Thanks to an additional three years of funding from BCSRIF, the project will extend until the spring of 2026, allowing us to continue using the novel PIT tagging infrastructure and techniques that we've created across Vancouver Island. Extra funding will allow us to dive into some of our initial learnings and limitations from the project thus far. But first, let's share just how far we've come.

To date, our project has led 46 antenna installations across 13 watersheds, creating the foundation for extensive data collection on salmon movements and survival. This infrastructure development led to several meaningful collaborations with a broad range of First Nation, government, and community partners which have contributed to the project's success thus far.

The data from these tagging efforts have been compiled into a comprehensive data information system. Additional years of return data are required before we can identify where survival bottlenecks are occurring, however, the infrastructure is in place and the monitoring and evaluation framework for survival analyses is nearing completion as we begin to work with preliminary return data.

TOGETHER, WE HAVE INSERTED MORE THAN 300,000 PIT TAGS IN SALMON AND TROUT SPECIES ACROSS 15 RIVERS ON VANCOUVER ISLAND.

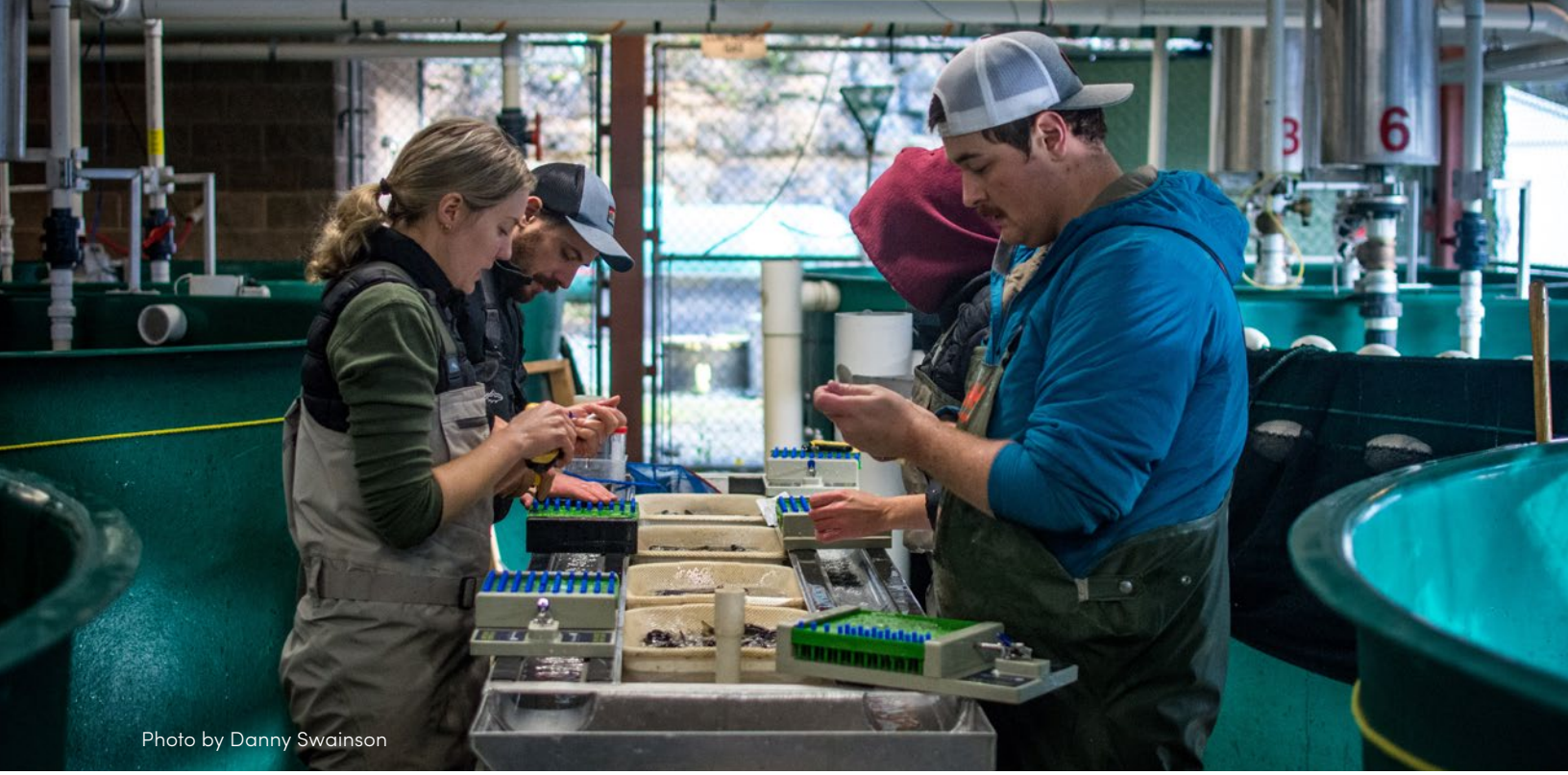


Photo by Danny Swainson

Herein, we bring to you the outcomes of this valuable work to date. But remember, Chinook, coho, and steelhead life spans range from 2-5 years, meaning our findings from the initial four years are preliminary, a 'first look'. You'll have to stay with us to the end if you want to know more!

