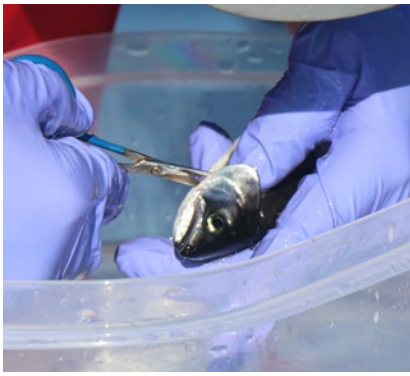
PACIFIC SALMON FOUNDATION



SALMON MIGRATION STUDIES

BOTTLENECKS TO SURVIVAL

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Photo by Eiko Jones
Cover photos by Will Duguid (top) Nick Bohlender (left and right), and Eiko Jones (centre)

We often think of salmon as world-class migrators. For example, Yukon River Chinook salmon migrate 3000 kilometres — and that's only to travel between the estuary and their upstream spawning grounds. British Columbia salmon commonly migrate to Alaska, while others migrate to the west of coast of BC and Washington State. In contrast, some Chinook salmon from rivers draining into the Salish Sea seem to be homebodies, staying close to their home rivers. We are left wondering: what are the implications of staying close to home for the overall survival of Strait of Georgia Chinook?

WHY DO SALMON MIGRATE?

After entering the Strait of Georgia as smolts, Chinook salmon from east coast Vancouver Island streams face a classic dilemma: Should I stay or should I go? Some salmon, called migrants, leave for the prey-rich continental shelf off the west coast of Vancouver Island and further north. Others stay resident in the Strait of Georgia, where they spend most or all of their marine life. Migrants travel hundreds or even thousands of kilometres to reach feeding grounds — and then they must swim just as far back to their natal streams to spawn. In contrast, residents might spend their entire marine life within a day's swim of their natal river.

We don't know much about these different migration strategies. For example, which fish become migrants versus residents? Do the big fish become residents and smaller fish are forced out to find a new home? Or are the large, strong fish willing to swim to the west coast for better food, while the small fish stay close to home? There may even be a third strategy, where juvenile salmon move between the Salish Sea and the continental shelf multiple times.

To fill these knowledge gaps, the Pacific Salmon Foundation is supporting University of Victoria student Wesley Greentree to track juvenile Chinook salmon as they migrate (or don't migrate!) out of the Salish Sea for his MSc research (Figure 1).

Photo by Nick Bohlender

Figure 1: *Wesley Greentree with an acoustic receiver that will monitor salmon movements off Comox.*

HOW DO YOU TRACK SALMON?

Wesley, who is supervised by Professor Dr. Francis Juanes and Postdoc and Bottleneck Program Manager Dr. Will Duguid, uses **small electronic tags that emit high-frequency pings ("acoustic tags") to track salmon** as they move around. Together with collaborators from LGL Limited, Fisheries and Oceans Canada, and British Columbia Conservation Foundation, they use microtrolling to safely catch juvenile salmon and tag them (Figure 2). Salmon are anesthetized and the acoustic tag is inserted into the body cavity through a small incision, which is closed with three sutures (Figures 3 and 4). A PIT tag is also inserted into the body cavity so that acoustic-tagged salmon can be detected by Bottlenecks PIT arrays when they return to the river to spawn. Once the salmon recovers from anesthesia and has returned to normal swimming behaviour, it is released to continue on its migration (or lack thereof). The team takes careful precautions to minimize the effects of the tagging procedure on the fish — maintaining fish welfare is important in its own right and, further, ensures that tagged salmon survive and behave like untagged salmon, which is key to study success.

Wesley never thought his childhood passion for salmon would lead to conducting fish surgery. To learn the surgical techniques to implant acoustic tags in salmon, he trained under Lucia Ferreira from the environmental consulting firm LGL Ltd. Lucia is one of the most experienced fish taggers in western North America, having surgically tagged more than 10,000 fish of many different species. Lucia's vast experience was critical to Wesley learning how to acoustic tag.

