

Acoustic and Satellite Tagging of Sockeye Salmon, *Oncorhynchus nerka*, Off the West Coast of Haida Gwaii, September 30 - August 11, 2024

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Abstract

Fleming, J., King, J.R., Tucker, S., and Freshwater, C. 2025. Acoustic and Satellite Tagging of Sockeye Salmon, *Oncorhynchus nerka*, Off the West Coast of Haida Gwaii, September 30 - August 11, 2024. Can. Data Rep. Fish. Aquat. Sci. 1441: vi + 16 p.

Fisheries and Oceans Canada Science staff conducted Year 1 of a two-year field study on Sockeye Salmon survival, predation, and habitat use from July 30th to August 11th, 2024 aboard a commercial charter purse seiner *Ocean Achiever*. The goal of this study is to use complimentary tagging technologies to study Sockeye Salmon marine survival to evaluate whether predation, particularly by pinnipeds, may constrain Fraser River Sockeye Salmon productivity.

Four primary field sites were visited during the cruise: 1) Triangle Island off the north end of Vancouver Island to deploy an acoustic receiver array, 2) Chad's Point off the west coast of Moresby Island, Haida Gwaii, to deploy an acoustic receiver array, 3) Hunter Point off the west coast of Graham Island to deploy an acoustic receiver array, and 4) Rennell Sound on the west coast of Graham Island to conduct Sockeye Salmon capture, tagging, and active acoustic tracking.

A total of 277 Sockeye Salmon were sampled and tagged from August 2nd – 9th, 2024. During 8 days of fishing, a total of 48 sets were made, capturing approximately 334 Sockeye Salmon. Bycatch included Chinook, Coho, Chum and Pink Salmon (approximately 138, 183, 329, and 684 fish respectively) as well as Blue Sharks (13) and Salmon Sharks (2).

Résumé

Fleming, J., King, J.R., Tucker, S., and Freshwater, C. 2025. Acoustic and Satellite Tagging of Sockeye Salmon, *Oncorhynchus nerka*, Off the West Coast of Haida Gwaii, September 30 - August 11, 2024. Can. Data Rep. Fish. Aquat. Sci. 1441: vi + 16 p.

L'équipe des Sciences de Pêches et Océans Canada a réalisé les activités de la première année d'une étude sur le terrain de deux ans portant sur la survie, la prédation et l'utilisation de l'habitat du saumon rouge, du 30 juillet au 11 août 2024 à bord d'un senneur à senne coulissante commercial affrété, le *Ocean Achiever*. L'objectif de cette étude est d'utiliser des technologies de marquage complémentaires pour étudier la survie en mer du saumon rouge afin d'évaluer si la prédation, en particulier par les pinnipèdes, peut limiter la productivité du saumon rouge du fleuve Fraser.

L'équipe a visité quatre principaux sites pendant le voyage : 1) l'île Triangle, au large de l'extrémité nord de l'île de Vancouver, pour déployer un réseau de récepteurs acoustiques; 2) la pointe Chad, au large de la côte ouest de l'île Moresby, à Haida Gwaii, pour déployer un réseau de récepteurs acoustiques; 3) la pointe Hunter, au large de la côte ouest de l'île Graham, pour déployer un réseau de récepteurs acoustiques; et 4) la baie Rennell sur la côte ouest de l'île Graham pour effectuer la capture, le marquage et le suivi acoustique actif du saumon rouge.

Au total, on a échantillonné et marqué 277 saumons rouges du 2 au 9 août 2024. Au cours des huit jours de pêche, on a effectué un total de 48 traits, permettant de capturer environ 334 saumons rouges. Les prises accessoires comprenaient le saumon chinook, le saumon coho, le saumon kéta et le saumon rose (environ 138, 183, 329 et 684 poissons respectivement) ainsi que le requin bleu (13) et le requin saumon (2).

1 Introduction

In 2024, Fisheries and Oceans Canada began a two-year field program to study returning Fraser River Sockeye Salmon with complementary tagging technologies (acoustic and satellite) to better understand Sockeye Salmon habitat use and sources of mortality, with a specific focus on Steller sea lion (*Eumetopias jubatus*) predation.

Acoustic tags transmit unique identification codes at regular intervals that can be detected by moored receivers to provide presence/absence data useful for studies of habitat use and survival (Crossin et al. 2017). Pop-up satellite archival tags (PSATs) provide fisheries independent information by allowing the remote recovery of temperature, depth, location, and activity data from non-surface oriented marine animals. These tags can be used to quantify guild-specific predation rates (e.g. cetacean, pinniped, shark) based on depth and temperature sensors, and to generate high resolution estimates of salmon habitat use (Seitz et al. 2019).

Fish capture and tagging will be conducted in early August over two years (2024-2025). Various acoustic receiver arrays will be deployed, retrieved and maintained at different intervals throughout the life of the program. Existing acoustic telemetry infrastructure throughout the Strait of Georgia will also be leveraged to increase the precision of mortality rate estimates. Year 1 of the study (reported here) deployed a small number (n=17) of PSATs to estimate guild-specific predation rates, paired with a larger number (n=260) of acoustic tags to provide information on overall survival rates and migratory behaviour. Here we report acoustic receiver deployments, as well as capture and biological data associated with Year 1 of the study. Equivalent Year 2 data and tagging results will be published as primary publications.

2 Methods

2.1 Study Area and Design

All fishing operations, sampling, and tag deployments were conducted on the west coast of Haida Gwaii, within 6 km of Rennell Sound on Graham Island during August (Figure 1). This location and time period was selected to provide the best opportunity to intercept returning Fraser River Sockeye Salmon before they encountered high Steller sea lion densities near Triangle Island.

Three acoustic receiver arrays were deployed in Year 1 (Figure 2). One was deployed 10 km south of Rennell sound at Hunter Point on Graham Island, Haida Gwaii. A second array was deployed 70 km south of Rennell sound at Chad's Point on Moresby Island, Haida Gwaii.

A third acoustic receiver array was deployed near Triangle Island, off the northern tip of Vancouver Island in the Scott Islands Marine National Wildlife Area (Figure 3) prior to fishing operations and remained in place until September 4th, 2024.

