PACIFIC SALMON FOUNDATION

SURVIVAL BOTTLENECKS STUDY

The Pacific Salmon Foundation, together with the British Columbia Conservation Foundation, are investigating survival bottlenecks for salmon and Steelhead throughout the Salish Sea and Southern BC regions

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Photo by Danny Swainson
Cover photos by Eiko Jones and Danny Swainson

BCCF staff members pull a beach seine near the Puntledge River estuary to capture and PIT juvenile Chinook, Coho, and Steelhead as they enter the ocean.

THE PROJECT

Pacific salmon are integral to freshwater and marine ecosystems and our way of life in BC. With steep declines being observed across many wild Chinook, Coho and Steelhead populations in the Salish Sea, it is urgent that we increase our understanding of the factors and mechanisms that may be contributing to the declines.

The Bottlenecks to Survival Program, a collaboration between PSF and BCCF, is aiming to do just that. The four-year research program, which kicked off in the fall of 2020, is investigating when and where Chinook, Coho and Steelhead are facing critical mortality periods or "bottlenecks" during the freshwater and early marine periods of life. We are particularly interested in understanding how bottlenecks may be affecting juveniles from target East Coast Vancouver Island (ECVI) stocks (Cowichan, Nanaimo, Englishman, Qualicum, Puntledge, Black Creek, Quinsam) during the first-ocean-winter period, and how this may differ between fish of wild and hatchery origin. Four primary activities make up this research project and further details can be found in the first edition of this newsletter:

1. establishment of an extensive marine and freshwater PIT-tagging program and antenna monitoring network on several priority river systems and hatcheries on ECVI;
2. conducting a detailed investigation of the ecology of first-ocean-winter Chinook;
3. evaluating survival bottlenecks and hatchery optimization strategies for juvenile and adult Steelhead; and
4. modernizing recreational catch monitoring using PIT and video technology to create enhanced fishery landing sites.

Together with a network of partners including First Nations, provincial, and federal governments, academic and citizen scientists, much has been accomplished over the last year (Fall 2020 to Fall 2021). In this newsletter, we highlight the progress and early results from our first full year of work focusing on the first of the two activities listed above. A subsequent edition will report on progress on activities 3 and 4 — Steelhead optimization strategies and enhanced fishery landing sites (remember to sign up to make sure you receive all our updates).

Photo by Danny Swainson

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Top: Installation of a PIT antenna array that will record when a tagged fish passes by. Bottom: BCCF staff PIT tag and sample juvenile Coho caught moving downstream in a smolt trap in a tributary of the Englishman River near Parksville BC. All fish are released immediately following sampling and will be detected later on antennas further downstream.

PIT-TAGGING AND ANTENNAS

This part of the project expands on a previous PIT study carried out during the Salish Sea Marine Survival Program which found considerably lower survival of hatchery origin Cowichan River Chinook relative to their wild counterparts. Clearly, this was an important finding that warranted further exploration across more systems. Using the same technology as the previous work — PIT tags and antennas — the Bottlenecks to Survival Study has been busy establishing a network of strategically placed detection antennas in a number of priority river systems on the East Coast of Vancouver Island (Figure 1) and has scaled up the tagging of wild and hatchery fish in these systems and throughout the Strait of Georgia.

To achieve robust sampling that encompasses multiple cohorts and environments, and of both hatchery and wild fish, the team has been busy tagging most of this past year. Hatchery origin fish are tagged on-site prior to release with the help of our partners at three community and five DFO hatchery facilities. Working between September 2020 and May 2021, 20,000 hatchery Coho smolts and 41,747 summer and fall-run Chinook fry were PIT-tagged and released later in the spring of 2021. Meanwhile, to target wild and hatchery origin fish that have already made it to marine waters, the team was out in the Strait of Georgia micro-trolling from October 2020 through April 2021. With the help of a group of dedicated citizen scientist anglers and First Nations, 3144 juvenile Chinook and 1241 juvenile Coho were PIT-tagged, sampled for genetic information and returned to the water. Then, from May to July 2021, together with partners, we captured thousands of smolts (10,429 Chinook and 18,935 Coho) with seine nets and traps in freshwater and estuary environments along the ECVI. Each fish was tagged on location and released back into the environment.

