2019 Bedwell River juvenile Chinook (*Onchorhynchus Tshawytscha*) out-migration assessment.

Prepared for:

Pacific Salmon Commision
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Prepared by:

Jared B. Dick
Uu-a-thluk Fisheries Program
Nuu-chah-nulth Tribal Council
161 1st Street, Tofino, BC
PO Box 1108, V0R 2Z0

Final Report
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Bedwell River Juvenile Chinook Out-Migration Assessment 2019

Submitted by: Jared Dick, NTC Central Region Biologist and Michael Swan, Ahousaht Fisheries Manager

Executive Summary

The Bedwell River juvenile Chinook (*Onchorhynchus tshawytscha*) out-migration assessment occurred during the spring of 2019. A rotary screw trap (RST) was installed on the lower reaches of Bedwell River and began fishing on March 15, 2019 and operated until June 14, 2019 with a total of 46 days sampled. Sampling was conducted primarily by 2 young Ahousaht technicians with assistance from the Uu-a-thluk (the Nuu-chah-nulth Tribal Council fisheries department) central region biologist and Uu-a-thluk technicians when required. A total of 2044 juvenile Chinook, 3801 juvenile Coho (*Onchorhynchus kisutch*), 906 juvenile Chum (*Onchorhynchus keta*) and 144 Rainbow trout (*Onchorhynchus mykiss*) were captured in the RST. 392 Chinook and 442 Coho were marked using Visible Implant Elastomer (VIE) tags with only a 9 marked individuals recaptured, producing very low trap efficiencies that ranged from 0.8% to 7.4%. Lengths and weights from a daily subsample were routinely taken for each species throughout the duration of the project. On April 17th, 30 age 0+ Chinook and 30 age 0+ Coho captured in the RST were euthanized and frozen whole in a liquid nitrogen dewar and transported to the Pacific Biological Station (PBS) to undergo infectious agent profiling by the molecular genetics lab. An additional 30 age 1+ Coho captured the same day were euthanized and dissected. Numerous tissue samples were removed to undergo infectious agent profiling and histopathological examination by the same lab at a later date.

Semi-regular sampling using a beach seine net within the Bedwell estuary began on March 1, 2019 and ceased on August 14, 2019 for a total of 15 days sampled. One section of the estuary was targeted for sampling due to previous year's identification of Chinook habitat usage. Captured juveniles were identified to species, had their weights (when possible) and lengths recorded followed by a release on-site. Additional height measurements were recorded starting in May. In total, 265 Chinook, 54 Coho and 313 Chum were captured and measured within the estuary. On May 30th, 30 age 0+ natural-origin Chinook juveniles captured in the estuary had their gills clipped and stored in vials containing RNAlater to undergo infectious agent profiling at the PBS lab. Sampling occurred on 5 separate occasions within Bedwell Sound outwards to Buckle Bay to trial capturing Bedwell Chinook smolts with a beach seine outside of Bedwell estuary, within the near-shore environment. The majority of the catch for these outward sets was Chum. Only 7 juvenile Chinook were captured and all within the Cypre River estuary, compared to the 329 juvenile Chum and 79 juvenile Coho captured. One Acoustic Trawl Survey (ATS) was trialed during the morning and early afternoon of May 29 within Bedwell Sound and within close proximity to the estuary. Unfortunately, only jellyfish were captured.

Introduction

Along the west coast of Vancouver Island (WCVI) numerous Chinook salmon populations have collapsed and remain in a depressed state of low production showing little to no signs of recovery. The Bedwell/Ursus wild Chinook population (hereafter referred to as "Bedwell Chinook") is among those currently in this state. The population belongs to the Southwest Vancouver Island Chinook Conservation Unit (CK-31) that was identified as being in the "red zone" under the Wild Salmon Policy (WSP). Under this biological status, the conservation unit is at risk of extirpation. The extremely low returns of Bedwell Chinook to their natal spawning grounds clearly illustrate this risk. From 2007 to 2011 there were less than 100 adult Chinook returning to the system each year with the lowest return of only 46 adults occurring in 2009. On the verge of extirpation, the Tofino Enhancement

Society (TES) commenced yearly broodstock collection in 2010 in an attempt to restore the population to a healthy level. Although enhancement efforts have helped increase the number of adult returns, with 252 returning in 2014 and 601 in 2015, definitive limiting factors for the diminished returns has yet to be clearly identified. A rebuilding plan for WCVI Chinook is required by the Canadian Department of Fisheries and Oceans (DFO) by 2020. This project will contribute to that rebuilding plan and the information provided will be included in the near-shore marine risk assessment being developed by the Area 24 (Clayoquot Sound) Salmon Roundtable.