Figure 4: *Lucia Ferreira closing the acoustic tag incision with sutures.*

Figure 2: *Juvenile Chinook salmon are caught by the microtrolling vessel (right), then transferred to the tagging vessel (left). Once tagged, the salmon is given time to recover before swimming away to either out-migrate to the west coast or move within the Salish Sea.*

Figure 3: *Mid-surgery on the tagging vessel, with the microtrolling vessel fishing nearby.*

These acoustic tags produce a series of pings every two minutes that encode the tag's unique identifier. When an acoustic-tagged salmon is within range (about 400 – 1000 metres) of a hydrophone listening for acoustic tags, the salmon's identification code and location are logged. Several hundred of these hydrophones, called acoustic receivers, are deployed along Vancouver Island, as well as in Puget Sound and the outer coast of Washington state. This network of acoustic receivers allows researchers like Wesley to track salmon as they move within the Salish Sea and migrate to the continental shelf. Acoustic telemetry technology has exploded in popularity in recent years, providing insights into fish movement ecology useful to fisheries management.

In addition to the many hydrophones deployed on the sea floor, Wesley and Will hang a hydrophone under their vessel when microtrolling for other Bottlenecks to Survival Project objectives. Often, when acoustic tagged salmon can be heard near the boat, the fishing is good! Through this "mobile tracking" of tagged salmon, they have detected salmon where they were tagged at Comox and further away, including off Quadra Island and Salmon Point near Campbell River.


Photo by Mitch Miller

HOW DO ACOUSTIC TAGS COMPARE TO OTHER TYPES OF TAGS USED IN THE BOTTLENECKS PROGRAM?

This particular study uses acoustic tags, which provide information on where a salmon goes anytime it is near enough to a receiver. How do acoustic tags differ from PIT tags that are the backbone of the larger Bottlenecks to Survival study and satellite tags which have been used to see where steelhead kelts travel?

Here is a table comparing these three tags:

Tag type:	Acoustic	PIT	Satellite
Cost per tag	$400-800	$3	$2000-3000
Life of tag	Up to 2.5 years	Indefinite	Variable, commonly up to 6 months
Implantation	Surgical incision	Injected with needle	External attachment
Size	2-5 grams	0.1 grams	60 grams
Minimum fish size it can be applied to	140 mm (large smolts)	70 mm (fry)	500 mm (subadults and adults)
Special features	Specialized acoustic tags can measure swimming depth, water temperature, and acceleration	Tag doesn't have a battery, instead powered by PIT array when fish passes — tag can't run out of battery	Tag "pops off" fish when fish dies, providing mortality location data
Best for	Tracking marine movements within defined area monitored by receivers	Large scale studies of survival (e.g., 10,000-100,000 fish)	Provides detailed information on movements in open ocean, where receivers cannot be installed
Drawbacks	Finite battery life Requires network of receivers to collect information, costly	Cannot be detected in saltwater	Costly Large external tag may hinder swimming performance


Acoustic


PIT


Satellite

WHY DO MIGRATION STRATEGIES MATTER?

While we don't know if migrants and residents differ in body size before the migrants out-migrate, previous studies indicate that migrants can take advantage of high-quality prey sources off the west coast to grow much larger than residents. Larger salmon can produce more offspring, which raises the question why don't all Chinook salmon become migrants?

Since some salmon stay resident in the Salish Sea, there must be trade-offs associated with each migration strategy. Food resources, predator abundance, and fishing pressure likely all differ between the Salish Sea and the west coast of Vancouver Island. Inevitably, there must be trade-offs between the costs of migration and benefits of migrating. By linking migration strategies to individual traits like body size and early marine growth rates, Wesley hopes to gain insight into why some salmon migrate far and others stay close to home.

We also don't know if one migration strategy leads to higher marine survival. Some stocks are highly resident in the Strait of Georgia, while other stocks tend to not just migrate to the continental shelf but far north to Alaska. Other research suggests that stocks with similar marine distributions experience similar survival rates. This makes sense, as marine movements dictate the risks and rewards that salmon experience. Therefore, understanding migration strategies is a key step in the Bottlenecks Project's objective to identify when, where, and which salmon experience high mortality in the ocean.

Photo by Will Duguid

THE FIRST FIELD SEASON

Wesley and the acoustic tagging team recently finished their first year of tagging (Figures 5-7). In October 2022 the team tagged in calm and sunny weather off Comox in the northern Strait of Georgia. Over four days, they tagged 95 Chinook salmon entering their first winter at sea (fork length: 18-27 cm). In contrast, during the next tagging block in January 2023, the team had to warm up with the boat's heater between tagging each fish. Over four days, they tagged 55 Chinook salmon (fork length: 21-33 cm). The 150 tagged salmon will provide an exciting view into Chinook salmon movement behaviour.