That's right, nearly 100,000 Chinook and Coho were tagged!

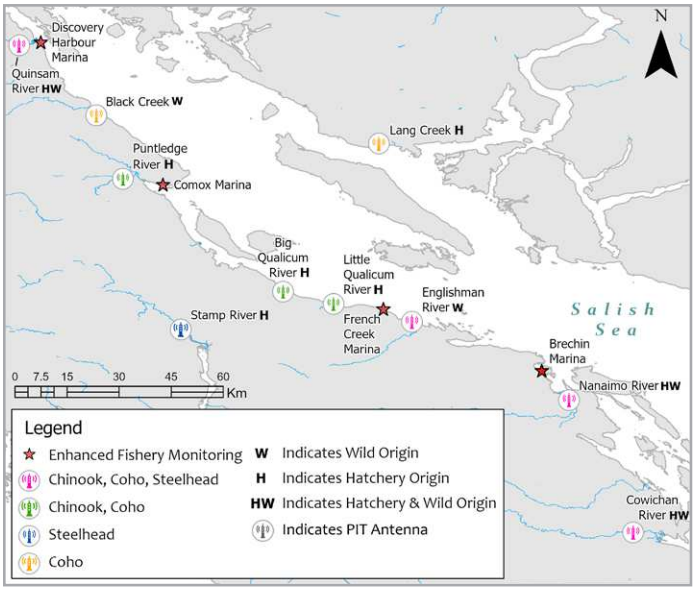


Figure 1. *Map of the Bottlenecks study region showing the locations of river systems outfitted with PIT infrastructure and target species for tagging (colour-coded circles), and recreational landing sites for enhanced fishery monitoring program (red stars).*

Full-stream PIT antenna array in the Nanaimo River near Cedar, BC. Using multiple transects in the array allows researchers to determine which direction fish are travelling.

The summer was busy too! From June to September 2021, we installed a network of seasonal and permanent mainstem, side-channel, and hatchery PIT-antennas in our target systems: the Cowichan, Nanaimo, Englishman, Qualicum, Puntledge, Black Creek, and Quinsam Rivers (Figure 1). The antenna systems are made up of a sensor encased in HDPE piping that are placed across the entire width of the river, fixed to the river bed and connected to a master controller. As a PIT-tagged out-migrating or returning fish passes by the sensors, its unique tag code is recorded along with the time and stored for download.

Similar antennas have also been set up to detect tags at predator hot spots (i.e. seal haul-outs and heron rookeries), and new recreational cleaning tables have been outfitted with PIT-antennas to allow for detections of fish that survived until capture by recreational fisheries. All of these detections, in river, at cleaning tables and at predator haulouts allow us to build a picture of the migration histories and fates of tagged individuals as they make their way through freshwater and marine environments.

Now what?

In fall 2021, we began to see small numbers of tagged Chinook and Coho returning to our target systems; these data are forming preliminary estimates of marine survival and run-timing curves for returning adults. In addition, this extensive investment in antenna infrastructure provides the foundation for new studies and collaborations utilizing PIT technology throughout the Salish Sea region.

JUVENILE WINTER ECOLOGY

It is widely believed that the first winter in the ocean plays a critical role in regulating salmon survival, however, very little is actually known on the subject. Working with our partners at the University of Victoria (UVic), we are beginning to address this knowledge gap by collecting some of the first data on the winter habitat, diet, and health of juvenile Chinook.

Through the darkest days of winter 2020-21 and 2021-22, researchers from UVic went out on the water for over 70 field days to sample and tag more than 700 juvenile Chinook. The fish were captured using micro-trolling techniques. Some fish were sacrificed and sampled for tissue and stomach content analysis while others were outfitted with PIT tags. The depth and location of where each fish was collected from are also recorded to give an indication of the habitat use and behaviours of young Chinook at this time of the year.