Current efforts assessing the health and recovery of Chinook salmon have been primarily focused on adult escapement to their natal spawning grounds while data and information around the health and available resources at other life-stages is lacking. Without information at all life stages, it is difficult to identify limiting factors to recovery; especially since cohort survival is generally determined in the early life-history stages. This project was designed to begin assessing the distribution and fitness of out-migrating Chinook fry and smolts to help determine if Chinook recovery and production is limited by fish health during these early juvenile stages. Although the project was focused on Chinook, data from captured Chum and Coho was also collected and analysed. The first goal of the project was to determine the run-timing, size, and abundance of the juvenile Chinook out-migrating from the Bedwell River into the estuary. This was monitored through the operation and sampling of a rotary screw trap (RST) installed in the lower reaches of the Bedwell River. A mark-recapture experiment using Visible Implant Elastomer (VIE) tags was trialed this year to determine the trap's efficiency and allow for the estimation of the proportion of juveniles bypassing the trap: information required to produce the total abundance estimate. A second goal of the mark-recapture experiment was to determine the amount of time batches of marked individuals reside upstream following a release through changing the colour and location of the VIE implants.

Once the juveniles enter the Bedwell estuary, little is known about their diet, growth, distribution among different habitat types and the duration of their residence. The same data gaps remain once they leave to continue their journey through the near-shore marine environment in and around Clayoquot Sound. Such information is not only lacking for the Bedwell/Ursus, but for all the salmon-bearing watersheds within Clayoquot Sound. Assessment of the juvenile Chinook, and other species of juvenile salmon, within the estuary was done by collecting samples with a beach seine from March to August. Subsamples of daily captures were measured to track their changes in length, weight and height which served as indicators of growth. Beach seining within Bedwell Sound and further outwards towards the surf line occurred in an attempt to collect the same information for the near-shore marine environment. The near-shore marine environment in this report is considered as being all the waters outside of the Bedwell estuary within 1 nautical-mile of the surf line. One Acoustic Trawl Survey within the Bedwell estuary and Bedwell Sound was trialed in an attempt to capture the elusive Chinook smolts.

Within the near-shore marine environment of Clayoquot Sound, a relatively high density of open net-pen salmon aquaculture farms operate along the migratory pathways of the local salmon populations. The farms located in and around Bedwell Sound raise Atlantic salmon (*Salmo salar*) while the farms raising Chinook are found further southeast within Fortune Channel and Tofino Inlet. The Atlantic salmon farms are each stocked with upwards of 500,000 individuals while the Chinook farms are stocked with upwards of 300,000 individuals. Bedwell Sound contains 5 aquaculture sites where as many as 3 farms may be active during an out-migration period that the Bedwell/Ursus smolts must migrate past. There are 2 additional aquaculture sites that Bedwell/Ursus smolts must migrate past once leaving Bedwell Sound in either direction. With the farms being open there are concerns about the interactions between out-migrating smolts and the emissions from the farms into the surrounding water column. In particular, there are concerns with the potential for pathogens and sea lice (*Lepeophtheirus salmonis*) originating from farms being transmitted to the smolts. To begin addressing these concerns, it's important to first understand the infectious agents present in the juvenile salmon prior to entering the marine environment and during their residence within the estuary. Therefore, samples from the river and estuary were sent to the molecular genetics lab at the Pacific Biological Station (PBS) to undergo infectious agent profiling to begin answering this question. To begin addressing the concerns of sea-lice transmission from farms to out-migrating smolts, the amount of sea-lice attached to a random subsample of juvenile salmon captured each day was enumerated for each beach seine set within the estuary and near-shore marine environment.

Under the WSP, salmon are considered "wild" if they have spent their entire life cycle in the wild and originate from parents that were also produced by natural spawning and continuously lived in the wild (DFO, 2005). Because of this, the juvenile Chinook sampled during this assessment that are known to be produced by natural spawning are not referred to as "wild" but rather as "natural-origin" since the origin of the parents is not known. Some, if not many, of the juveniles sampled may have been produced by parents that originated from the hatchery ("hatchery-origin) and returned to Bedwell River to spawn naturally in 2018.