Mobile tracking with a hydrophone was performed from a skiff in a ~2x2 km grid over the main tagging location (Figure 2) during the last two days of tagging to quantify short term mortality. The northern half of the tagging area was surveyed on August 8th with three tags still left to be deployed, while the southern half of the tagging area was surveyed on August 9th, 2024 after all remaining tags had been deployed. Additionally, mobile tracking was conducted in areas of limited receiver coverage around Triangle Island on September 4, 2024 (Figure 3) to increase the probability of detecting expelled tags.

The study will leverage data from a broader acoustic receiver network (Figure 4) that extends from Queen Charlotte Strait to the Strait of Juan de Fuca and the lower Fraser River. This network includes DFO receivers as well as arrays maintained by the Ocean Tracking Network and University of British Columbia. Data from this network is retrieved at regular annual intervals.

2.2 Acoustic Receiver Moorings

Temporary subsurface acoustic receiver arrays were deployed in multiple locations (Figure 2, Figure 3). Four Innovasea VR2AR acoustic release receivers were deployed around Triangle Island at depths between ~27-40 m on July 31st, 2024. Each mooring was comprised of one ~32 kg chain clump shackled to an acoustic receiver. Each receiver was shackled to ~4.5 m of 5/16ths polysteel rope and suspended upright in the water column by a 30 cm trawl float. The Triangle Island receiver array was recovered on September 4, 2024 to provide ample time to record potential detections during the migration window.

Two subsurface arrays were deployed off the West Coast of Haida Gwaii on August 1st, 2024 during transit to the fishing grounds. These moorings (n=6) employed Innovasea VR2W Acoustic Receivers and required buoy line and a surface float for retrieval without an acoustic release. Each mooring consisted of 1-2 chain clump anchors weighing ~32 kg total. Anchors were connected with buoy line (60 -396 m depending on bottom depth) to a scotchman at the surface with a trailing crab float. The receiver was affixed to the buoy line 2 m above the anchor. Two gillnet floats were tied to the buoy line 3m above the anchor to help orient the receiver vertically in the water column.

Two acoustic receiver moorings were deployed westward of Chad's Point, on Moresby Island at depths of 48 and 190 m. Another four were deployed westward of Hunter Point on Graham Island at depths of 30, 80, 137, and 182 m. The detection range of both Haida Gwaii arrays extended from shore out to the 180 m isobath. Both Haida Gwaii arrays were retrieved during return transit on August 10th, 2024, with the exception of one receiver deployed at Chad's Point, which could not be located.

2.3 Fishing Operations

Fishing operations during 2024 occurred onboard the M.V. *Ocean Achiever*, a 60.3 ft commercially licenced purse seine fishing vessel. All sets were conducted using a standard 575, 220 commercial salmon seine net (~40 m in depth, ~402 m in length), deployed in open water with the aid of a power skiff. Fishing operations were conducted in daylight hours between approximately 07:15 and 17:40. Wind and weather, catch per unit effort (CPUE, count/seine set) and fish processing constraints determined fishing start and end times, and the number of sets completed per day. The start time and coordinates of the set were recorded when the power skiff was released from the boat and end time recorded when the cork line was hooked to the block and suspended by the boom.

At the end of each set, the net was loosely pursed alongside the boat while captain and crew retrieved Sockeye Salmon from the catch via long handled dipnet. Sockeye Salmon were placed either directly into the tagging sling with flow through sea water, or into a recovery tote with flow through seawater to be sampled as time allowed. Temperature and dissolved oxygen in the recovery tote were monitored to ensure temperatures did not exceed 16° C and dissolved oxygen (DO) was not below 6 mg/L as per Animal Use Protocols (Protocol Number: 24-004). After a fish was tagged and sampled, it was released over the ship's rail via a wetted aluminum slide. All fish were appropriately restrained, sampled and released as rapidly as possible. Following the release of the set, captain or crew provided species composition and bycatch numbers (recorded as estimates or exact counts) to biologists to be recorded.

2.4 Biological Sampling

Each captured Sockeye Salmon was measured for fork length to the nearest cm. Girth measurements (cm) were initially recorded (n=104 fish) but discontinued to reduce scale loss and handling time. Scale samples and fin clips were taken for genetic stock identification (GSI) and each fish received a health assessment quantifying natural and capture-related injuries, scale loss, fin damage, and gill condition. Additionally, the duration each fish was held in the tagging sling and live tank were recorded. Energy density was recorded using a Distell Model 692 Fish Fatmeter, which provides a non-invasive index of lipid content. Two energy density readings were taken per fish. Prior to analysis, these readings were averaged, and log-normally transformed. Gross somatic energy (MJ/kg) and percent somatic lipid content were estimated using the regression equations developed by Crossin and Hinch (2005) for Fraser River Sockeye Salmon. These equations were applied to the dataset to calculate energy and lipid content based on the transformed energy density values. We used a Kruskal-Wallis test to assess differences in somatic lipid content and fork length across four Stock Management Units (SMUs) due to non-normal data distribution. Post hoc pairwise comparisons were conducted using Dunn's test with Bonferroni correction.

2.5 Acoustic and Satellite Tagging

Fish that met size and condition metrics (>44 cm, no major injuries) received coded acoustic transmitters (Innovasea Inc.; model V13P; 39 mm length, 5.5 g weight in water, approximately 400 days battery life; mean 120-second delay between transmissions at 69 kHz). Acoustic transmitter tags were affixed to the fish externally using a numbered Floy spaghetti tag anchored through the musculature posterior to the dorsal fin (Figure 5).

Fish that met size and condition metrics for satellite tagging (>=60 cm, in good condition) were fit with Wildlife Computers' MiniPAT pop-up, archival transmitting tags (n=17). MiniPAT tags are equipped with temperature sensors, light, pressure, and activity/acceleration sensors. Tags archived data and transmitted data summaries to the ARGOS satellite network at a pre-determined date or if the tag releases prematurely, i.e., a potential mortality. Satellite tags were affixed to the fish externally via small backpack harness (Figure 6) constructed out of plastic and silicone pads, and 1mm Z-Line Cord. This harness was mounted through the dorsal musculature, in-line with the dorsal fin using two, 14-gauge x 3.5" needles, 0.08mm stainless steel wire, and #20 vinyl tubing. A detailed list of tag harness materials and specifications are provided in Courtney et al. (2016).