Early assessment of growth, condition, stomach contents, and energy density suggest the late winter may indeed be a critical period of physiological stress that may elevate mortality rates of juvenile Chinook during their first year in the ocean. While the indicators show that the fish are apparently growing, increasing their energy content, and maintaining their body condition through late-fall, by mid-late winter, their condition declines as they become skinnier and exhibit slower growth and lower in energy density until spring (Figure 2). These results, along with assessments of previous growth (determined from scale rings), disease status, and pathogen loads (determined using novel molecular techniques), and robust bioenergetic models, will contribute to a comprehensive picture of the role of winter in regulating Chinook survival.

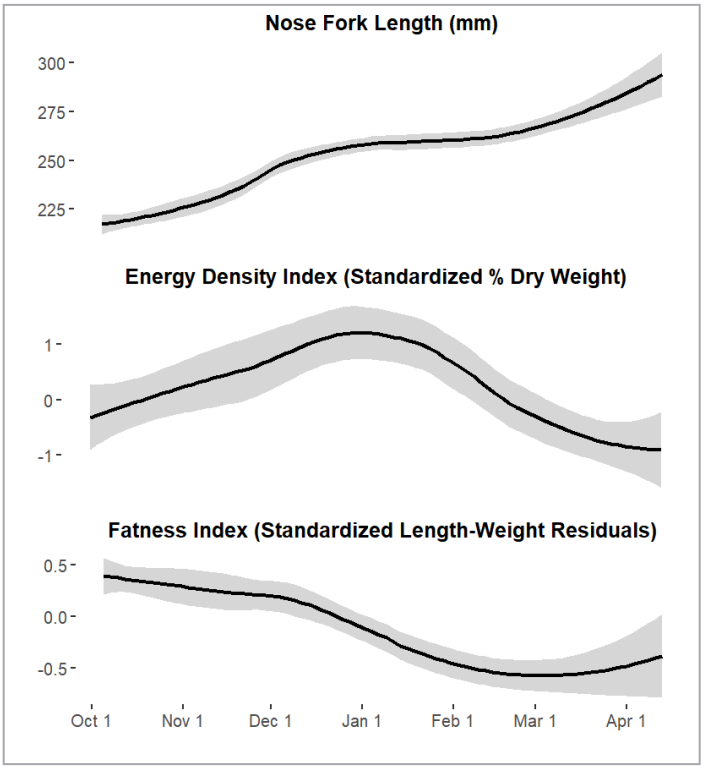


Figure 2. *Smoothed trends in size (length), and indices of energy content and condition (fatness) for juvenile Chinook sampled in the Northern Strait of Georgia in their first marine winter (Winters 2020-21 and 2021-22). Through the fall and early winter these fish are apparently growing, increasing their energy content, and maintaining their body condition. In mid-late winter growth slows and fish begin to become skinnier and lower in energy density.*

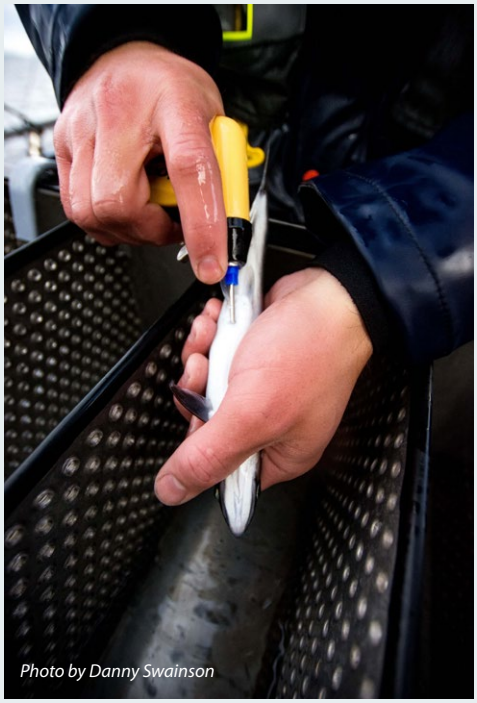


Photo by Danny Swainson

So, what are PIT tags?

