BOTTLENECKS TO SURVIVAL
FIRST MARINE WINTER COHO SALMON DISTRIBUTION IN THE STRAIT OF GEORGIA

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PACIFIC SALMON FOUNDATION

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EXECUTIVE SUMMARY

Declines in the abundance of Chinook and coho salmon, and steelhead in the Strait of Georgia have resulted in ecological, economic, and cultural impacts throughout the Pacific Northwest. Established approaches cannot pinpoint periods of elevated mortality (survival "bottlenecks") that may be responsible for these declines. Identifying survival bottlenecks and their causes is necessary to evaluate the relative costs and benefits of strategies that improve survival at specific life stages, including decisions around hatchery rearing and release strategies. The primary objective of this study was to enhance our understanding of the marine distributions of juvenile coho within the Strait of Georgia during their first marine winter. By employing microtrolling techniques, we aimed to capture and monitor juvenile coho throughout their first marine winter (i.e. August to May) of each study year (2020 – 2024) to collect comprehensive data on their spatial and temporal distribution patterns, and create a detailed interactive marine hotspots map. This report explores the first study year 2020-2021.

Microtrolling efforts as part of the *Bottlenecks Program* provided a unique dataset to explore marine distributions of coho in the Strait of Georgia. Unlike historical data collected using large vessels, the small vessels and micro fishing gear allowed us to sample previously unexplored habitats and throughout the winter months. This innovative approach demonstrated that microtrolling can be an effective method of capturing first winter coho. While the extremely low catches during the late winter posed challenges for the broader survival objectives of the *Bottlenecks Program*, we were able to effectively map the spatial and temporal distributions of coho during their first marine winter.

The catch per unit effort (CPUE) and stock distribution data collected through microtrolling highlighted the benefits of this method in sampling different depths and nearshore environments and provided new information on first-year coho distributions. Most areas sampled in the *Bottlenecks Program* did not overlap with Fisheries and Oceans Canada trawl survey data, which offered different insights.

The Eastern Strait of Georgia and East Coast Vancouver Island target (ECVI) stock groups were prevalent in several Pacific Fisheries Management Areas (PFMAs), particularly during the late summer and early autumn months. Fraser River stocks were consistently present across multiple months, indicating their widespread distribution. The temporal distribution of CPUE indicated that coho presence peaks around October, declines during winter, and increases in early spring around the Discovery Islands. Spatially, coho were consistently captured in PFMAs 17 and 14, especially in October and September, respectively. This pattern suggests that coho may form large mixed schools during these months, potentially moving offshore to the Pacific Ocean or to deeper waters within the Strait of Georgia, which could explain the sharp decline in catches after October.

In conclusion, this study highlights the effectiveness of microtrolling in providing detailed data on the spatiotemporal distributions of juvenile coho. The identified hotspots for coho provide information on key first-year foraging habitats, which had not been previously sampled. However, an analysis of key habitats utilized by coho was not explored in this report but will be completed in the future. The insights gained from this research corroborate results from previous studies; however, new information has been obtained, which is important for understanding the seasonal migration patterns and habitat preferences of juvenile coho and can likely facilitate predictions of their interactions within the food web and their impact on the marine environment.

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INTRODUCTION

Declines in coho salmon (*Oncorhynchus kisutch*) populations in the Strait of Georgia (SOG) since the 1970s have necessitated widespread fisheries closures and have had significant ecological, economic, and cultural impacts in British Columbia (BC) (Beamish et al. 2008; Beamish and Neville 2021). Targeted closures of commercial SOG troll fisheries were implemented in the 1990s to try and prevent further coho declines, decreasing commercial harvest rates by 90% between the 1980s and 2000s. The economic consequences of these population declines have been substantial, as marine recreational fisheries in BC generate over $700M in annual revenue (Bradford and Irvine 2000; Zimmerman and Reeves 2002; Beacham et al. 2019).

Over the years, a large body of research investigating the potential causes of these declines has accumulated. The dominant hypotheses include predation, disease, competition, climate change, and fishing mortality, but the relative contributions of each remain uncertain. Evidence also suggests that the first year in the marine environment is pivotal in regulating Pacific salmon productivity (Beamish and Mahnken 2001; Beamish et al. 2008, 2010; Bass et al. 2023; Nelson et al. 2024). Understanding the factors limiting productivity is critical for communities in the Northeast Pacific, given the significance of coho (Irvine and Ward 1989; Bradford and Irvine 2000; Nelson et al. 2024).

Collecting information on coho marine distributions throughout the first winter provides insight into their habitat preferences and the spatiotemporal distributions of stocks during this critical rearing and foraging period. Further, by providing stock distributions alongside coho presence and abundance, we gain information on stock-specific marine survival rates, which are highly variable (James et al. 2024).

Historical studies have typically used coded wire tags (CWTs) to assess coho marine distributions, with few utilizing genetic analysis (Weitkamp and Neely 2002; Quinn et al. 2005; Weitkamp et al. 2011). Many of these studies focused on developing forecast models for escapement estimates for hatchery stocks but were conducted only during the summer months, and made several assumptions for wild cohorts due to limited data (Weitkamp and Neely 2002; Beamish et al. 2010; Beacham et al. 2020; Beamish and Neville 2021). However, these studies did indicate distinct marine distribution patterns, low distribution overlap with Chinook (*Oncorhynchus tshawytscha*), and differential habitat use by Chinook and coho (Weitkamp and Neely 2002; Quinn et al. 2005; Weitkamp et al. 2011; Beacham et al. 2017).

Current information on the marine distributions of coho in the Strait of Georgia indicates that coho migrate into the Strait in the spring and reside in deep open water habits, residing mostly in the surface water down to 45 m, for five months before migrating to the Pacific Ocean in October and November (Beamish et al. 1999, 2010; Chittenden et al. 2009; Beamish and Neville 2021). This research also suggested that some coho resided within the Strait of Georgia for their entire life, with only a portion migrating to the Pacific Ocean. This resident life history strategy experienced significant declines during the 1990s (Beamish et al. 1999). However, the sampling frequency of this program was not sufficiently high to assess fine-scale spatial and temporal marine distributions in the Strait of Georgia. Although these studies primarily represented hatchery stocks, they provided a baseline for comparisons between hatchery and wild coho distributions that would otherwise be unavailable (Weitkamp and Neely 2002; Quinn et al. 2005; Weitkamp et al. 2011; Bass et al. 2023).

While these historical studies provided a foundation for marine assessments of juvenile coho, they sampled from large research or commercial fishing vessels using purse seine, trawl, or trolling methodologies which have inherent biases (Weitkamp and Neely 2002; Quinn et al. 2005; Weitkamp et al. 2011; Bass et al. 2023). Trawl surveys only sample a fixed portion of the water column, which may reduce captures of coho from deeper or shallower areas (Beamish et al. 2010). Additionally, due to the size of the research vessels, sampling was typically confined to deeper, more open-water environments, preventing high-effort sampling within nearshore and shallower areas of the Discovery and Northern and Southern Gulf Islands. Finally, these studies were mostly conducted during the spring, summer, and fall months, with few sampling events throughout the winter (Weitkamp and Neely 2002; Beamish et al. 2010; Weitkamp et al. 2011; Zimmerman et al. 2015; Beacham et al. 2019; Beamish and Neville 2021; Bass et al. 2023).

Biases associated with traditional sampling methodologies for salmon, particularly young-of-the-year coho, are crucial considerations in fisheries management and research. Sampling high in the water column in relatively small sampling areas, which are limited to larger, more open-water habitats due to vessel size, can impact the accuracy and representativeness of collected data. Studies have highlighted challenges in sampling fish at different depths, with variations in catch rates observed based on vertical distribution (Stockwell et al. 2007). Understanding the spatial distribution of ocean habitats for salmon has been highlighted as a critical factor in predicting the presence of Chinook and coho, underscoring the importance of considering habitat accessibility in sampling designs (Bi et al. 2007). Small sampling areas can lead to biases in estimating fish abundance and population dynamics (Bonvechio et al. 2008). Addressing these biases through alternative sampling designs and innovative technologies is important for comparing against previous research using more traditional methods.

The Bottlenecks to Survival Program (*Bottlenecks Program*), a partnership between the Pacific Salmon Foundation (PSF) and BC Conservation Foundation (BCCF), was initiated to investigate trends in survival rates of coho, Chinook, and steelhead in the Strait of Georgia. One of the Program's primary objectives was to capture coho in their first marine winter and apply Passive Integrated Transponder (PIT) tags to map the spatiotemporal distributions of first-winter coho and develop stage-specific survival estimates. This approach aims to pinpoint survival bottlenecks and better understand the factors limiting survival. The program employed a novel fishing technique, "microtrolling," using small recreational vessels and micro-sized lures to capture first-winter salmon (Duguid and Juanes 2017). This method allowed for discrete sampling of nearshore environments that are largely underrepresented when using traditional sampling methods (i.e., seining, trawling, and trolling) (Beamish et al. 2010; Weitkamp et al. 2011; Beacham et al. 2019; Beamish and Neville 2021;

Bass et al. 2023). In addition, by applying Parentage Based Tagging or Genetic Stock Identification analysis on all sampled coho, the program was not restricted to using CWT's for stock identification, allowing for direct comparisons of hatchery and wild coho (Beacham et al. 2020). Thus, we used the novel technologies and methodologies of the *Bottlenecks Program* to shine a new light on the marine distributions of coho in the Strait of Georgia.