Site Description

The Bedwell/Ursus watershed (hereafter referred to as the "Bedwell River") resides within the traditional territory of the Ahousaht First Nation and is located within Clayoquot Sound approximately 24 km northeast of Tofino on the west coast of Vancouver Island (WCVI), British Columbia, Canada (Figure 1). The watershed is comprised of two major sub-basins: the Bedwell River and Ursus Creek sub-basins (Smith & Wright, 2016). The Bedwell sub-basin drains approximately 21.1 km^2 while the Ursus sub-basin drains approximately 13.1 km^2 (Smith & Wright, 2016). The Bedwell sub-basin drains the year-round snow pack and glaciers of Mount Tom Taylor and Big Interior Mountain in Strathcona Park (Smith & Wright, 2016). It flows southeast for approximately 28.7 km to the head of Bedwell Inlet. The Ursus Creek sub-basin drains from a maximum elevation of approximately 1,000 m and flows in a westerly direction for approximately 17 km through a steep sided valley into the Bedwell River (Smith & Wright, 2016). A portion of the Bedwell sub-basin was logged with the majority of the logging taking place between 1946 and 1968 (Smith & Wright, 2016). Although only 2% of the watershed was reported as logged by 1968, the majority of the logging occurred along the riparian zone of the Bedwell River (Figure 2) (Smith & Wright, 2016). This included the practice of cross-stream yarding and clear-cutting to the stream banks which heavily degraded the riparian habitat and greatly reduced bank stability.

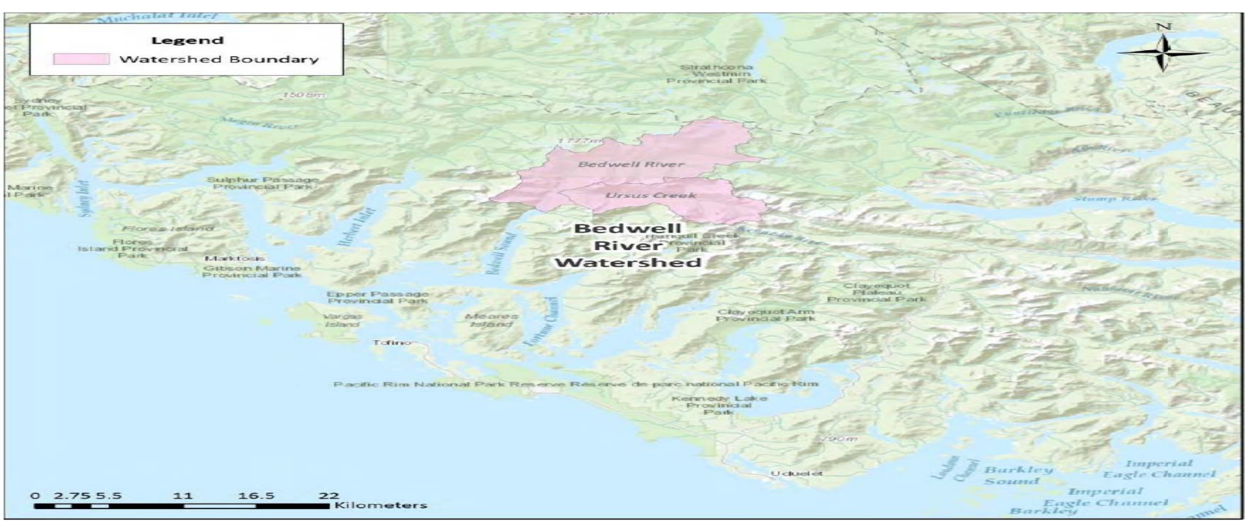

Figure 1. Overview of the Bedwell/Ursus Watershed located in Clayoquot Sound, Canada (Smith & Wright, 2016)