3 Results

3.1 Fishing Operations

All fishing operations were conducted between August 2 – August 9, 2024. A total of 48 sets were completed, of which 29 captured Sockeye Salmon, with an average of 7 individuals per set. Sets averaged 35 minutes in duration. Handling times for fish sampling and tagging averaged 3.6 minutes per fish.

3.2 Catch Composition

Catch composition estimates were recorded for each set (Table 1). Pink salmon accounted for 41% of the total catch, Sockeye Salmon 21%, Chum Salmon 19%, Coho Salmon 11%, and Chinook Salmon 8%. All encountered Pacific Salmon were mature adults. Blue Sharks (*Prionace glauca*) and Salmon Sharks (*Lamna ditropis*) (13 and 2 respectively) were also caught during fishing operations, along with

significant numbers of Pacific Sea Nettle Jellyfish (*Chrysaora fuscescens*), and trace numbers of Pacific Saury (*Cololabis saira*).

3.3 Biological Sampling

A total of 277 Sockeye Salmon were sampled. Sockeye Salmon fork length ranged between 42–68cm with a mean fork length of 58cm (SD = ± 3.9) (Figure 7). Girth (n=102) ranged from 23-37cm with a mean girth of 30cm (SD = ± 2.6). The majority (97%) of Sockeye Salmon captured were assigned a stock probability of > 80% Fraser River origin, with 58% of tagged fish originating from the Chilko conservation unit (CU) (Figure 8). Sockeye Salmon stock management units, which contain one or more CU, included Summer (73%), Early Summer (19%), and Late (8%) (Figure 8). Fork length differed significantly between the Late SMU and all other groups (Figure 9), additionally, fish of non-Fraser River origin (classified as “Other”) differed significantly from the Summer SMU. Sampled fish’s gross somatic energy ranged from 6.8 – 10.4 MJ/kg, with a mean of 9.4 MJ/kg (SD ± 0.6 MJ/kg). Somatic lipid content ranged from 6.4% to 14.2%, with a mean of 11.9% (SD $\pm 1.2\%$) (Figure 9). Fish from the Summer SMU group exhibited the highest median lipid content (12.1%), while those from the Other SMU group had the lowest (10.7%). There was no significant difference in somatic lipid content among the Fraser River SMUs (Figure 9); however, the Other SMU differed significantly from the Summer SMU ($p = 0.00054$).

3.4 Acoustic and Satellite Tagging

A total of 260 Sockeye Salmon were tagged with acoustic transmitters and released between August 2 – August 9. Satellite tags were affixed to a total of 17 fish between 60–64 cm fork length (62.2 ± 1.4 cm, mean \pm SD) during the same time period. Mobile tracking in the vicinity of the tagging site returned nine unique tag detections, of which, six were likely mortalities. No tags were detected during mobile tracking in the vicinity of Triangle Island.

4 Discussion

Year 1 field operations were successful in capturing the study’s target number of Sockeye Salmon in an area of historic interception and deploying all acoustic and satellite tags (260 and 17, respectively). Additionally, genetic stock identification (GSI) indicated a high proportion (97%) of tagged fish were of Fraser River origin (Figure 8). Sockeye Salmon were captured exclusively inshore of Rennell Sound and typically less than 2 km from shore. These data, combined with results from Year 2 will contribute to broader research objectives on Sockeye Salmon habitat use and survival.

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7 Tables

Table 1. Summary of catch from August 2 – 9, 2024, aboard the charter vessel *Ocean Achiever*.

Scientific Name	Common Name	Proportion of Sets Present (n = 48)	Count	Percent of Catch %
Oncorhynchus gorbuscha	Pink Salmon	0.85	684	41
Oncorhynchus nerka	Sockeye Salmon	0.69	334	20
Oncorhynchus keta	Chum Salmon	0.63	329	20
Oncorhynchus kisutch	Coho Salmon	0.65	183	11
Oncorhynchus tshawytscha	Chinook Salmon	0.54	138	8
Prionace glauca	Blue Shark	0.23	13	-
Lamna ditropis	Salmon Shark	0.04	2	-