Purpose

The primary goal of this research was to advance our knowledge of the marine rearing locations and distributions of juvenile coho within the Strait of Georgia (SOG) during the first marine winter.

Specifically, this study aimed to achieve the following objectives:

1. Utilize microtrolling as an effective method for capturing and monitoring juvenile coho in the Strait of Georgia.

2. Collect comprehensive data on the spatial distribution patterns of coho during their first winter in the marine environment.

3. Create a detailed marine hotspot map that visually represents the areas within the Strait of Georgia where juvenile coho were found during winter.

4. Develop a stage-specific survival model for coho.

By accomplishing these objectives, this study aimed to provide valuable insights into the first winter marine distributions, of juvenile coho within the Strait of Georgia, thereby contributing to the development of informed conservation strategies and fisheries management practices.

MATERIALS AND METHODS

Study Area

The Strait of Georgia is an inland sea located on the eastern side of Vancouver Island and bordered by the Strait of Juan De Fuca, Puget Sound, and Johnstone Strait (**Figure 1**). The area spans from Campbell River on Vancouver Island to the Olympic Peninsula. The *Bottlenecks Program's* target systems are located on the ECVI (Goldstream, Cowichan, Nanaimo, Englishman, Little Qualicum, Big Qualicum, Puntledge, Black Creek, and Quinsam rivers).

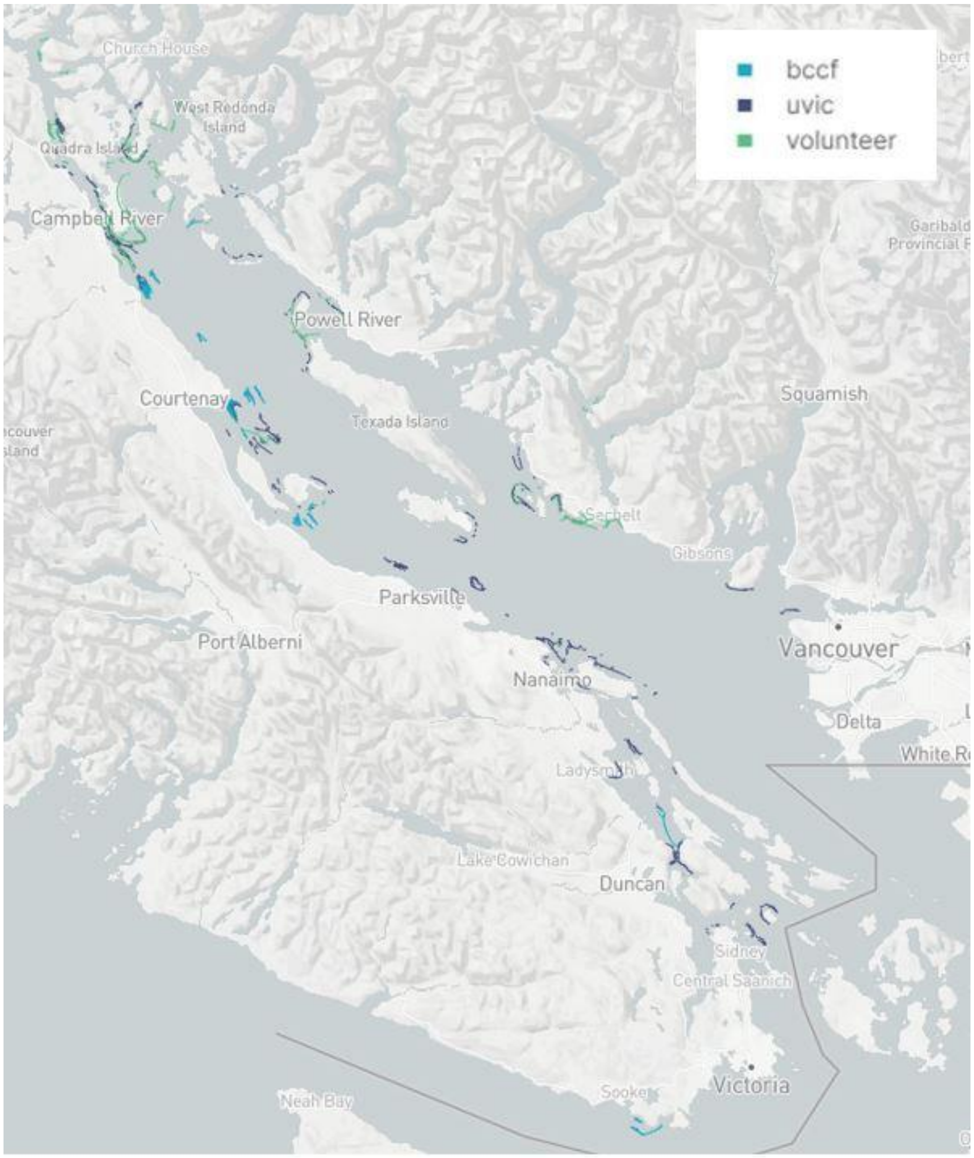

Figure 1. Map of the Salish Sea depicting sampling locations using arcs, for each microtroll sampling day. Map developed using the Bottlenecks Data System (White-Gluz 2024).

Microtrolling

In the 2020-2021 study year, the *Bottlenecks Program* targeted first ocean winter coho in marine waters from August to May. However, after the first year microtrolling for coho, a number of limitations, including low catches mid-winter and low captures of target coho stocks, led to a decision to avoid coho and focus microtrolling efforts on Chinook. Coho captures in the second and third years of the program were enumerated and sampled for fork length and visual health, but quickly released otherwise unprocessed. In the fourth year, incidental coho catches were fully processed and tagged; however, coho were still generally avoided. Given the avoidance of coho for the purposes of the broader *Bottlenecks Program*, only the first year (2020-2021) of microtrolling data were used in this report to describe marine distributions and catch per unit effort.

Microtrolling was conducted by BCCF staff, personnel from the University of Victoria, PSF's volunteer angler program, and First Nation partners. Each microtrolling vessel was equipped with two downriggers (minimum of 91 m of braid or cable) upon which up to 12 clips (6 per downrigger) can be deployed simultaneously. A 'clip' is defined as one fishing line consisting of 2 m of clear 22.3-26.7 kg monofilament with a trolling clip (typically Scotty 7.5 to 12.5 cm), snubber (Luhr-Jensen Dipsy Diver Rubber Snubber, 30 cm heavy), and flasher (Hot Spot 'Micro' Plaid Mylar), connected by snap swivels to a 3 ft leader (Maxima Ultragreen 6.7 kg monofilament) with a spoon (Dick Nite #1 Nickel or Gibbs Mini G) and hook (Mustad #10 Signature C67S egg/caddis fly hook, August and September; Gamakatsu #10 siwash open eye, October to March).

The bottom clip is attached to the cable approximately 2.5 m above the cannonball (5.3 – 8.0 kg), with any remaining clips attached at a specified interval depth. The interval depth varies based on the depth of the fishing area and desired fishing depths and can vary throughout the day. The clips are "fished" for five minutes and retrieved, checked, and re-set. The time and GPS location are recorded at the start (as soon as the first clip enters the water) and end (when the last clip is out of the water) of the set.

A detailed standard operating procedure document describing microtrolling methods and use of the EForms Mobile data collection app (Rodgers et al. 2021) is attached.

Fish Handling & Biodata Collection

Once landed, salmon were transferred into an aerated livewell containing an anesthetic bath prepared with local seawater and 50 mg/L of tricaine methanesulfonate (TMS) following the Canadian Council on Animal Care's standardized methodology (Ackerman, Morgan & Iwama 2005). All anesthetic baths included Vidalife (Syndel Canada, Nanaimo, BC), a water conditioner that preserves the fish's natural mucous layer to help prevent abrasions (Syndel 2019). Once fish were adequately anesthetized (i.e., slowed breathing and movement, subdued response to touch), they were handled carefully and quickly to reduce both TMS and air exposure. Fish were held firmly but gently (not squeezed), and returned to water between procedures/measurements to reduce stress.