TAKING STOCK

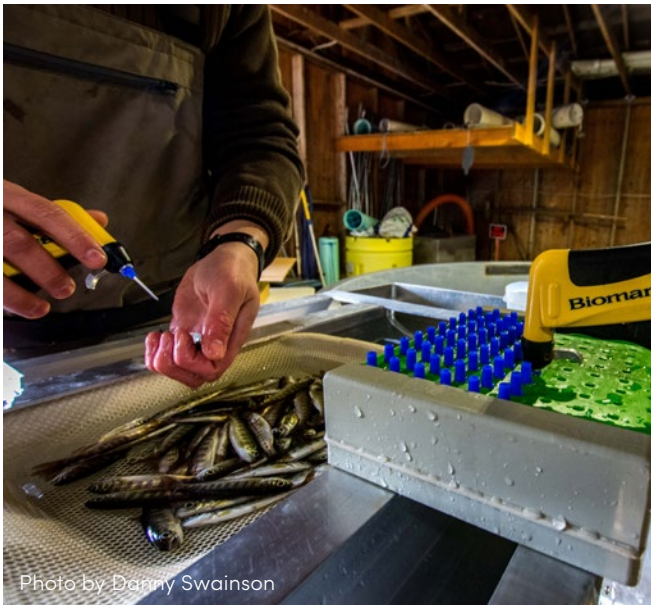
During the first four years of the project, **we deployed a total of 148,578 PIT tags in Chinook, 115,795 in coho, and 16,613 in steelhead trout**. While we are still waiting for many of those fish to come back, we've been busy!

Here are some of the preliminary findings to date (click on the links in the headings to be taken to the full reports on our website):

1. TAGGING-RELATED MORTALITY:

When designing a tag-based research program, it is important to consider the type and size of tag, the size of the study species, and the impact of tagging on fish behaviour and survival. The PIT tagging process and the tags themselves can impact the fish's health and performance, thus affecting the validity of the study. To ensure we were following best practices and limiting harm to tagged fish, we monitored all hatchery- tagged Chinook and coho post-tagging in the first three years.

We found that our overall tagging-related mortality rate was 1.7% for Chinook and 0.6% for coho — very much at the lower end of the 0.0-5.0% mortality rates typically reported by tagging studies. Furthermore, we noticed that those mortalities or tag rejections could be reduced by ensuring that taggers were adequately trained, and by using flow-through tagging tables to reduce post-tag handling.



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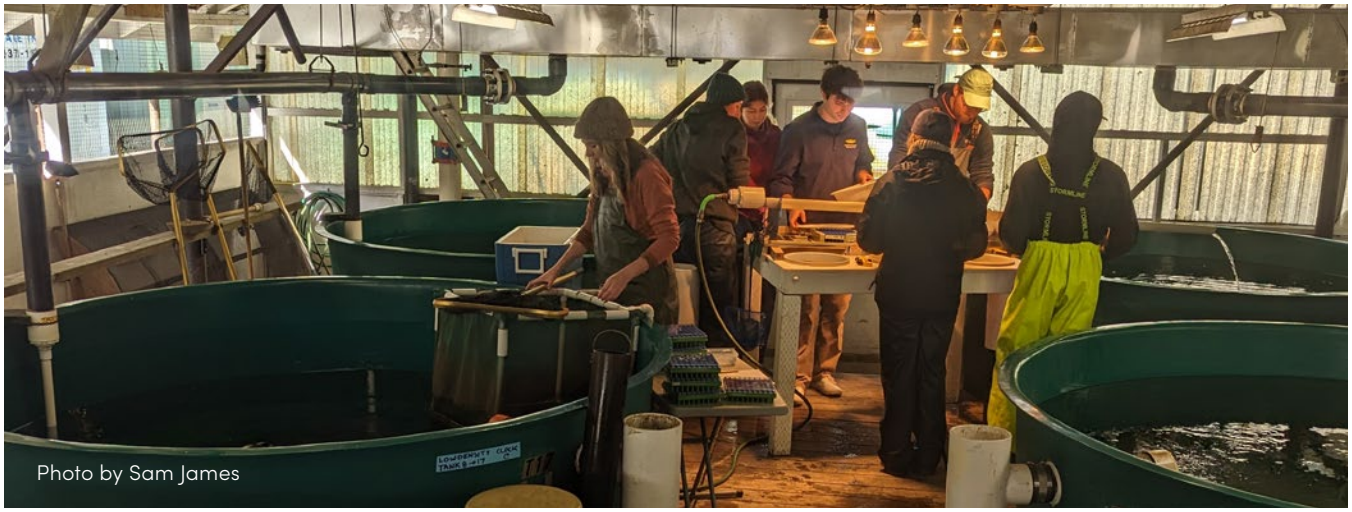