8 Figures

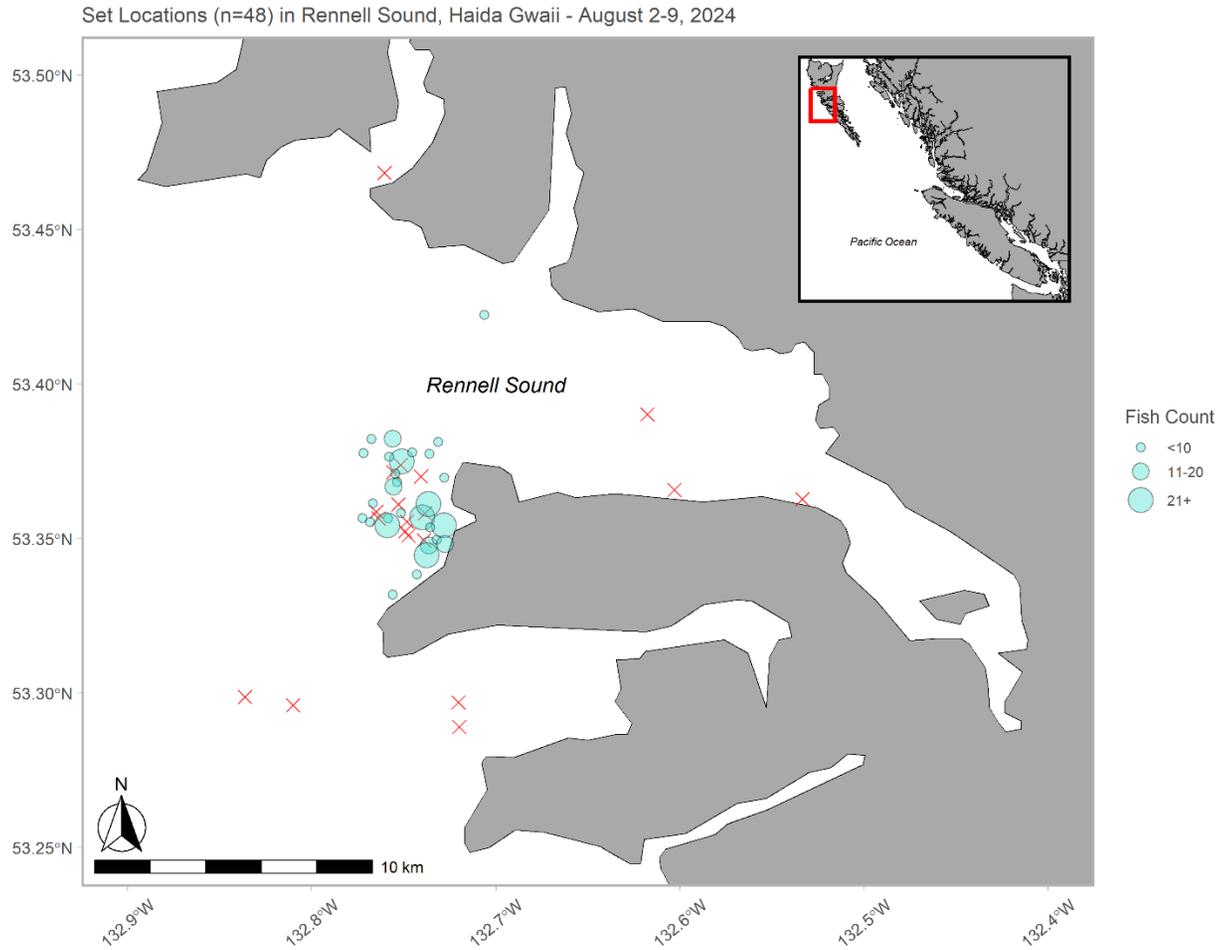


Figure 1. Set Locations from August 2024 fishing operations in Rennell Sound, Graham Island, Haida Gwaii. Red "x" denote set locations where no Sockeye Salmon were captured, while turquoise circles represent locations of sets that captured <10, 11-20, or >=21 Sockeye. Points have been jittered for display purposes.

Haida Gwaii Acoustic Telemetry Locations - 2024
(Graham and Moresby Island, Haida Gwaii, BC)

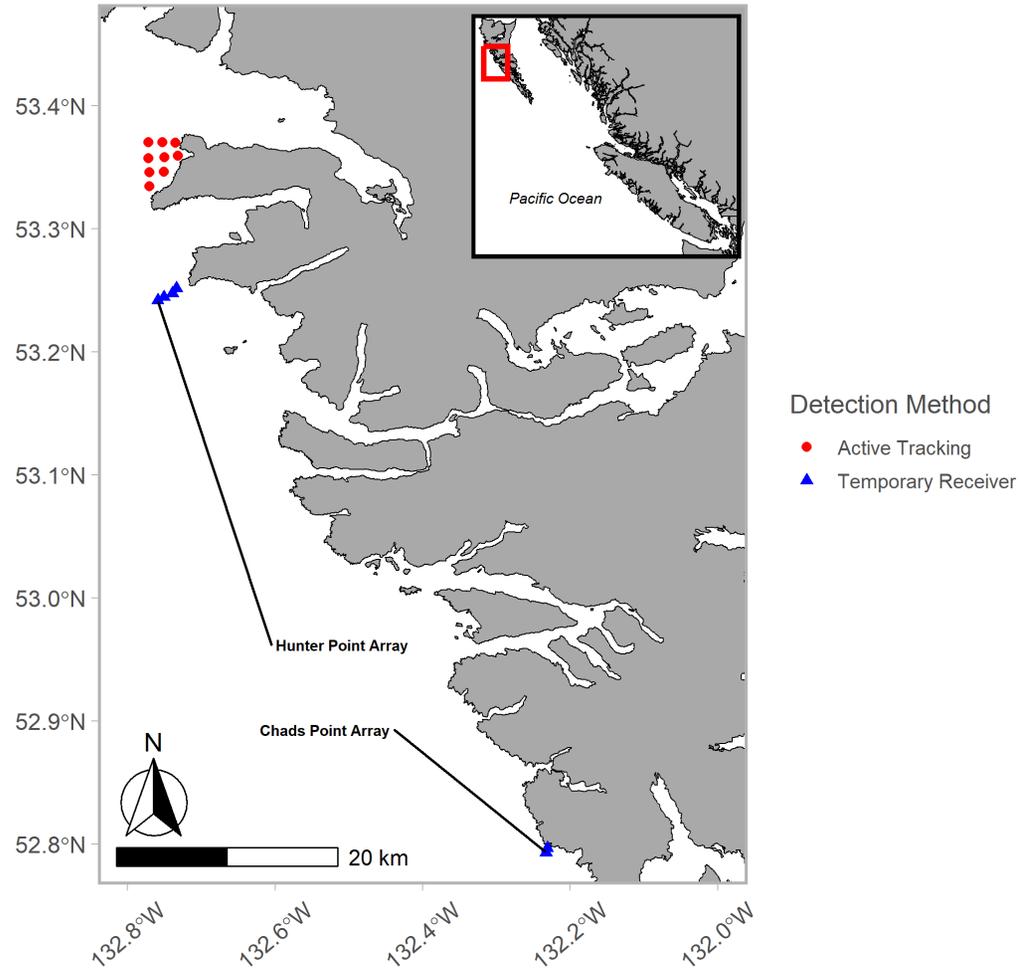


Figure 2. Haida Gwaii temporary acoustic telemetry locations from August 2024.