Fish were assessed for any injuries, either pre-existing or due to hooking or handling, and biodata, including species identification, adipose fin clip status, fork length (nearest mm), and weight (nearest g), were collected. Fish weights were measured using a 500 g scale (Pesola® 10500 Light-Line Metric Spring Scale) or a 2,500 g scale (Pesola® 42500 Light-Line Metric Spring Scale) for larger fish. Fin clips and/or scales were taken to assess the stock of origin (see *Genetic Sampling and Analysis* for methods). The fish were then scanned with an HPR-Lite hand scanner (Biomark®, Boise, ID), and if no tag was detected, a 12 mm FDX-B PIT tag was applied (Biomark, Boise, ID).

Following measurements, tagging, and sample collection, fish were held in a saltwater livewell to recover fully (i.e., restored equilibrium and movements) before returning to the marine environment (Ackerman et al. 2005).

Genetic Sampling and Analysis

Genetic analyses varied for hatchery and wild fish. While most hatchery stocks (e.g. Quinsam River coho) have 100% external marking (adipose clip) to indicate hatchery origin, some hatchery production is unmarked. Both genetic stock identification (GSI) and parentage-based tagging (PBT) were therefore employed to identify the origin and stock of coho (Beacham et al. 2017, 2020).

The majority of genetic tissue samples were taken as fin clips, although scale samples were also used. Fin clip DNA samples were taken from the caudal fin with a target clip width of 2 mm and stored on Whatman sheets, scissors or forceps were wiped after each sample to avoid contamination. Scales (n = 5-10) were removed from the preferred area (above or below the lateral line just posterior to and under the dorsal fin) and stored in gummed scale books.

Tissue samples were transferred to the Molecular Genetics Laboratory (MGL at Pacific Biological Station), prepared, and genotyped as described in Beacham et al. (2022) and references therein. Each sample was first run against species-specific baselines of genotyped hatchery parents using COLONY software. Fish that could be assigned to two hatchery parents were successful PBT assignments and were identifiable to population, hatchery, and brood year. Fish that could not be assigned to hatchery parents by COLONY were assigned to stocks using GSI, which uses single nucleotide polymorphisms (SNP) allele frequencies in species-specific population baselines in a Bayesian genetic stock identification modelling framework using the software RUBIAS. The GSI procedure assigned probabilities of each fish belonging to one or more stocks. For the preliminary analyses presented in this document, fish were assumed to belong to the stock with the highest probability without the application of a threshold. In the present document, we assume that successful assignment of stock of origin by PBT indicates hatchery origin and assignment using GSI indicates wild origin.

Data Management and Analysis

Coho capture, biological, and tagging data from microtrolling are collected and managed using a custom-built data collection application designed by *Bottlenecks Program* (EForms software). For detailed procedures and guidelines regarding data collection using the application, please refer to the Standard Operating Procedures outlined in Rodgers et al. (2023). The data are stored in the Bottlenecks Data System, a modern Postgres data warehouse on a cloud server hosted by the University of British Columbia's Institute of Oceans & Fisheries (White-Gluz 2024). All microtroll data wrangling, analysis, and visualizations were conducted in R Studio (V 2024.04.01 "Chocolate Cosmos"; R core Team 2019) using either Base R or the tidyverse package (Wickham et al. 2019)

Trends in Fork Length

To investigate the growth patterns, we analyzed fork length measurements. Summary statistics were calculated, including minimum, maximum, mean, median, and standard deviation.

CPUE

CPUE was calculated to the "hook" level of effort. We considered the number of hooks deployed per set i (typically 3 – 12), the number of sets conducted, and the number of coho captured in a single day d, with a single crew in a single PFMA a. The calculation of $CPUE_{da}$ for each day d in each area a was as follows:

$$CPUE_{da} = \frac{\sum Coho\ Captures_{id}}{\sum Hooks\ Deployed_{id}}$$

where coho captures for each set i on a given day d are summed and divided by the sum of hooks used in each set i on that day d in each area a. These values were then rolled into a monthly t average $CPUE_{ta}$ by PFMA:

$$\overline{CPUE_{ta}} = \frac{\sum CPUE_{da}}{N}$$

where N is the total number of days of effort in month t and area a.

Spatiotemporal Trends in Hatchery vs Wild Coho

We conducted Pearson's chi-squared tests to assess whether the distributions of clipped (hatchery) and unclipped (wild) coho differed temporally and spatially. We first created contingency tables summarizing the clipped and unclipped coho counts across different months and PFMA. The chi-squared test was applied to these tables to test the null hypothesis that the clipped and unclipped coho distributions are independent of the month and PFMA. The tests were performed using R, with the significance level set at 0.05.

RESULTS

Across the 2020-2021 microtrolling sampling season, 197 sampling days were conducted with more than 3,666 sets, and 750 coho were captured overall. All coho were processed for biodata collection, and of these, 721 coho were considered healthy and were tagged with PIT tags and released. A summary of coho captures and tag status for each study year are presented in Table 1.

Genetic Analysis

Of the 750 genetic samples collected, 742 were submitted and analyzed by the Molecular Genetic Lab at the Pacific Biological Station (Table 1). Eight samples were likely lost during collection. We had a success rate of 92% from the 742 samples analyzed (62 were not viable for analysis). An additional 8.4% of samples were misidentified and were determined to be non-target species (Table 1).

Parentage-based tagging (PBT) identified a relatively low proportion of samples (Table 1). Despite this, the results comparing marked (clipped) versus unmarked (unclipped) coho, used as a proxy for wild versus hatchery cohorts, indicated a higher percentage of hatchery fish in the sample (Table 1). This suggests that successful PBT assignment to stock origin requires further decision rules.

Table 1. Summary of tagging status for coho captured via microtrolling *(top)*. Summary of coho adipose clip rate (marked) and Genetic Results (bottom).

EUTHANIZED	NOT TAGGED	TAGGED	RECAPTURES	TOTAL
3	26	721	0	750
Marked (Y/N)	GSI	PBT	Non-Viable Samples	Not Target Species
N	434	12	37	63
Y	25	144	25	2

Trends in Fork Length

The analysis of fork length for coho during the 2020-2021 study year reveals patterns in growth and distribution. The lengths of coho ranged from 157 mm to 430 mm, with an average length of 281 mm and a standard deviation of 32.3 mm (Figure 2).

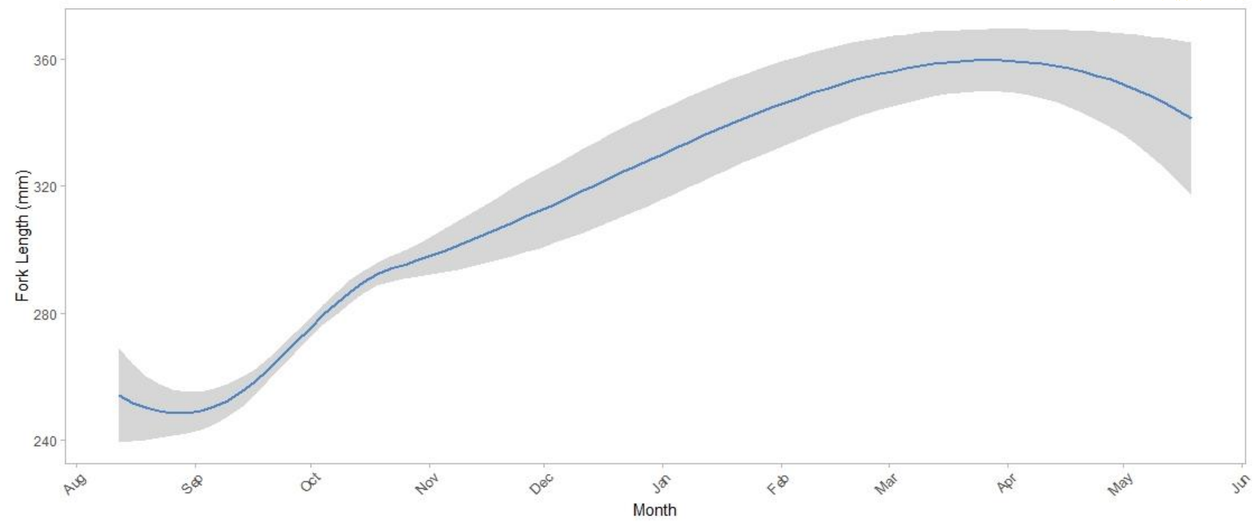

Figure 2. Average fork length (mm) of coho by month for the 2020-2021 study year. The plot shows the trend in fork length over time, with a loess smooth curve and a confidence interval (CI) set using standard error.

Catch-Per-Unit-Effort and Spatial and Temporal Distribution

The summary analysis of Catch Per Unit Effort (CPUE) for coho across various Pacific Fishery Management Areas (PFMAs) during the study year revealed significant temporal and spatial variations (Table 2; Figure 3).

Table 2. Summary of coho captured by PFMA with days of effort for the 2020-2021 study year.