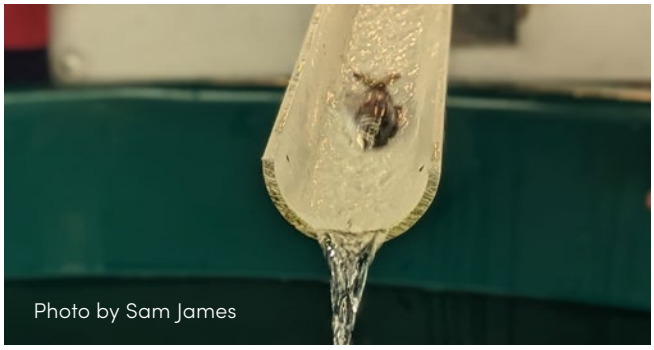
Photo by Sam James

2. PRE-RELEASE MORTALITY IN EARTHEN CHANNELS:

Some of the differences in hatchery and wild salmon survival rates are due to underestimating pre-release mortality of hatchery fish. Coho are held at hatcheries overwinter in earthen channels — specialized, outdoor, pond-like habitats excavated from the earth, designed for juvenile salmon rearing — and released the following spring. While hatchery managers know how many coho are put into the channels, they have no way of knowing how many fish survive that extended rearing period and successfully leave the channels and swim downstream. By PIT tagging a subset of coho in the channels, we can then detect how many fish are leaving them via fish counting technology and estimate mortality in the channels.

Knowing how many tagged fish left the channels, and how long they were held for, we developed an estimated daily mortality rate for each of the hatcheries. We found a huge range of daily mortality rates across the four hatcheries in our study, ranging from 0.1 fish per day to 61 fish per day. Some of the higher mortality rates at one hatchery were caused by a family of otters that took a particular liking to the coho in the channels. Overall, inaccurate accounting of pre-release mortalities can lead to inaccuracies in hatchery survival estimates. Continued tagging and monitoring of coho in earthen channels was recommended to allow for more accurate estimates of release numbers each year.

Photo by Sam James



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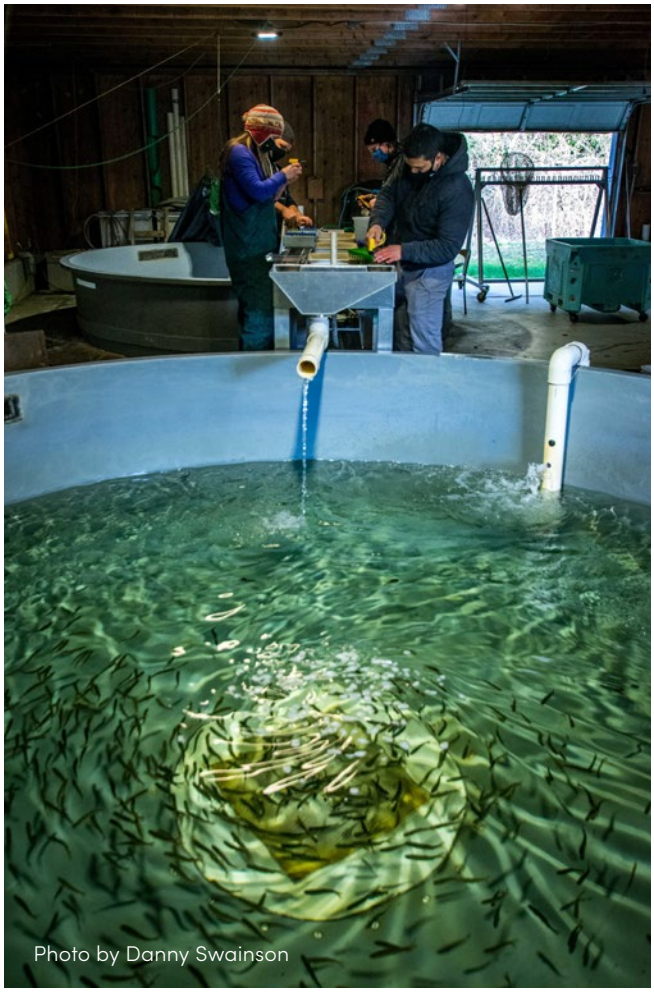