Triangle Island Acoustic Telemetry Locations - 2024

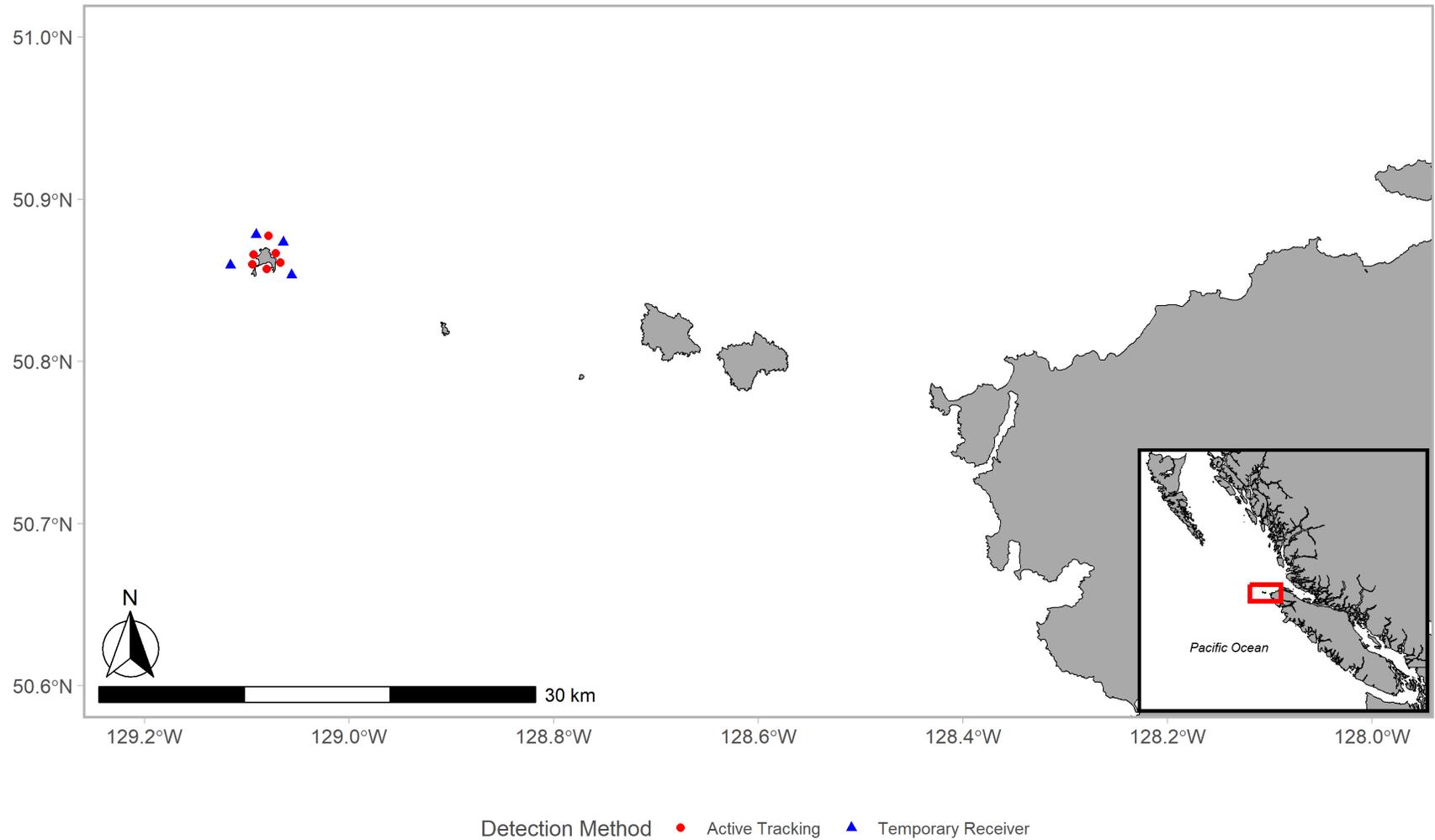


Figure 3. Triangle Island acoustic telemetry locations, July – September, 2024.