PIT tags, or Passive Integrated Transponders, are tags that are inserted into and remain in a salmon's body. The tags are small enough that they can be used on juveniles as small as 70 mm. Each PIT tag has a unique identifier and when a fish passes through or over an antenna, this information (which includes the original location of tagging, size of the fish at tagging, and whether the fish was a hatchery or wild fish) is recorded.

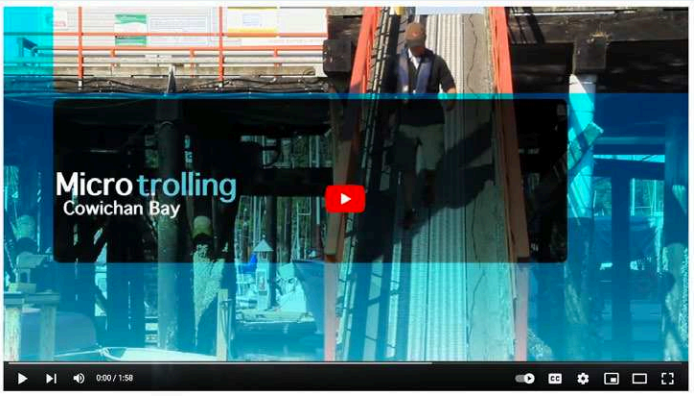
Here is a short video of PIT tags being inserted into Coho at Nanaimo Hatchery:

In a hatchery a juvenile salmon is having a PIT tag inserted. The tag, which will remain inside the fish, will relay an identifying code as it goes past detection antennas along the rivers. The will allow us to better understand the timing of migrations and estimate mortality rates.

And, what is micro-trolling?

To differentiate survival rates and to identify survival bottlenecks, the project requires collection of fish over their first summer, fall and winter from the Salish Sea. While it is relatively easy to tag captive juvenile hatchery fish, it is far less simple to safely collect, tag and return juvenile fish in the marine environment. To effectively target these small fish, special techniques and gear that the team has developed and coined 'micro-trolling' are required. (see Duguid and Juanes, 2017). Similar to normal recreational fishing, micro-trolling involves gear such as hooks, spoons and flashers to attract and land the fish as a boat trolls along in the water. The only difference is that the gear is miniature sized to allow us to target the necessary cohorts for the study while reducing harm to the fish.

Here is a short video of Dr. Will Duguid, part of our bottlenecks team, explaining what microtrolling is:



THANK YOU TO OUR MANY PARTNERS!

Cowichan Tribes, Cowichan Hatchery, Thornton Creek Hatchery, River Quest Charters, DFO (Stock Assessment Division), DFO (Salmon Enhancement Program), FLNRORD, Nanaimo River Stewardship Society, Mosaic Forest Management, Snuneymux First Nation, Toquaht Nation, Nanoose First Nation, Komoks Nation, Sechelt First Nation, A-Tlegay Fisheries Society, Tsolum River Restoration Society, Mid-Vancouver Island Habitat Enhancement Society, Nature Trust of BC, Cedar Grove Campground, City of Courtenay, Peninsula Streams Society, Freshwater Fisheries Society, Goldstream Volunteer Salmonid Enhancement Association, Bright Fish Charters, Northwest Saltwater Adventures, Tipsup Fishing Adventures, Island Pursuit Sport Fishing, Coastal Wilderness Adventures, Bon Chovy and Robin Sharko, The University of British Columbia, University of Victoria, Simon Fraser University and University of Northern British Columbia.

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UBC The University of British Columbia

Cowichan Tribes

Snuneymuxw First Nation

K'ómoks First Nation

A-Tlegay Fisheries Society

Toquaht Nation

Freshwater Fisheries Society of BC

Nanaimo River Stewardship Society

MVIHES Mid Vancouver Island Habitat Enhancement Society

Nature Trust British Columbia

Thornton Creek Enhancement Society

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