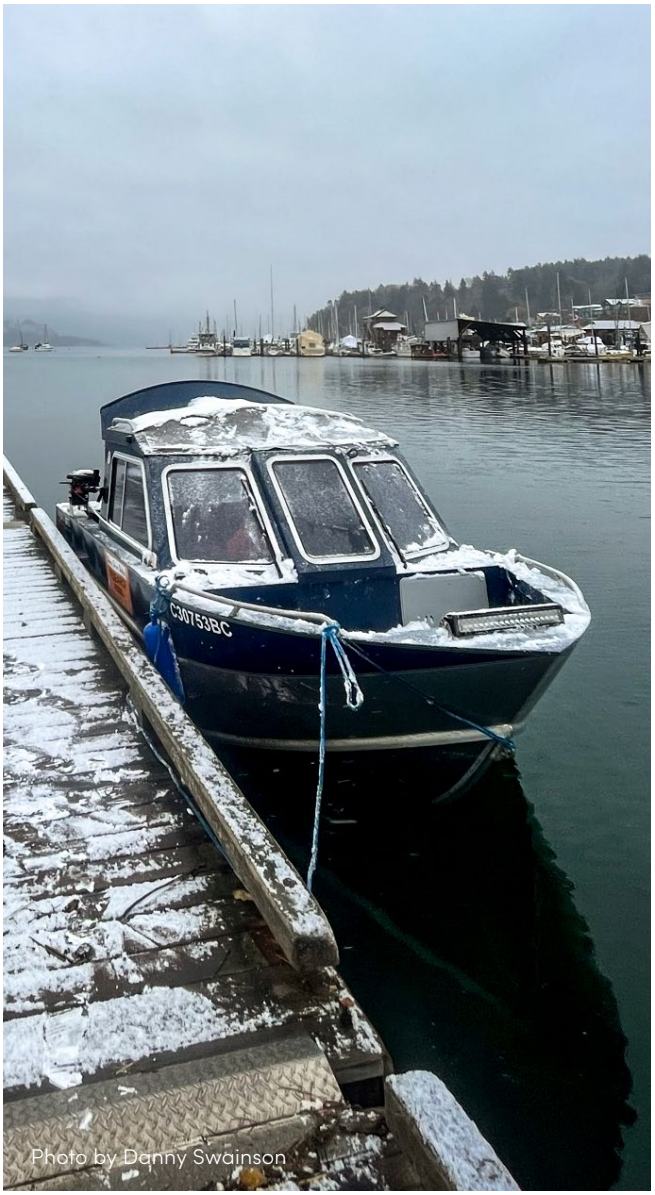
Photo by Danny Swainson

3. WINTER ECOLOGY:

Scientists hypothesize that the survival of juvenile Pacific salmon during their first winter at sea is dependent on how large they grow, or how much energy they can store, prior to a winter reduction in food availability. But studying salmon in the ocean during winter is difficult which is why data from this season is limited. We set out to test this hypothesis and find out if the first winter at sea is a bottleneck to survival for Chinook salmon. And we went all in, exploring habitat preferences, migratory rates, diets, growth patterns, and health. We found that juvenile Chinook were more often caught in relatively shallow water compared to deeper waters offshore, with the highest catches on hooks around 60 metres deep. In addition, our acoustic tagging study revealed that more Chinook spend their first winter in the Strait of Georgia before migrating out to the Pacific Ocean than was previously thought (see our Bottlenecks Newsletter Volume 4 from August 2023 for more info on the acoustic tagging study).

Our diet studies show that these young Chinook are eating mostly fish (particularly Pacific herring), krill, amphipods, and squid, with different diet profiles in different regions of the Strait of Georgia. Overall, the Chinook that eat herring have signifi-cantly higher dietary energy content than those that do not. In addition, while foraging and growth are reduced overwinter, Chinook don't appear to be starving — rather they reallocate energy gained from the summer and fall into storage to make it through the winter. However, there is some evidence from our analysis of Chinook scales and growth patterns that faster growing fish over the summer and fall have higher chances of survival through the winter in some years. Meanwhile, we are collaborating with scientists at DFO to identify genetic markers for nutritional stress to eventually understand the degree to which food limitation and overwinter conditions can impact salmon health.

When PIT tagged Chinook from all study years return, we will be able to bring together these winter ecology results with PIT tag-based survival data to gain unprecedented understanding of the role of winter in regulating survival.