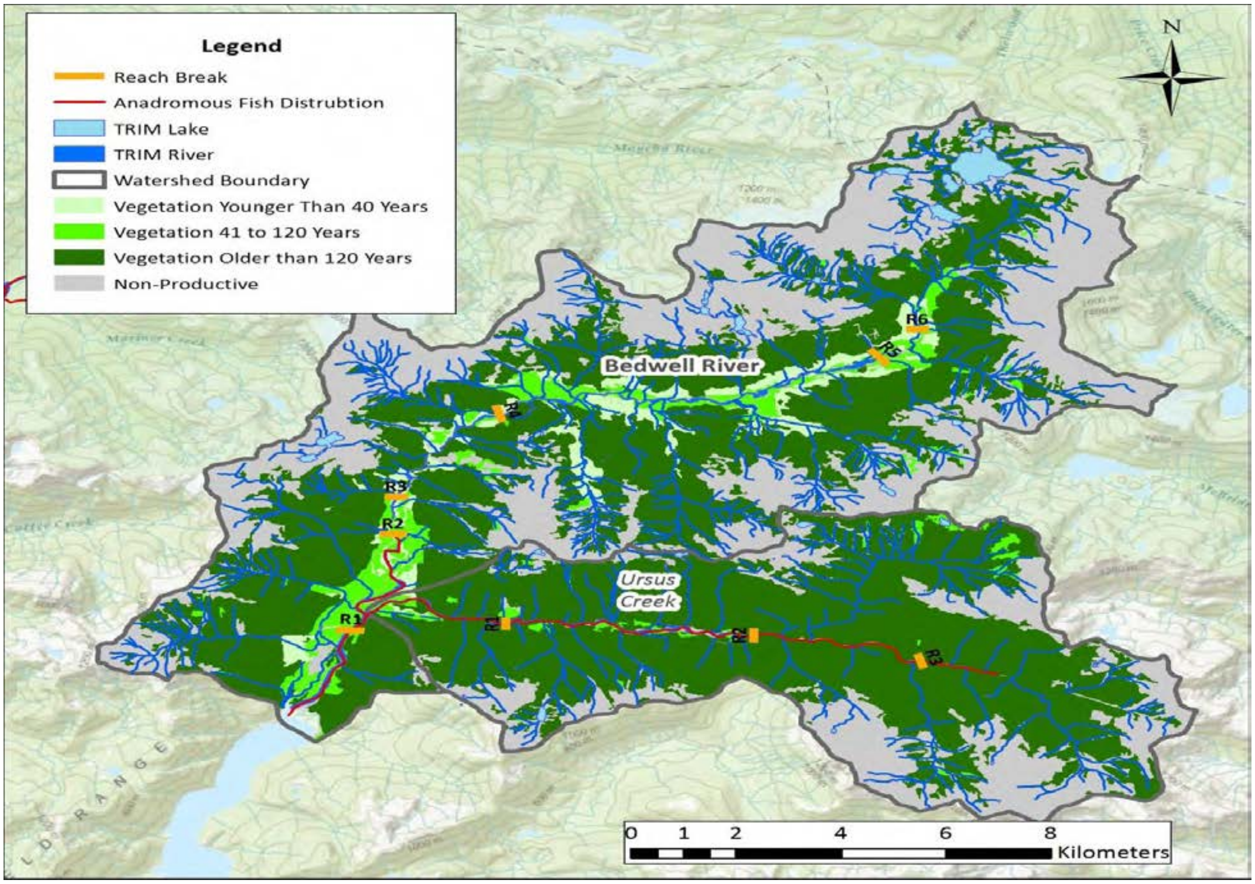

Figure 2. Land cover alterations in the Bedwell/Ursus watershed. Date of reference for the legend is 2016 (Smith & Wright, 2016).