PFMA	DAYS OF EFFORT	COHO (N)
13	35	33
14	81	414
15	6	0
16	9	4
17	40	243
18	15	9
19	2	2
28	3	0
29	12	2

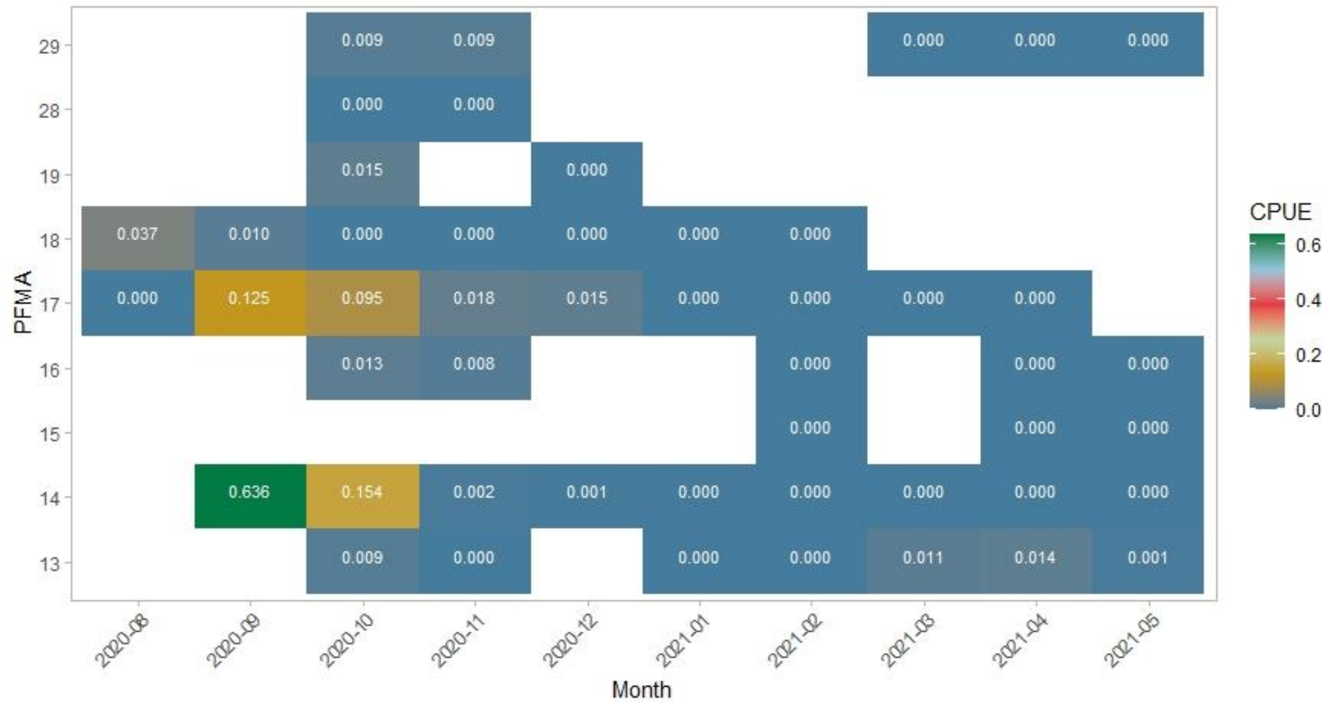

Figure 3. Catch-Per-Unit-Effort of coho by month and PFMA (2020-2021). CPUE was calculated to the "hook" level.

In August and September, CPUE values were relatively low and variable. In August, PFMA 18 and 17 had CPUE's of 0.03 and 0.000, indicating a minimal presence of coho. However, there was a notable increase in September, particularly in PFMA 17, which recorded a CPUE of 0.125. PFMA 14 had a CPUE of 0.636, suggesting large movements of coho in the Strait of Georgia during this period.

In October, CPUE increased across several PFMAs with PFMA 17 exhibiting the highest CPUE value, during this time at 0.095. Other PFMAs, such as 14, 16, 18, and 28, also showed elevated CPUE values in October, with PFMA 16 at 0.013 and PFMA 14 at 0.154. This suggests that on average September/October are peak months for coho presence in these regions.

In November, CPUE values varied considerably, with PFMA 29 recording a similar value to October 0.009, while 17 had a reduced CPUE of 0.018. Similarly, most sampled PFMAs showed lower CPUE values. From December onward, CPUE continued to decline across all PFMAs, except for area 17 which had a similar CPUE in both November and December (Figure 3). However, across all PFMAs, very low or CPUE values of 0.0 were predominant in December and continued throughout the later winter months (Figure 3).

March and April were characterized by an increase in CPUE values in PFMA 13, which had CPUE values of 0.011 and 0.014, while other PFMAs, including 14, 17, and 29, had CPUE values of 0.0.

Stock Composition

The total number of fish captured was recorded, and the stock of each fish was determined. Of the 615 successfully amplified samples, 129 (20.9%) were from target systems (Table 3; Figure 4). A total of 58 unique stocks were identified within our catch (see Appendix A). The most common stock was Puntledge River (N = 53), followed by Chilliwack River (n = 51) and Jones Creek (n = 42), both of which are non-target stocks.

A total of 23 Goldstream River coho were captured, representing 3.7% of the total catch. The Cowichan River yielded 5 coho, accounting for 0.81% of the total catch. The Nanaimo River showed a minimal presence, with 1 coho captured, representing 0.2% of the total catch. The Big Qualicum River had a substantial representation with 35 coho, making up 5.6% of the total catch. The Puntledge River was the most dominant among the target stocks, with 53, representing 8.6% of the total catch. The Quinsam River accounted for 12, which constituted 1.9% of the total catch.

Table 3. Summary of percent contribution of stock to coho captures during the 2020-2021 study year. Target stocks are highlighted, and non-target stocks that contributed > 2% were included.

STOCK	COUNT	PERCENTAGE OF CATCH
Puntledge River	53	8.6
Big Qualicum River	35	5.7
Goldstream River	23	3.7
Quinsam River	12	1.9
Cowichan River	5	0.8
Nanaimo River	1	0.2
Little Qualicum River	0	0.0
Chilliwack River	51	8.3
Jones Creek	42	6.8
Capilano River	39	6.3
Mamquam River	26	4.2
Chehalis River	25	4.1
Shovelnose Creek	25	4.1
Pitt River Upper	18	2.9
Tenderfoot Creek	18	2.9
Stave River	17	2.7
Coldwater River	15	2.4
Birkenhead River	14	2.3
Eagle River	14	2.3

In addition to the target stocks, several non-target stocks were captured during the microtrolling season. Notable among these were Chilliwack River stock, with 51 coho representing 8.3% of the total catch; the Capilano River, with 39 coho accounting for 6.3% of the total catch; and Jones Creek, with 42 coho constituting 6.8% of the total catch. The Mamquam River also showed a significant presence, with 26 coho, making up 4.2% of the total catch.

Temporal Distribution by Stock

During the 2020-2021 study year, the temporal distributions of coho by the derived stock grouping exhibited distinct seasonal patterns (Figure 4). The ECVI Target stock group was prominent during the late summer and early autumn months, peaking in October (Figure 4). The Fraser stock group displayed a consistent distribution across multiple months, with notable spikes in September and October, highlighting its widespread temporal presence. The Eastern Strait of Georgia stock group demonstrated a marked seasonal significance, with a high presence in September and October. While less dominant, the US stock group appeared consistently throughout the study period but was also present in higher abundances in September and October, indicating a persistent presence. These temporal patterns suggest distinct seasonal preferences and highlight the dynamic nature of coho migrations across different stock groups.