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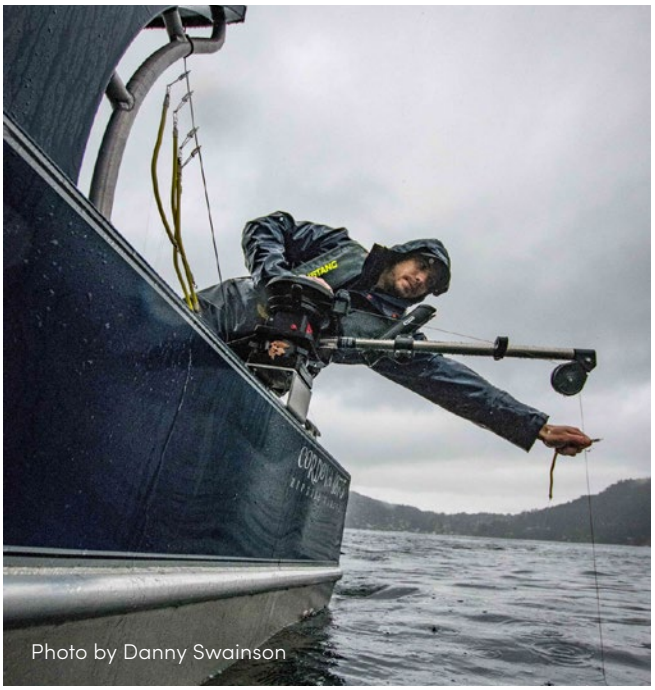


Photo by Danny Swainson

4. COHO MARINE DISTRIBUTION:

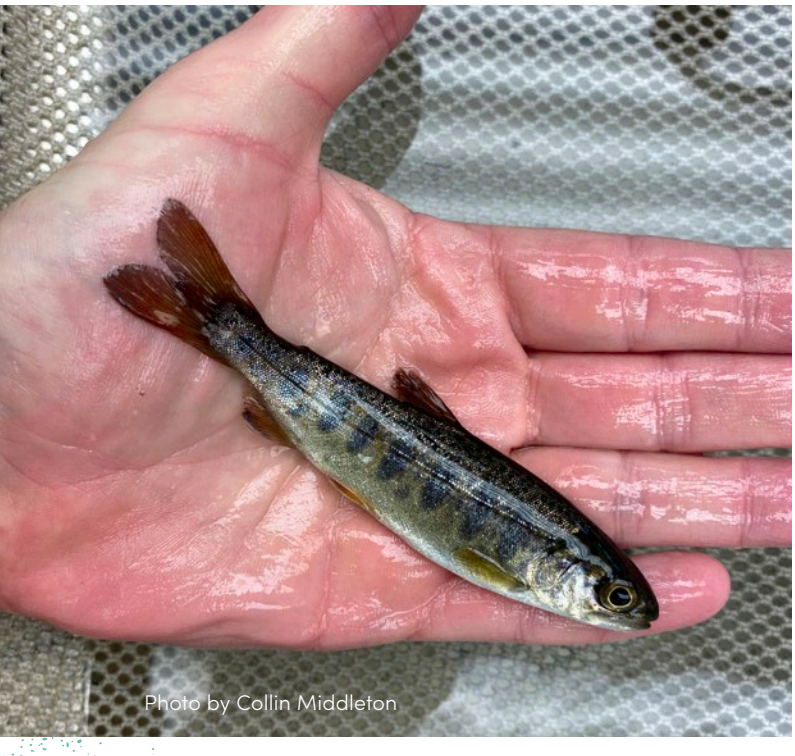
The Bottlenecks Project's microtrolling method allows for fishing in nearshore habitats, which are underrepresented in previous scientific research that used more traditional fishing methods like commercial seining or trawling. And by taking genetic samples to determine who's who, we can now start to take a look at the spatial and temporal distributions of Chinook and coho stocks in the Strait of Georgia through the first fall and winter at sea. Check out our interactive map!

Although the original objective of the project was to explore stage-specific survival of both Chinook and coho salmon, we found that our target coho stocks were near impossible to capture consistently through the winter months. It is believed that they may be leaving the Strait of Georgia in late fall, or forming large mixed schools in deeper, open waters of the Strait beyond our reach. We therefore had to cut microtrolling for coho after the first year and re-allocate those resources. However, that first year provided a valuable insight into coho marine distributions in the first fall and winter at sea. We found that coho catches were highest in September and October, particularly in the waters of the central Strait off Nanaimo and Parksville, declining through the winter months. In addition, other, non-east coast Vancouver Island stocks were found overwinter, namely Fraser and mainland stocks.

5. STEELHEAD:

To fill in some of the data gaps surrounding BC's steelhead populations, the Bottlenecks Project partnered with biologists from the Province of BC to investigate marine migrations and mechanisms of mortality of adult steelhead. To do this, mini pop-up archival transmitting tags (miniPATs) were applied to 47 steelhead kelts over three years to collect previously unattainable data on adult steelhead movements and mortality (see our Bottlenecks Newsletter Volume 3 from September 2022). These tags allow us to track the large-scale movements and behaviours of fish using a combination of light, depth, acceleration, and temperature sensors.