Coastwide Acoustic Receiver Network - 2024

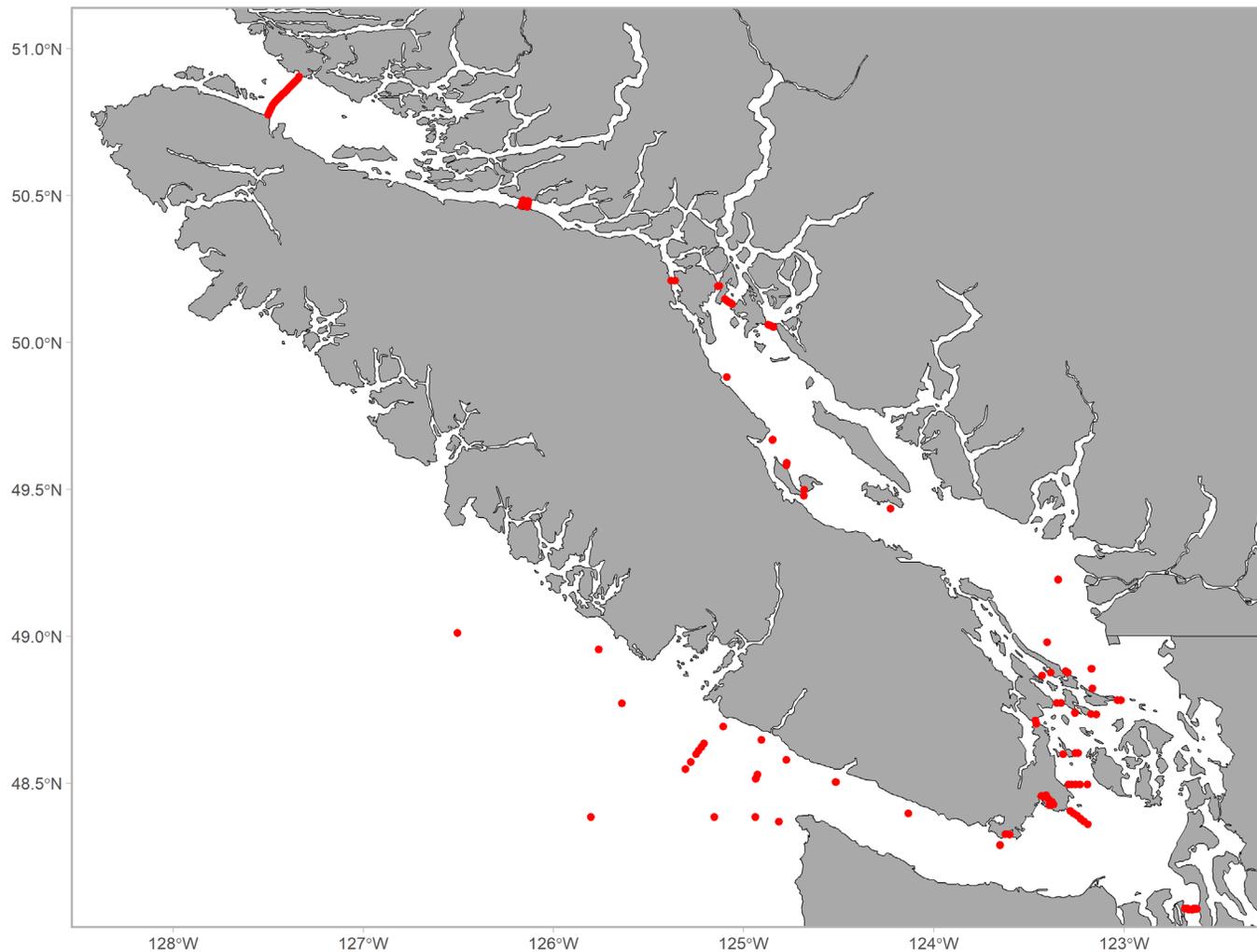


Figure 4. Coastwide acoustic receiver network in 2024. Receiver locations are denoted as red dots. Receivers managed by DFO, Kintama, University of British Columbia, University of Victoria, Ocean Tracking Network, and NOAA.



Figure 5. Picture of a dorsally attached Innovasea model V13P acoustic transmitter affixed to a Chinook Salmon (separate study).



Figure 6. Picture of a dorsally anchored Wildlife Computers *MiniPat* satellite tag affixed to a Sockeye Salmon.

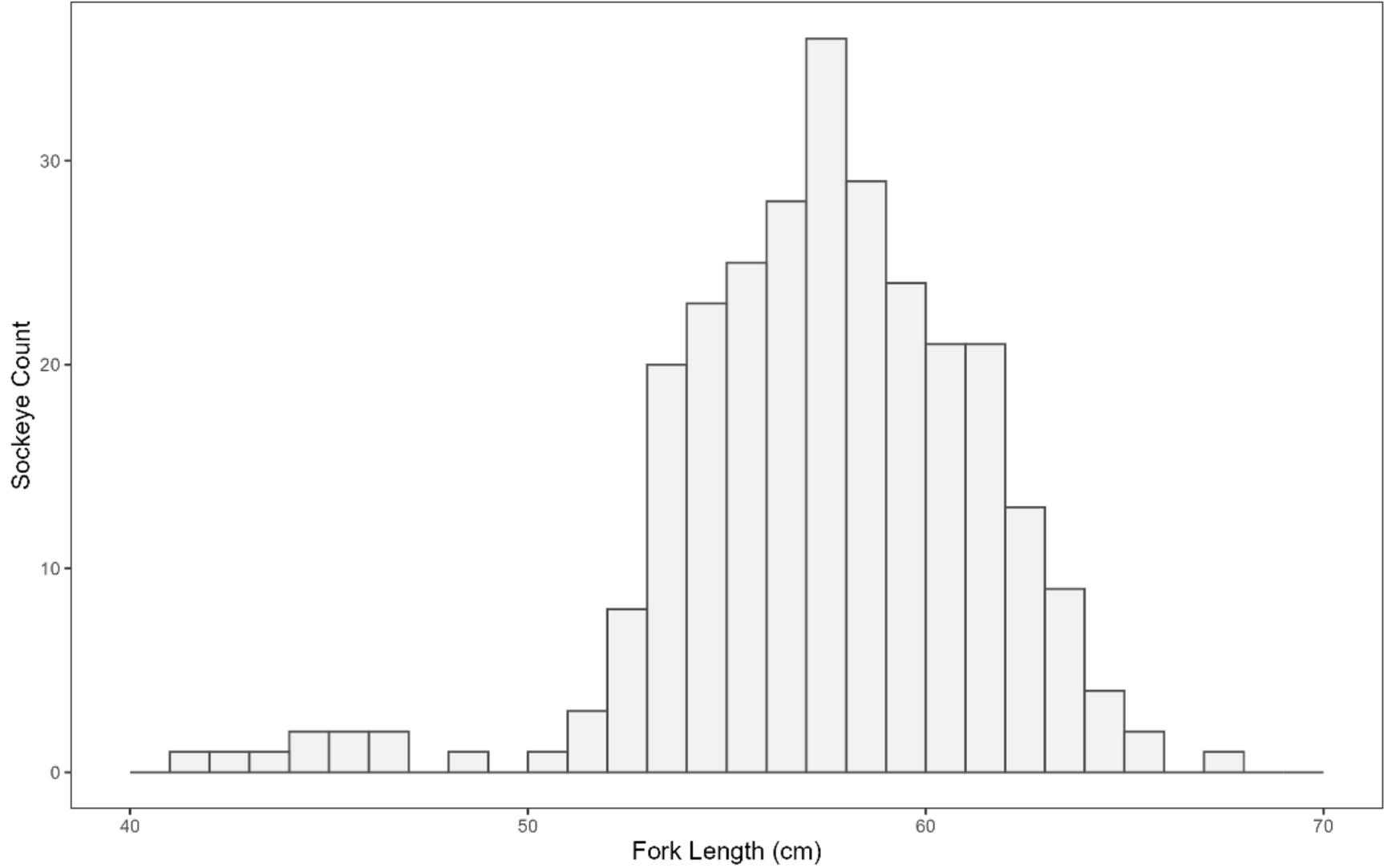


Figure 7. Sockeye Salmon (*Oncorhynchus nerka*) length frequency plot.