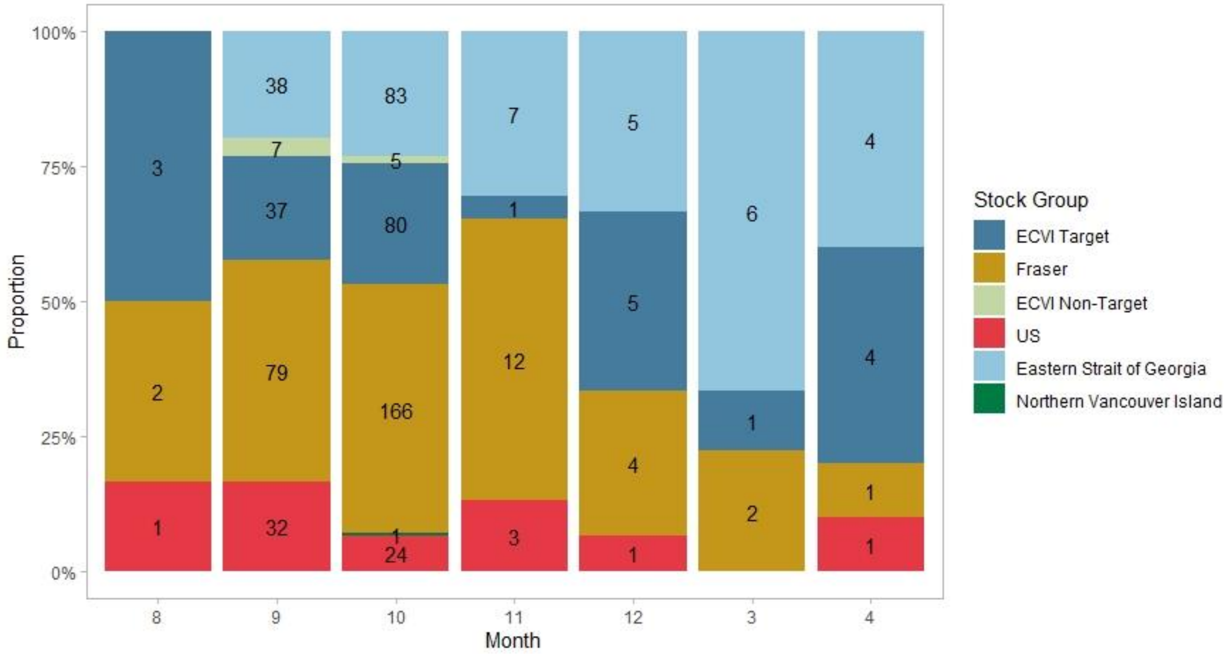

Figure 4. Temporal distributions of coho stock groups across during the 2020-2021 study year. The y-axis indicates the percent contribution (%) of each stock group, and the x-axis represents the months.

Spatial and Temporal Distribution by Stock and PFMA

During the 2020-2021 study year, the distribution of coho across various months and PFMAs demonstrated notable spatiotemporal patterns.

A diverse distribution was evident, with PFMA 17 recording the highest contributions from various stock groups. The Fraser stock group led with a significant proportion of 28.13%, while the Eastern Strait of Georgia group showed a notable presence in PFMA 13, contributing 16.67%. ECVI Target stocks maintained a significant proportion in PFMA 17 and showed consistent distribution across multiple areas (Figure 5).

October was characterized by a spike in the Fraser stock group within PFMA 14, where they accounted for 28.13% of the sample. ECVI Target stocks were also prominent in PFMA 14, contributing 12.02%. The Eastern Strait of Georgia stocks were well represented in PFMA 14, making up 11.25% of the sample, highlighting their seasonal importance.

In December, the Fraser and ECVI Target stock groups showed a notable presence in PFMA 17. The Fraser stock had a proportion of 1.62%, while the ECVI Target group contributed 1.62%.

March and April recorded limited activity from the ECVI Target and Fraser stock groups, indicating minimal presence during these months. Despite this, the Eastern Strait of Georgia group had notable proportions in PFMA 13, especially in March (25%). The ECVI Target group also maintained a presence in various PFMAs, albeit with lower proportions.

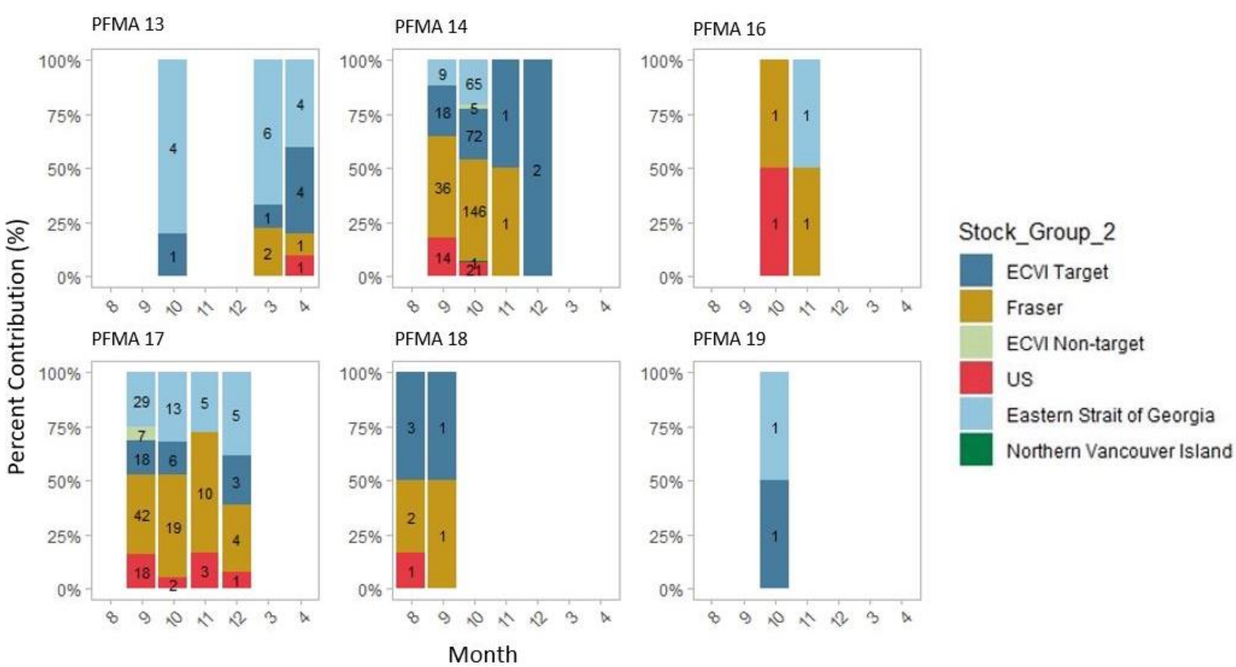

Figure 5. Temporal distributions of coho stock groups across various Pacific Fishery Management Areas (PFMAs) during the 2020-2021 study year. Each subplot represents a different PFMA. The y-axis indicates the percent contribution (%) of each stock group, and the x-axis represents the months from August (8) to April (4).

Spatial and Temporal Distribution by Stock, PFMA and Origin

Clipped coho were predominantly observed in September and October (Figure 6). In October, clipped coho were mainly encountered in PFMA 17 and PFMA 14 (Appendix B). In contrast, unclipped coho demonstrated a more diverse distribution across months and PFMAs (Appendix B). In August and September, notable proportions of unclipped coho were present, with the highest proportions observed in PFMA 18 in August and PFMA 14 in September.

Overall, the temporal distribution indicates that both clipped and unclipped coho have peak presence in October, followed by a decline in subsequent months. Spatially, PFMAs 14 and 17 were critical for both groups. Even with some observed differences, chi-squared tests indicated no significant differences in the distribution of clipped versus unclipped coho across months (X-squared = 6.15, df = 8, p-value = 0.630) or PFMAs (X-squared = 5.02, df = 6, p-value = 0.541).

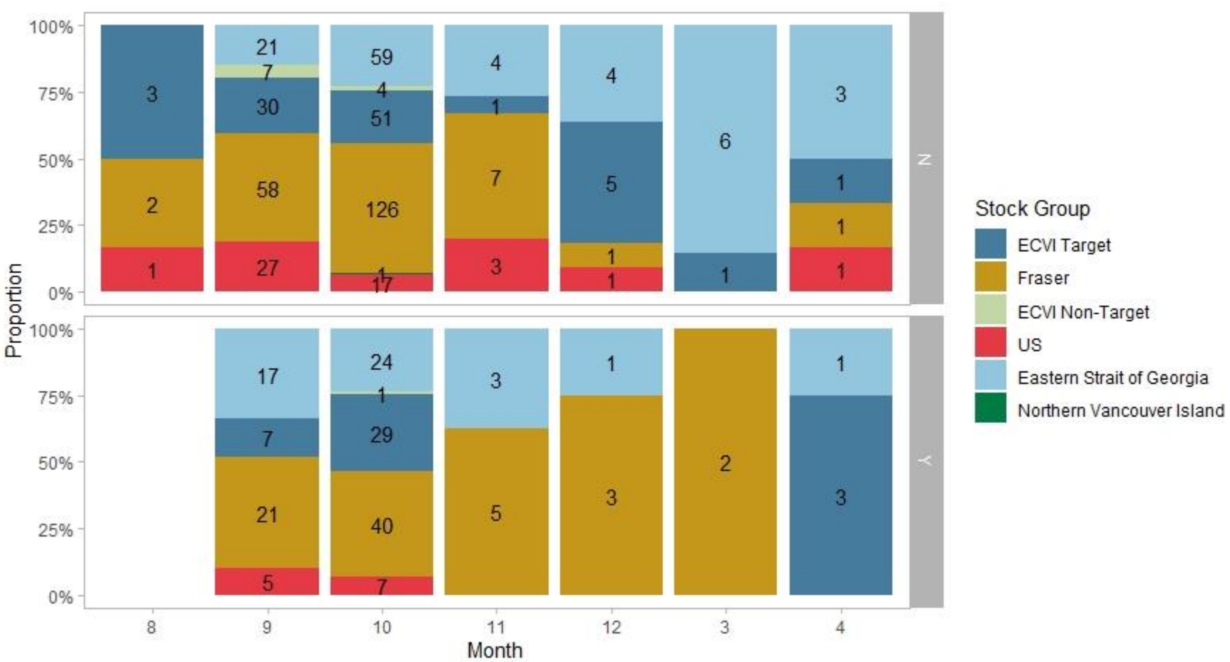

Figure 6. Temporal distributions of coho stock groups, separated by adipose clip status. The top plot represents clipped coho (hatchery) and the bottom plot represents unclipped coho (wild). The y-axis indicates the percent contribution (%) of each stock group, and the x-axis represents the months from August (8) to April (4).