The watershed hosts populations of Chinook, Coho, Chum and Sockeye (*Onchorhynchus nerka).* Pink salmon (*Onchorhynchus gorbuscha*) are observed most years in Bedwell but only in small numbers since the 1980's (≤ 55). 7 km upstream in the Bedwell sub-basin are waterfalls and a canyon that act as a barrier to anadromous upstream migration. Chinook and Coho are thought to rarely bypass this barrier (Smith & Wright, 2016). Within the Ursus sub-basin there are a set of cascades approximately 3.5 km upstream from the Bedwell-Ursus confluence that acts as a barrier to upstream migration. However, Chinook are occasionally seen upstream of this barrier. Coho migrate past this barrier and have been observed 13 km upstream of the Bedwell-Ursus confluence (Smith & Wright, 2016). Chum and Sockeye do not migrate past these barriers. The Bedwell/Ursus Chinook population belongs to the Southwest Vancouver Island Conservation Unit (CK-31) which is one of the three WCVI Chinook salmon groups (Figure 3). Hatchery supplementation of Chinook began in 2010 with broodstock taken from the autumn 2010 return for release in the spring of 2011. The system has continued to receive hatchery input every year since and in 2019 received an input of 20,000 age 0+ Chinook with an average weight of 5.3 grams and 18,000 age 0+ Chinook with an average weight of 5.8 grams on May 17th and May 27th respectively. Bedwell is unique because 100% of the hatchery release receive an external mark (adipose fin clip) and a Coded Wire Tag (CWT) implant allowing for visual verification of hatchery-origin upon capture.

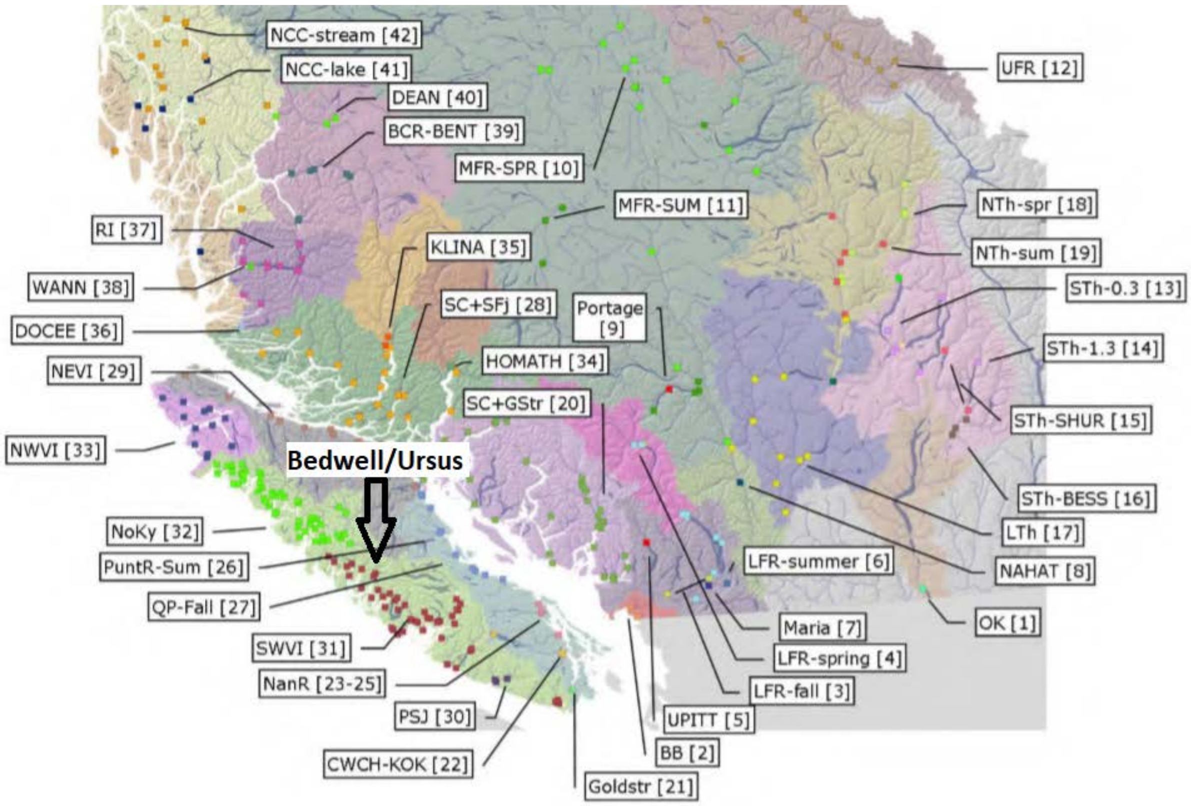

Figure 3. Location of the Bedwell/Ursus watershed on the west coast of Vancouver Island (WCVI) and Chinook salmon conservation units as identified by Holtby and Ciruna (2007).