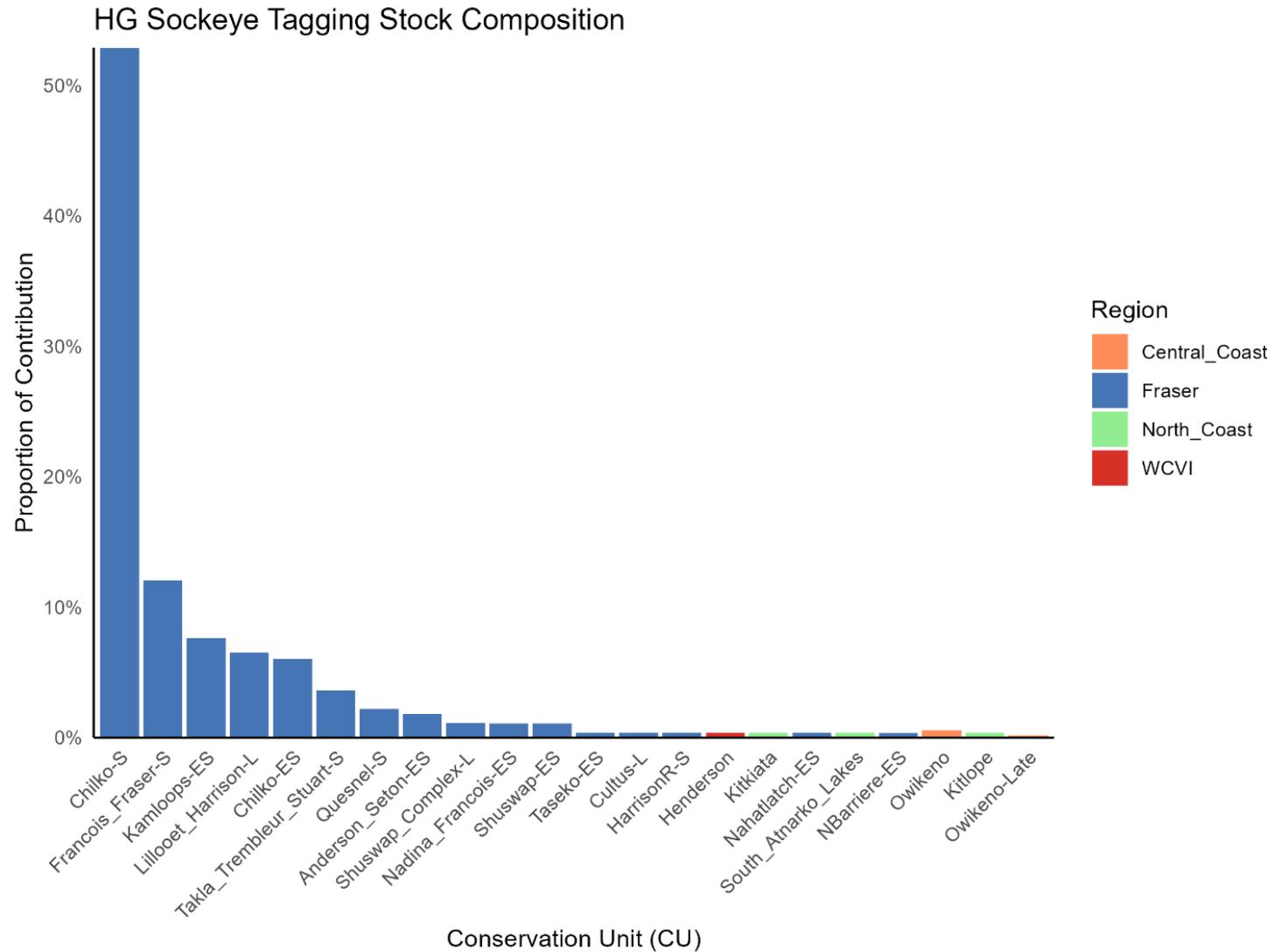


Figure 8. Stock Composition of tagged Sockeye Salmon (*Oncorhynchus nerka*), with percent of contribution on the y-axis and conservation unit (CU) on the x-axis. Region is denoted by colour. WCVI: West Coast Vancouver Island. HG: Haida Gwaii