Photo by Nick Bohlender

Figure 5: *Wesley collects a small biopsy of gill tissue, which will be analyzed for pathogen load and transcriptomic markers of fish health by Fisheries and Oceans Canada's Molecular Genetics Lab.*

This study uses long-lived acoustic tags that will continue to ping for up to 2.5 years — meaning they will be tracking the first year's tagged Chinook until 2025. As a result, the team will gain a high-resolution view into how salmon move throughout the ocean. Already, after only 6 months, the tagged salmon have been detected more than 200,000 times. Needless to say, the team is excited to see where the salmon migrate, as well as where they stay for longer periods of time.

Early results show that Chinook salmon made very different movements during their first winter at sea. Many salmon stayed close to Comox where they were tagged, moving between Cape Lazo and Denman Island. A few fish remained in such a small area at Comox over consecutive days that Wesley assumed the fish had died, then the fish moved away from Comox later in the winter. Away from Comox, two fish migrated out of the Salish Sea past Port Hardy. Another fish made it to Victoria. One fish left the Strait of Georgia, was detected in the Discovery Islands north of Campbell River, then returned to Comox a month later — we are not sure. Overall, the team is excited to see where these fish move and eagerly awaits further data as the tagged salmon continue to move around coastal British Columbia.

To learn more about this research, check out this video from Pacific Salmon Foundation.

Figure 6: *What a field team! Lucia Ferreira (LGL), Jake Dingwall (PSF), Will Duguid (UVic/PSF), Katie Innes (UVic).*

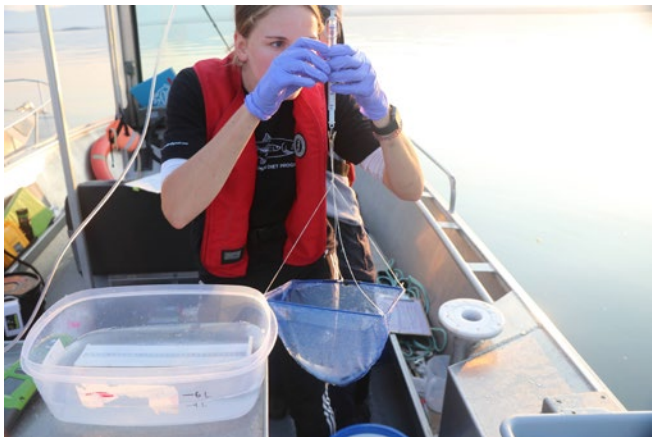

Figure 7: *Field scientist Katie Innes (UVic) weighs a salmon before tagging.*

Figure 8: *Will and Jake Dingwall (PSF) wait with anticipation for their microtrolling catch.*

FOR FURTHER INFORMATION, PLEASE CONTACT:

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WHAT'S NEXT?

Wesley is excited to continue tagging Chinook salmon in winter 2023/2024. In the second year of tagging, he will continue to study salmon movements in the Salish Sea and identify which fish leave. Additionally, in the second year of the study, additional specialized acoustic tags equipped with depth sensors will provide an exciting three-dimensional look at salmon habitat selection in the ocean. Together, the two years of tagging will provide a novel and extensive dataset on salmon movements in the Salish Sea and beyond.

Stock-specific data on Chinook salmon distributions and migration patterns are a key part of salmon fisheries management, with spatial fisheries closures becoming a leading management measure in British Columbia. Through this study, the team hopes to fill important gaps about the movement behaviour of Strait of Georgia Chinook salmon, particularly

1) **when migrants leave the Salish Sea** and
2) **if migrants and residents differ in early life traits (e.g., size, early marine growth, pathogen load) before migration occurs.**

Further, the results of this study will inform broader efforts by the Bottlenecks to Survival Project to model stage-specific survival and the bioenergetic status of Chinook salmon. Together, the Pacific Salmon Foundation and partners like the University of Victoria are working to develop management-relevant insights into the survival and ecology of Pacific salmon in British Columbia.

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