Overall, our tagged steelhead kelts were actively transmitting data for 0.5 to 72.6 days before the tags popped off (a presumed mortality), revealing an intricate collection of fish movements and fates. While some steelhead likely died shortly after release and thus remained local to the area, others travelled up to 2,016 kilometres making their way all the way up to the Gulf of Alaska! Furthermore, the sensor data provided insights into some of the ways that steelhead might be lost at sea, with certain patterns in light, depth, and temperature data indicating pelagic ectotherms (e.g. sharks, large fish) as some of the leading predators of steelhead. A publication of final results is in the works so stay tuned!



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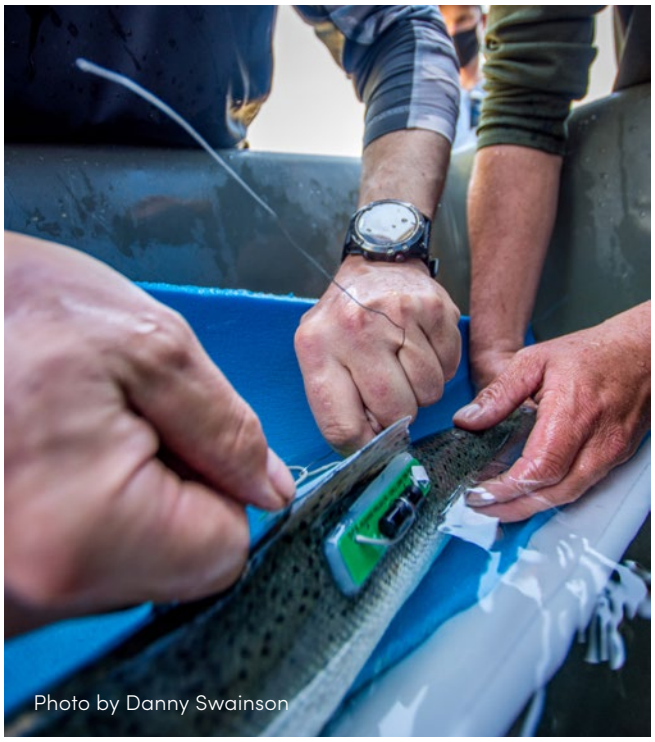


Photo by Danny Swainson

6. ENHANCED FISHERY MONITORING:

Given the hundreds of thousands of PIT tags being deployed in wild and hatchery-produced Chinook and coho through the Bottlenecks Project, PIT tag detections at cleaning tables can provide valuable information about the individual fish and the recreational fishery. 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. The camera only captures what's on the table (i.e. the fish, fishers are not visible in the frame) to inform species composition and rates of adipose clipped fish.

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, however video footage has revealed that head submission rates are low. Chinook head submission rates ranged from 11% to 25%, while coho submission rates ranged from 12% to 34%. The majority of Chinook landed were unmarked (presumed wild origin) with only 12-23% of the landings being hatchery-origin fish. The opposite was true for coho, as the majority of coho landed were of hatchery-origin (31% to 89%). Landings were also tallied by hour at one location, which showed that the largest numbers of fish were actually landed between 8 and 10 p.m. — outside of the traditional creel survey hours. This information has now been used by DFO Stock Assessment to modify creel surveys to better capture fishing activity.