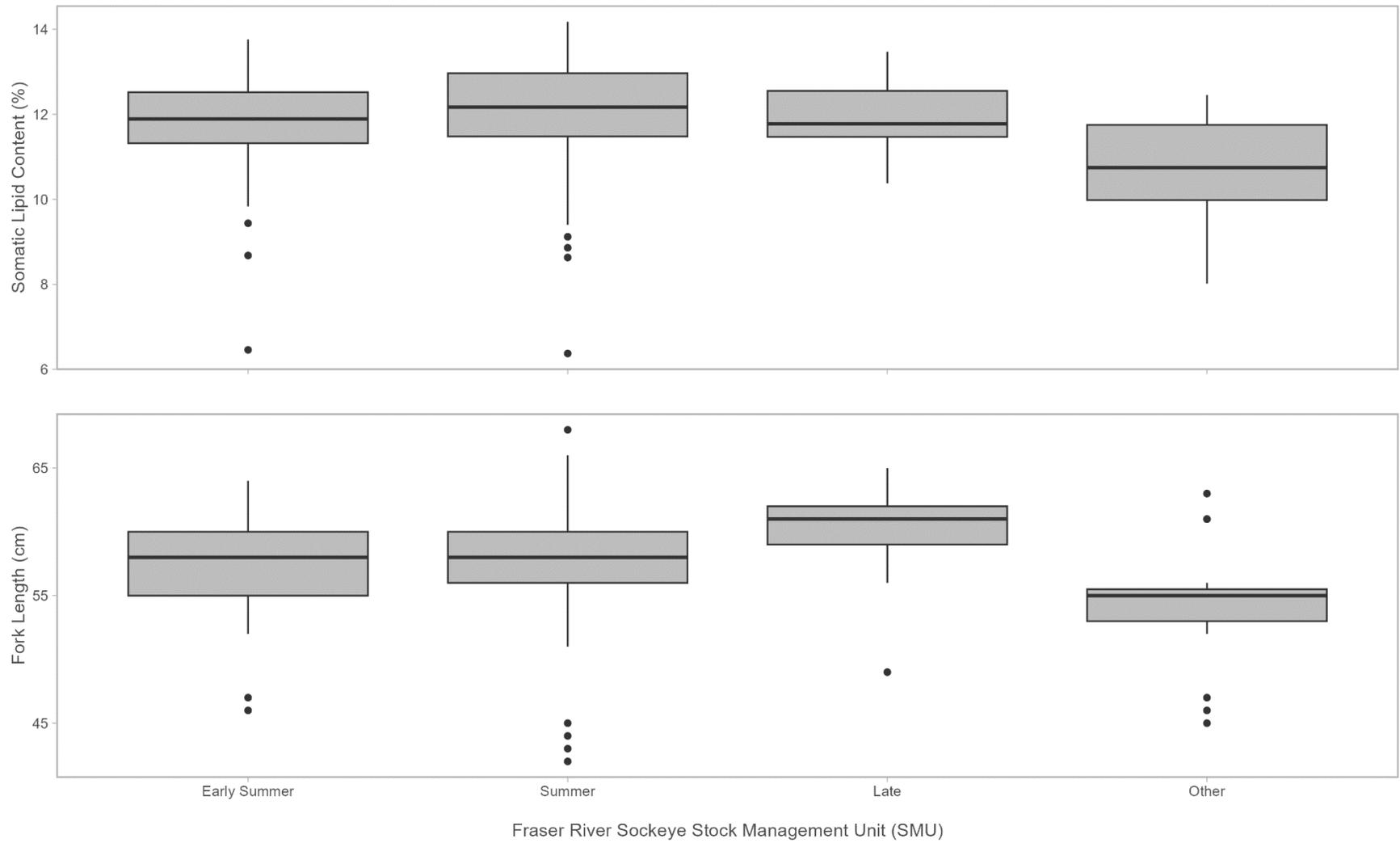


Figure 9. Box plots showing Somatic lipid content (%) and fork length (cm) by stock management unit (SMU) for Fraser River Sockeye. All non-Fraser Sockeye classified as "Other".

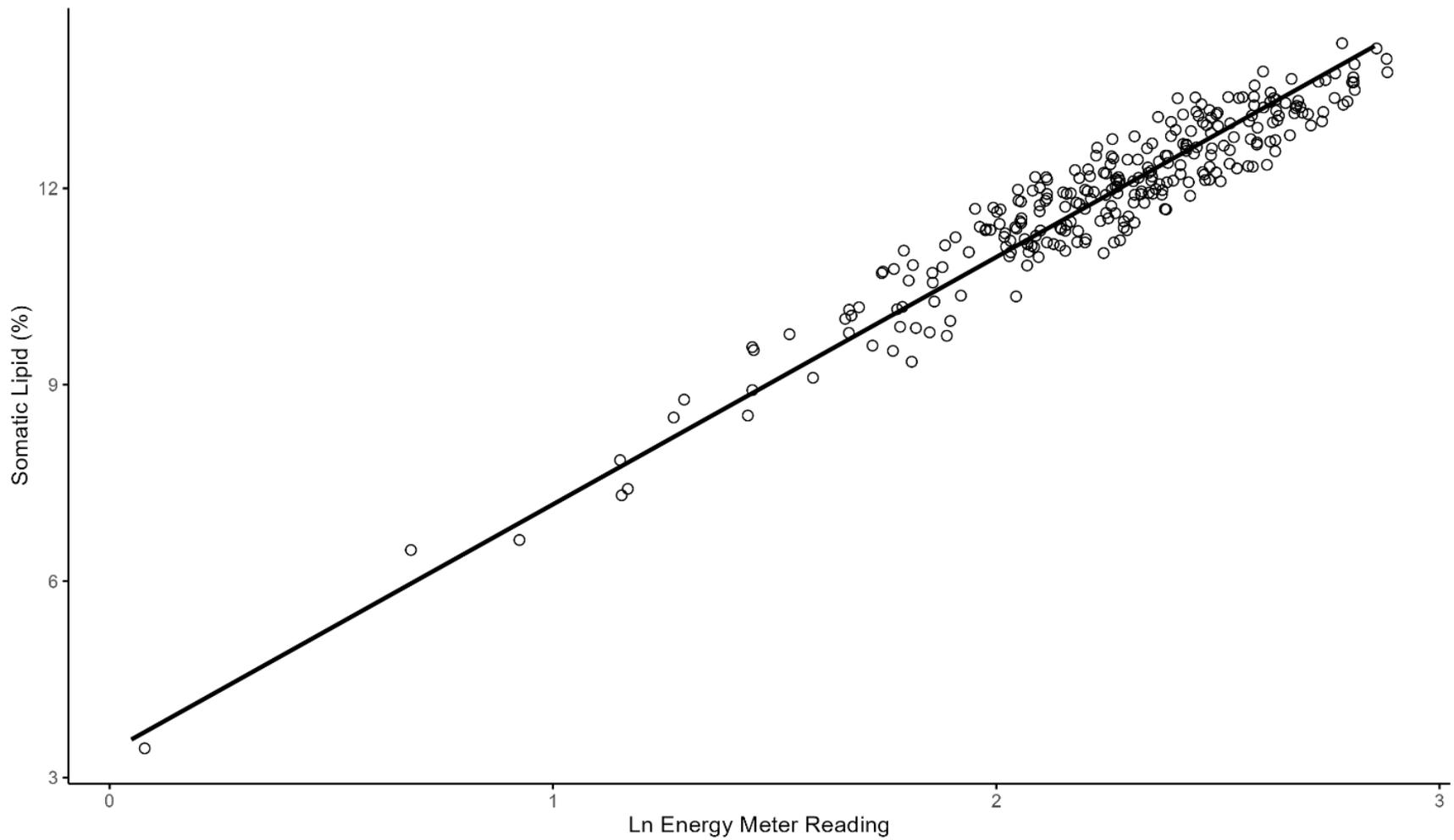


Figure 10: Relationship of Sockeye Salmon (*Oncorhynchus nerka*) percent somatic lipid to \log_e transformed energy meter readings (average of 2 readings).