Strait of Georgia Data Centre's "Southern B.C. Microtroll Samples"

The Pacific Salmon Foundations Strait of Georgia Data Centre developed an interactive marine hotspot map (Figure 7). This dashboard allows users to visualize and break down microtroll data collected by the Bottlenecks Project. It offers the functionality to filter the graph both spatially (by selecting areas on the map) or by attributes (by selecting options on the sidebar).

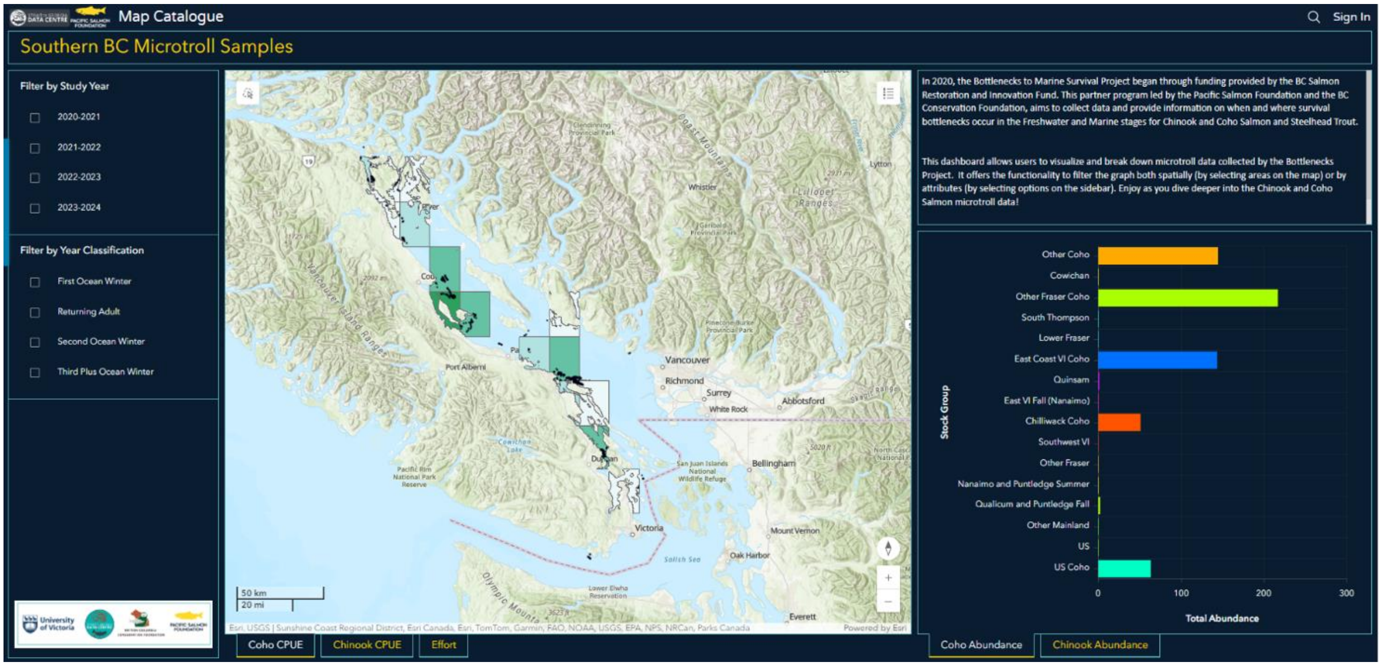

Figure 7. A still image of the "Southern B.C. Microtroll Samples" interactive dashboard (map). The dashboard was constructed by PSF's Strait of Georgia Data Centre 2024.

DISCUSSION

The primary objectives of this study were to enhance our understanding of the marine distributions of juvenile coho within the Strait of Georgia during their first marine winter and to develop a stage-specific survival model. By employing microtrolling techniques, we aimed to capture and monitor juvenile coho, collect data on their spatial and temporal distribution patterns, collect data on their habitat preferences, and create a detailed interactive map using the ESRI ArcGIS platform. Our findings indicate that we successfully achieved most of these objectives, providing valuable insights for informing conservation strategies and fisheries management.

Microtrolling efforts as part of the *Bottlenecks Program* provided a unique dataset to explore marine distributions of coho in the Strait of Georgia. Unlike historical sampling methods using large vessels, the small vessels and micro fishing gear approach allowed us to study the first marine year distributions of coho in previously unexplored habitats and throughout the fall and winter months (August to May). This innovative approach demonstrated that microtrolling can be an effective method of capturing first winter coho. While the extremely low catches during the late winter months (December to March) posed challenges for the broader survival objectives of the *Bottlenecks Program*, CPUE, when coho were present, was at times extremely high, which demonstrated the efficacy of this sampling method. We effectively mapped the spatial and temporal distributions of coho during their first marine year. From this effort, an interactive, publicly accessible map was created to share valuable information on winter habitat utilization within the Strait of Georgia with community partners and resource managers. Unlike this report, this interactive map utilizes all microtroll coho capture data from all years (2020 – 2024).

The CPUE and stock distribution data collected through microtrolling highlighted the benefits of this method in sampling different depths and nearshore environments, providing new information on coho distributions. Most areas sampled in the *Bottlenecks Program* did not overlap with Fisheries and Oceans Canada (DFO) trawl survey data (Beamish and Neville 2021), offering new insights into the spatiotemporal movements of coho. Traditional large vessel methodologies are often confined to sampling the upper water column and in deeper, more open water environments, limiting their ability to capture coho in nearshore and shallower areas (Weitkamp and Neely 2002; Beacham et al. 2019; Beamish and Neville 2021). These methods also sample fixed areas, i.e., areas encompassed within the confines of the net size used and may bias CPUE's if fish are outside of the sampling area.

In comparison, we sampled a greater variety of habitats from 30 to 150 m of water, with gear deployed from the surface, 2 m, down to 91 m. The microtrolling methodology does not confine captures to a fixed area, like purse seines and trawls. Due to it not having a fixed sampling area, microtrolling allows fish to move horizontally or vertically from further away from the exact hook location to be captured. This provides a different representation of coho distributions compared with the more traditional methods.

The temporal distribution of CPUE indicated that coho presence peaks around the end of September into October and declines during the winter and early spring, corroborating previous research (Chittenden et al. 2009; Beamish and Neville 2021). Spatially, PFMAs 17 and 14 were consistently significant for coho presence, especially in September and October, respectively. Additionally, while not discussed in the report, the majority of coho were captured in more open water areas (i.e. French Creek humps and Entrance Island near Nanaimo). This pattern suggests that coho may form large mixed schools during late fall and winter, potentially moving offshore to the Pacific Ocean or deeper waters within the SoG, which could explain the sharp decline in catches after October and aligns with previous research (Beacham et al. 2016).

The spatiotemporal distribution of coho in the 2020-2021 study year revealed significant seasonal and spatial variations. The ECVI Target stock group showed substantial presence in several PFMAs, specifically 14 and 17, during the late summer and early autumn months. The Fraser and Eastern Strait of Georgia stock groups were consistently present across multiple months, and PFMAs indicate their widespread distribution.

While there were trends in spatiotemporal distributions of clipped (hatchery) unclipped (wild) coho, the results of the chi-squared tests found no significant difference during the 2020-2021 study year. This suggests that hatchery and wild coho may utilize similar habitats and follow similar migratory patterns within the Strait of Georgia; this finding is similar to that of previous research (Weitkamp and Neely 2002). However, our sample sizes for a number of PFMAs and months were small, and further research should be conducted to explore whether these patterns hold true across different years and under varying environmental conditions. This will be explored within the *Bottleneck Program's* larger dataset with three additional microtroll seasons 2021 - 2024.

The results of this study have important implications for fisheries management and the broader marine ecosystem. The identified hotspots for coho during the late fall and early winter provide information on key foraging areas; however, additional analysis is required. Collecting data such as these are critical to understanding the seasonal migration patterns and habitat preferences of juvenile coho which help in predicting their interactions within the food web and their impact on the marine environment (Bi et al. 2007). Results from the hatchery vs wild analysis suggest that hatchery-origin and wild coho exhibited similar spatiotemporal distributions within the Strait of Georgia during the 2020-2021 study year. However, additional years and an increased sample size are required to confirm this result.