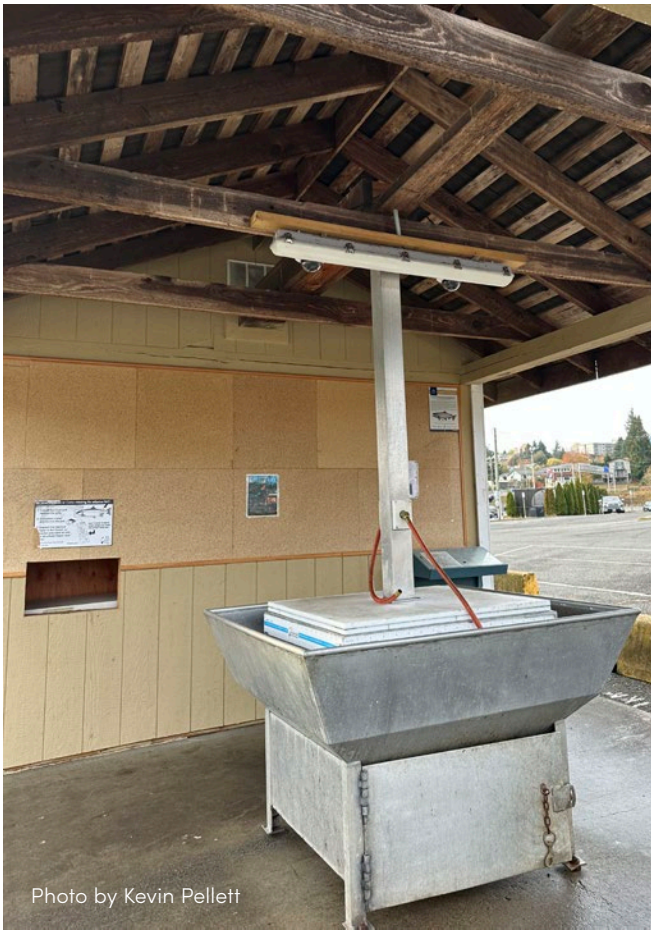
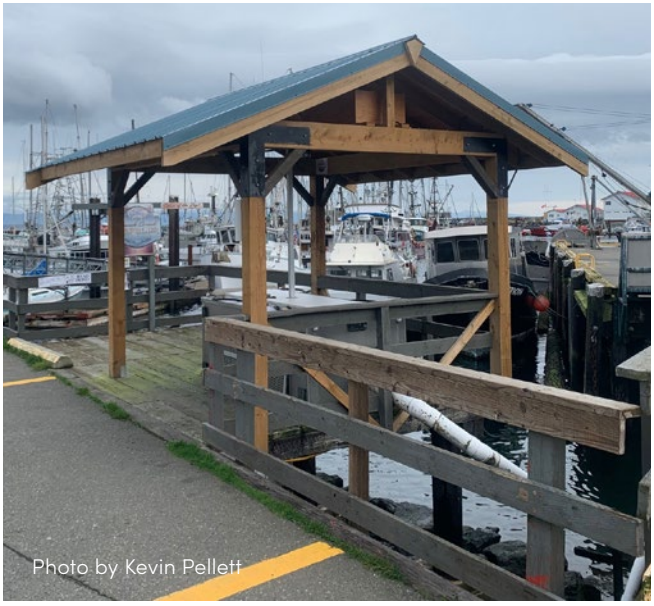


Photo by Kevin Pellett



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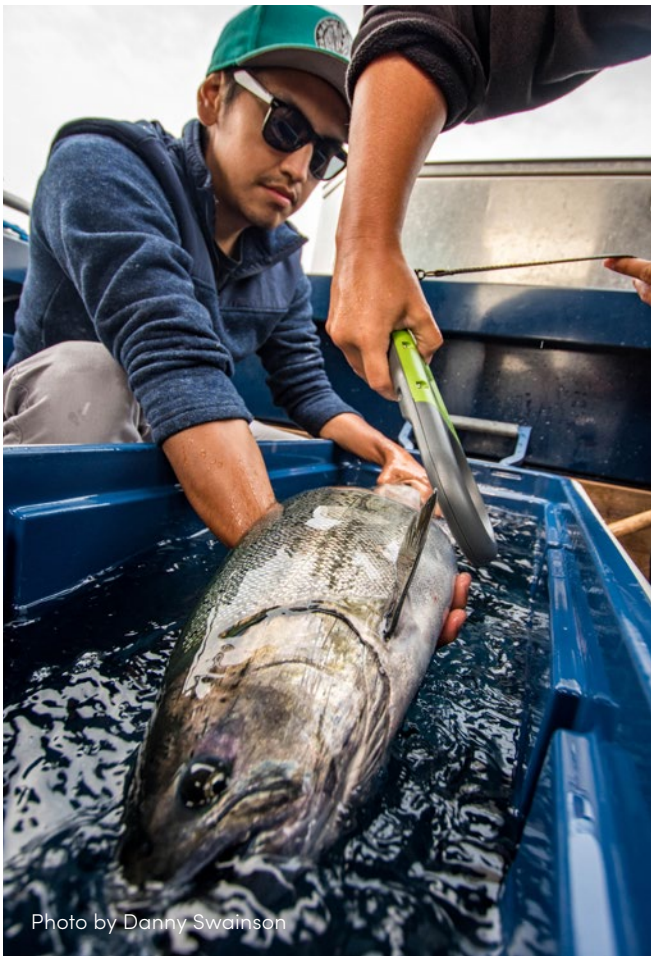