In conclusion, this study highlights the effectiveness of microtrolling in providing detailed and accurate data on the spatiotemporal distributions of juvenile coho. The insights gained from this research are crucial for developing targeted conservation strategies and ensuring the long-term sustainability of coho populations in the Strait of Georgia. The results of this study corroborated previous research while adding new insights into the distributions of coho during the first year at sea.

Study Limitations

Due to the changes to the microtrolling field program to meet the broader *Bottlenecks Program* objectives, only one year of targeted coho sampling were available for this analysis. Low catches of coho throughout the winter and concerns on the low number of Chinook captures resulted in project staff and volunteers being advised to concentrate on juvenile Chinook. This strategy has continued since the fall of 2021.

There are limitations to using microtrolling for marine distributions, particularly if coho form larger schools in the middle of the Strait, which we may not be capturing (Beacham et al. 2016). The lack of set transects and potential gaps in sampling coverage are additional challenges that need to be addressed in future studies. Despite these limitations, microtrolling offers a valuable tool for answering important research and management questions about coho.

There were inherent issues in the genetic results of coho, which were not further investigated for this report. In future analyses, we will account for both ungenotyped broodstock and DNA sample quality in assessing the robustness of the hatchery vs wild relationship. Hatchery-origin fish may have been assigned to stock by GSI rather than PBT because either their parents were not successfully genotyped or the number of loci genotyped was insufficient for successful COLONY assignment but sufficient for RUBIAS assignment. A high proportion of hatchery broodstock are currently being genotyped at SEP facilities, and we are working with MGL to consider the number of successfully genotyped loci as a metric of confidence in using GSI as a proxy for natural origin.

There is a coarse genetic baseline for coho in BC which makes specific stock identification difficult. Also, due to the close genetic relationship of most coho along ECVI, analyzing down to the individual stock is problematic. Further, RUBIAS analysis applies a Bayesian approach to assign stock probabilities, and final assignments are sensitive to the stock composition of the mixtures, which are run together through the model. It is, therefore, beneficial to stratify samples into spatiotemporal groupings that are expected to have similar stock composition. Analytical mixtures have been largely ad hoc based on the logistics of sample submission to MGL. While this approach provides preliminary results that deliver a good overall picture of stock composition to facilitate project refinement, all samples will be re-run in carefully considered spatiotemporal and age/size strata prior to stock assignment for final survival analysis.

Bottlenecks Program Continued (2024 – 2026)

The *Bottlenecks Program* began winter microtrolling in the fall of 2020 and will continue until spring 2026. The Program's continued objectives are provided below:

- Continue to collect data on the first marine winter of coho in the SoG via microtrolling
    - Continue to collect DNA for stock analysis
- Collate and analyze all data (2020 – 2024) for primary publication
    - Further considerations will be required to include study years 2021 – 2024 in the analysis due to changes in the sampling program beyond the first year (2020-2021).

    - Develop habitat-based analysis (using bathymetry)
    - Compare coho and Chinook distributions by habitat

Recommendations

This section provides recommendations for the future of the first marine winter coho sampling in the SoG. Recommendations are derived from information collected in the first four years of the *Bottlenecks Program.*

- Conduct an intensive sampling effort via microtrolling for coho throughout the early fall to increase spatiotemporal information.
- Conduct informed mid-winter microtrolling in the open waters of the SoG.
    - Utilize recreational fishing information to advise effort to target large schools of coho in the SoG
- Combine DFO's historic summer and fall trawl survey data with winter microtroll data to develop a comprehensive spatiotemporal analysis.

LITERATURE CITED

Ackerman PA, Morgan JD, Iwama GK. 2005. Anesthetics: Guidelines on the care and use of fish in research, teaching and testing. Available at: https://ccac.ca/Documents/Standards/Guidelines/Add_PDFs/Fish_Anesthetics.pdf

Bass, A.L., Bateman, A.W., Kaukinen, K.H., Li, S., Ming, T., Patterson, D.A., Hinch, S.G., and Miller, K.M. 2023. The spatial distribution of infectious agents in wild Pacific salmon along the British Columbia coast. Sci. Rep. **13**(1): 1–12. Nature Publishing Group UK. doi:10.1038/s41598-023-32583-8.

Beacham, T.D., Beamish, R.J., Neville, C.M., Candy, J.R., Wallace, C., Tucker, S., and Trudel, M. 2016. Stock-Specific Size and Migration of Juvenile Coho Salmon in British Columbia and Southeast Alaska Waters. Mar. Coast. Fish. **8**(June): 292–314. doi:10.1080/19425120.2016.1161683.

Beacham, T.D., Wallace, C., Jonsen, K., McIntosh, B., Candy, J.R., Willis, D., Lynch, C., Moore, J.S., Bernatchez, L., and Withler, R.E. 2019. Comparison of coded-wire tagging with parentage-based tagging and genetic stock identification in a large-scale coho salmon fisheries application in British Columbia, Canada. Evol. Appl. **12**(2): 230–254. doi:10.1111/eva.12711.

Beacham, T.D., Wallace, C., Jonsen, K., McIntosh, B., Candy, J.R., Willis, D., Lynch, C., and Withler, R.E. 2020. Insights on the concept of indicator populations derived from parentage-based tagging in a large-scale coho salmon application in British Columbia, Canada. Ecol. Evol. **10**(13): 6461–6476. doi:10.1002/ece3.6383.

Beacham, T.D., Wallace, C., Macconnachie, C., Jonsen, K., McIntosh, B., Candy, J.R., Devlin, R.H., and Withler, R.E. 2017. Population and individual identification of coho salmon in British Columbia through parentage-based tagging and genetic stock identification: An alternative to coded-wire tags. Can. J. Fish. Aquat. Sci. **74**(9): 1391–1410. doi:10.1139/cjfas-2016-0452.

Beamish, R., and Neville, C. 2021. The Natural Regulation and Relevance of Wild and Hatchery Coho Salmon Production in the Strait of Georgia. Fisheries **46**(11): 539–551. doi:10.1002/fsh.10651.

Beamish, R.J., and Mahnken, C. 2001. A critical size and period hypothesis to explain natural regulation of salmon abundance and the linkage to climate and climate change. Prog. Oceanogr. **49**(1–4): 423–437. doi:10.1016/S0079-6611(01)00034-9.

Beamish, R.J., McFarlane, G.A., and Thomson, R.E. 1999. Recent declines in the recreational catch of coho salmon (*Oncorhynchus kisutch*) in the Strait of Georgia are related to climate. Can. J. Fish. Aquat. Sci. **56**(3): 506–515. doi:10.1139/cjfas-56-3-506.

Beamish, R.J., Sweeting, R.M., Lange, K.L., and Neville, C.M. 2008. Changes in the Population Ecology of Hatchery and Wild Coho Salmon in the Strait of Georgia. Trans. Am. Fish. Soc. **137**(2): 503–520. doi:10.1577/t07-080.1.

Beamish, R.J., Sweeting, R.M., Lange, K.L., Noakes, D.J., Preikshot, D., and Neville, C.M. 2010. Early Marine Survival of Coho Salmon in the Strait of Georgia Declines to Very Low Levels. Mar. Coast. Fish. **2**(1): 424–439. doi:10.1577/c09-040.1.

Bi, H., Ruppel, R.E., and Peterson, W.T. 2007. Modeling the pelagic habitat of salmon off the Pacific Northwest (USA) coast using logistic regression. Mar. Ecol. Prog. Ser. **336**: 249–265. doi:10.3354/meps336249.

Bonvechio, T.F., Pouder, W.F., and Hale, M.M. 2008. Variation between Electrofishing and Otter Trawling for Sampling Black Crappies in Two Florida Lakes. North Am. J. Fish. Manag. **28**(1): 188–192. doi:10.1577/m07-030.1.

Bradford, M.J., and Irvine, J.R. 2000. Land use, fishing, climate change, and the decline of Thompson River, British Columbia, coho salmon. Can. J. Fish. Aquat. Sci. **57**(1): 13–16. doi:10.1139/cjfas-57-1-13.

Chittenden, C.M., Beamish, R.J., Neville, C.M., Sweeting, R.M., and McKinley, R.S. 2009. The Use of Acoustic Tags to Determine the Timing and Location of the Juvenile Coho Salmon Migration out of the Strait of Georgia, Canada. Trans. Am. Fish. Soc. **138**(6): 1220–1225. doi:10.1577/t09-037.1.

Irvine, J.R., and Ward, B.R. 1989. Patterns of timing and size of wild coho salmon (*Oncorhynchus kisutch*) smolts migrating from the Keogh River watershed on northern Vancouver Island. Can. J. Fish. Aquat. Sci. **46**(7): 1086–1094. doi:10.1139/f89-140.