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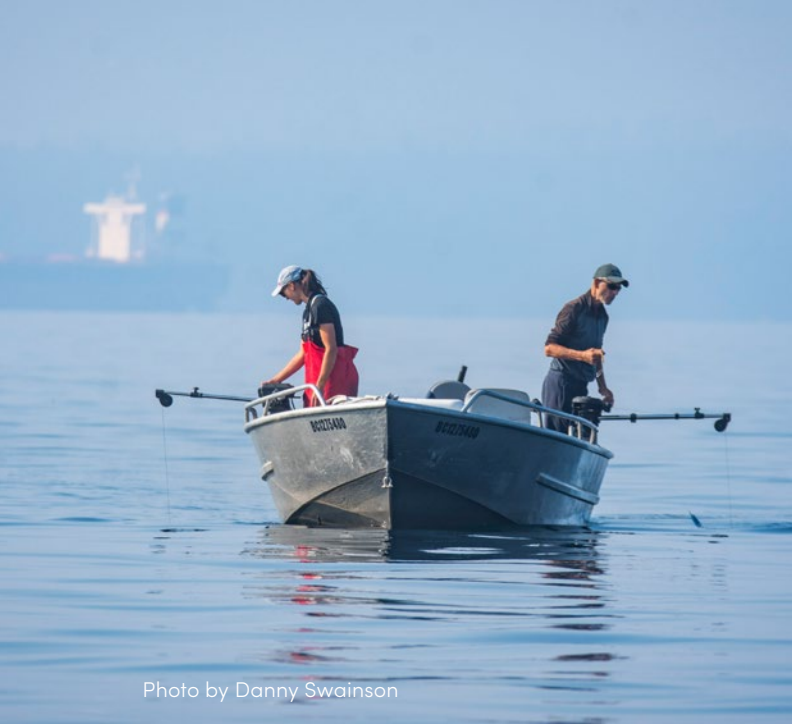

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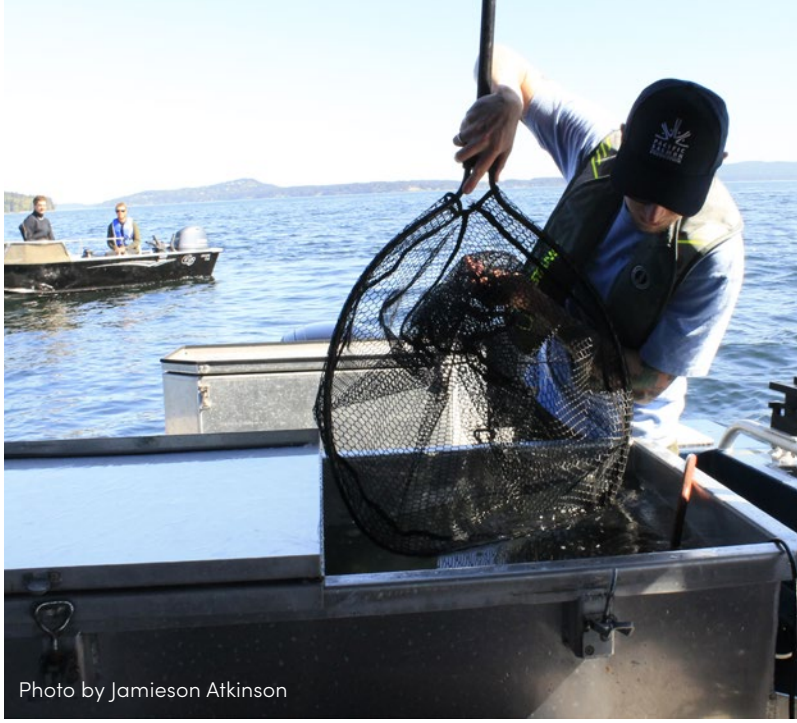

Photo by Jamieson Atkinson

PROJECT APPLICATIONS

With the infrastructure in place to tag and detect fish, we've been able to work with several First Nations, other NGOs, government scientists and streamkeepers to conduct meaningful studies with a broad range of applications. For instance, data on outmigration timing, survival, and life history strategies of the endangered Nanaimo summer-run Chinook are being collected in partnership with the Snunyemuxw First Nations, which can be used to aid in the rebuilding planning. In addition, our data have been used to supplement DFO escapement estimates, explore hatchery experimental releases, and amend creel survey practices. We've also teamed up with groups like Peninsula Streams and Shorelines to help them evaluate the effectiveness of local restoration projects by leveraging the power of PIT tags to track the fates of individual fish. We have also collaborated with the Mid Vancouver Island Habitat Enhancement Society to monitor coho and trout survival and movements in Shelly Creek, an urban system. Moving forward, we are looking to continue and expand upon these collaborations to maximize the utility of the data being produced by the Bottlenecks Project.

NEXT STEPS

Our work here is not done. Moving forward, we intend to continue the core project activities, informed by the lessons learned during the project's initial phase and will explore a number of additional topics, including: size at ocean entry of Chinook using otoliths; migration patterns of Chinook; rearing and release strategies with Quinsam River coho; freshwater outmigration survival of summer-run Puntledge Chinook; and interactions of Chinook and coho with pinnipeds through lower river and estuarine monitoring programs. More to come in our next newsletter!

FOR FURTHER INFORMATION, PLEASE CONTACT:

Sam James, PSF Project Manager
sjames@psf.ca

Jamieson Atkinson, BCCF Project Manager
jatkinson@bccf.com

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PACIFIC SALMON FOUNDATION
1385 West 8th Ave,
Vancouver, BC, V6H 3V9
Tel: 604-664-7664
Email: salmon@psf.ca

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