Nelson, B.W., Thomas, A.C., Trites, A.W., McAllister, M.K., and Walters, C.J. 2024. (In Prep) Quantifying impacts of harbour seal predation on Chinook and coho salmon smolts in the Strait of Georgia, British Columbia. Can. J. Fish. Aquat. Sci. (July 2023): 1–22. doi:10.1002/mcf2.10271.

Stockwell, J.D., Yule, D.L., Hrabik, T.R., Adams, J. V., Gorman, O.T., and Holbrook, B. V. 2007. Vertical Distribution of Fish Biomass in Lake Superior: Implications for Day Bottom Trawl Surveys. North Am. J. Fish. Manag. **27**(3): 735–749. doi:10.1577/m06-116.1.

Weitkamp, L., and Neely, K. 2002. Coho salmon (*Oncorhynchus kisutch*) ocean migration patterns: Insight from marine coded-wire tag recoveries. Can. J. Fish. Aquat. Sci. **59**(7): 1100–1115. doi:10.1139/f02-075.

Weitkamp, L.A., Orsi, J.A., Myers, K.W., and Francis, R.C. 2011. Contrasting early marine ecology of Chinook salmon and Coho salmon in southeast Alaska: Insight into factors affecting marine survival. Mar. Coast. Fish. **3**(1): 233–249. doi:10.1080/19425120.2011.588919.

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T., Miller, E., Bache, S., Müller, K., Ooms, J., Robinson, D., Seidel, D., Spinu, V., Takahashi, K., Vaughan, D., Wilke, C., Woo, K., and Yutani, H. 2019. Welcome to the Tidyverse. J. Open Source Softw. **4**(43): 1686. doi:10.21105/joss.01686.

Zimmerman, C.E., and Reeves, G.H. 2002. Identification of Steelhead and Resident Rainbow Trout Progeny in the Deschutes River, Oregon, Revealed with Otolith Microchemistry. Trans. Am. Fish. Soc. **131**(5): 986–993. doi:10.1577/1548-8659(2002)131<0986:iosarr>2.0.co;2.

Zimmerman, M.S., Irvine, J.R., O'Neill, M., Anderson, J.H., Greene, C.M., Weinheimer, J., Trudel, M., and Rawson, K. 2015. Spatial and Temporal Patterns in Smolt Survival of Wild and Hatchery Coho Salmon in the Salish Sea. Mar. Coast. Fish. **7**(May): 116–134. doi:10.1080/19425120.2015.1012246.

APPENDIX A: PERCENT STOCK CONTRIBUTION TO MICROTROLL BASED SAMPLING

STOCK	COUNT	PROPORTION
Albreda_R	4	0.006451613
Alouette_R	3	0.00483871
Ashlu_Cr	5	0.008064516
Barriere_R	10	0.016129032
Big_Qualicum_R	35	0.056451613
Birch_Island_Channel	4	0.006451613
Birkenhead_R	14	0.022580645
Blaney_Cr_LWFR	2	0.003225806
Capilano_R	39	0.062903226
Chapman_Cr	2	0.003225806
Chehalis_R	25	0.040322581
Chemainus_R	7	0.011290323
Chilko_R	7	0.011290323
Chilliwack_R	51	0.082258065
Chilqua_Cr	2	0.003225806
Coldwater_R	15	0.024193548
Coquitlam_R	1	0.001612903
Cowichan_R	5	0.008064516
Eagle_R	14	0.022580645
French_Cr	4	0.006451613
Goldstream_R	23	0.037096774
Grizzly_R	1	0.001612903
Harbour_Cr	4	0.006451613
Inch_Cr	12	0.019354839
Jones_Cr	42	0.067741935
Kanaka_Cr	9	0.014516129
Klinaklini_R	1	0.001612903
Little_Campbell_R	12	0.019354839
Mamquam_R	26	0.041935484
Marblemount_H	3	0.00483871
McKinley_Cr	2	0.003225806
Momich_R	4	0.006451613
Nahatlatch_R	5	0.008064516
Nanaimo_R	1	0.001612903

Nathan_Cr	12	0.019354839
Norrish_Cr	8	0.012903226
Pig_Channel	12	0.019354839
Pitt_R_upper	18	0.029032258
Puntledge_R	53	0.085483871
QUALICUM_RIVER	2	0.003225806
QUINSAM_RIVER	1	0.001612903
Quatsese_R	1	0.001612903
Quinsam_R	12	0.019354839
Rosewall_Cr	2	0.003225806
Salish_Cr	1	0.001612903
Serpentine_R	8	0.012903226
Seymour_R_GSMN	6	0.009677419
Shovelnose_Cr	25	0.040322581
Siddall_Cr	1	0.001612903
Silverdale_Cr	2	0.003225806
Skagit_R_Up	3	0.00483871
Skykomish_R	5	0.008064516
Sorenson_Cr_WA	5	0.008064516
Stave_R	17	0.027419355
Stillaguamish_R	3	0.00483871
Tenderfoot_Cr	18	0.029032258
Trent_R	1	0.001612903
Upper_Birkenhead_R	9	0.014516129
Yaquina_R	1	0.001612903

APPENDIX B: SUMMARY TABLE SHOWING PROPORTION OF STOCK GROUP CAPTURED BY CLIP STATUS, BY MONTH, BY PFMA

MONTH	STOCK GROUP	CLIP STATUS	PFMA	COUNT	PROPORTION
3	Eastern Strait of Georgia	N	13	1	0.1
3	Fraser	Y	13	1	0.1
4	Eastern Strait of Georgia	N	13	1	0.1
4	Eastern Strait of Georgia	Y	13	1	0.1
4	Fraser	N	13	1	0.1
8	ECVI Target	N	18	3	0.375
8	Fraser	N	18	2	0.25
8	US	N	18	1	0.125
9	Eastern Strait of Georgia	N	14	3	0.007832898
9	Eastern Strait of Georgia	Y	14	4	0.010443864
9	ECVI Target	N	14	16	0.041775457
9	ECVI Target	Y	14	2	0.005221932
9	Fraser	N	14	23	0.060052219
9	Fraser	Y	14	9	0.023498695
9	US	N	14	12	0.031331593
9	US	Y	14	4	0.010443864
9	Eastern Strait of Georgia	N	17	14	0.080924855
9	Eastern Strait of Georgia	Y	17	13	0.075144509
9	ECVI Non-target	N	17	6	0.034682081
9	ECVI Target	N	17	13	0.075144509
9	ECVI Target	Y	17	5	0.028901734
9	Fraser	N	17	30	0.173410405
9	Fraser	Y	17	11	0.063583815
9	US	N	17	15	0.086705202
9	US	Y	17	1	0.005780347
9	ECVI Target	N	18	1	0.125
9	Fraser	N	18	1	0.125
10	Eastern Strait of Georgia	N	13	4	0.4
10	ECVI Target	Y	13	1	0.1
10	Eastern Strait of Georgia	N	14	39	0.101827676
10	Eastern Strait of Georgia	Y	14	21	0.054830287
10	ECVI Non-target	N	14	5	0.01305483
10	ECVI Non-target	Y	14	2	0.005221932

10	ECVI Target	N	14	47	0.122715405
10	ECVI Target	Y	14	24	0.062663185
10	Fraser	N	14	104	0.27154047
10	Fraser	Y	14	37	0.096605744
10	Northern Vancouver Island	N	14	1	0.002610966
10	US	N	14	18	0.046997389
10	US	Y	14	8	0.020887728
10	Fraser	N	16	1	0.25
10	US	N	16	1	0.25
10	Eastern Strait of Georgia	N	17	10	0.057803468
10	Eastern Strait of Georgia	Y	17	1	0.005780347
10	ECVI Target	N	17	2	0.011560694
10	ECVI Target	Y	17	2	0.011560694
10	Fraser	N	17	14	0.080924855
10	Fraser	Y	17	3	0.01734104
10	US	N	17	2	0.011560694
10	Eastern Strait of Georgia	Y	19	1	0.5
10	ECVI Target	N	19	1	0.5
11	ECVI Target	N	14	1	0.002610966
11	Fraser	Y	14	1	0.002610966
11	Eastern Strait of Georgia	N	16	1	0.25
11	Fraser	Y	16	1	0.25
11	Eastern Strait of Georgia	N	17	3	0.01734104
11	Eastern Strait of Georgia	Y	17	2	0.011560694
11	Fraser	N	17	7	0.040462428
11	Fraser	Y	17	3	0.01734104
11	US	N	17	3	0.01734104
11	Eastern Strait of Georgia	Y	29	1	1
12	ECVI Target	N	14	2	0.005221932
12	Eastern Strait of Georgia	N	17	4	0.023121387
12	Eastern Strait of Georgia	Y	17	1	0.005780347
12	ECVI Target	N	17	3	0.01734104
12	Fraser	N	17	1	0.005780347
12	Fraser	Y	17	3	0.01734104
12	US	N	17	1	0.005780347

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