Methods

In-River Sampling

All in-river samples were collected using the RST installed on March 15, 2019. The trap was situated in the lower Bedwell River at N 49.38023, W -125.76470: approximately 2 km upstream from the estuary (Figure 4). This location is above the area where the majority of the Chum spawn. The RST was attached to a winch and cable system that spanned across the width of the river that allowed for the trap to be moved back and forth with ease. The trap was placed in the deepest section of the channel with the most flow when fishing. During unsafe high flow events the trap was pulled as close to shore as possible behind a large pile of erosion-control boulders that stretched into the river creating a back eddy. The personnel operating the RST checked the trap each morning that sampling occurred.

Figure 4. Location of the rotary screw trap (red star) in the lower reaches of the Bedwell River.

During sampling, all captured fish were placed in large 5 gallon buckets with an aerator and ice-packs to keep them cool and oxygenated. Juveniles that received a VIE implant were first anesthetised using Tricaine Methanesulfonate (TMS). A designated 5 gallon bucket, with an aerator and ice packs, used for anesthetizing the juveniles was filled with 8 litres of water from the Bedwell River with 0.48 grams of TMS added to achieve the concentration of 60 ppm (mg per litre). An equal amount (0.48 grams) of Baking Soda ($NaHCO_3$) was added to neutralize the pH of the freshwater anesthetic bath. The juveniles receiving a tag were taken from a holding bucket and placed into the bath. Within 1 -2 minutes the juveniles were sedated and individuals were removed one at a time and placed on a wet sponge where they were then injected with the elastomer (Figure 5). If the time required for anesthesia or recovery started to change, or if the temperature difference between the source water and anesthetic bath exceeded 2 °C, the bath was renewed. Following tagging, the individual was placed in a large cooler with ice packs and aerators to recover. A different colour of elastomer was used each day along with changing location of the tag (i.e. left of the dorsal fin, right of the dorsal fin) to, upon recapture, identify the exact day the juveniles were tagged and released. Following marking and recovery, the fish were released 2 pools upstream from the trap which was the pool located at the confluence of the Bedwell River and Ursus Creek. Fish that weren't marked or measured were counted and placed in separate 5 Gallon buckets with ice packs and aerators and were released directly downstream of the trap below the back eddy. Each time the trap was checked the following was recorded on the data sheet:

1) The instantaneous rotation rate (the amount of time it takes the cone of the RST to complete 3 full revolutions).
2) The amount of debris removed.
3) The number of fish captured by species
4) Subsample of lengths and weights
5) The location and colour of VIE tag if applied
6) The number of fish recaptured (marked with VIE Tags) with location and colour of tag

Figure 5. A juvenile salmon being marked with a Visible Implant Elastomer (VIE) tag. Retrieved January 15, 2020 from https://www.nmt.us/tagging-small-fish-with-vie/

On April 17th 2019, 30 age 0+ Chinook, 30 age 0+ Coho and 30 age 1+ Coho captured in the RST were lethally sampled by placing them in a 5 gallon bucket containing Bedwell River water and a lethal concentration of TMS provided by DFO. Once euthanized, the age 0+ Chinook and Coho were measured and then wrapped separately in Aluminum tinfoil with a label and placed in a liquid nitrogen dewar to be flash frozen as they were too small to be dissected. These individuals were sent to the PBS to undergo infectious agent profiling. A new lethal TMS bath was mixed to euthanize the Coho samples and avoid cross-contamination.

The 30 age 1+ Coho were placed in a 5 gallon bucket filled with ice packs and aerators while they awaited dissection. The following tissues were removed from each specimen and placed into a perforated numbered cassette (Figure 6): muscle tissue, gill, spleen, liver, kidney, heart, pyloric caeca, intestine, brain and eye. Prior to being placed into the cassette, the following tissue samples were first cut in half with one half placed into a separate vial containing a solution of RNAlater: muscle tissue, gill, spleen, liver, heart, kidney and brain. A sample of blood was also extracted and stored in a vial containing RNAlater. The samples within the vials were sent to the PBS to undergo infectious agent profiling. The samples within the perforated cassettes were stored in a solution of 3.7% formaldehyde and sent to the same lab to undergo histopathological examination.

M_i

Figure 6. Jessica Hutchinson placing an Age 1+ Coho tissue sample into a vial containing RNAlater with the perforated cassette containing tissue samples (yellow arrow) in the background.

The dissection process for each Coho was performed as follows: first, the dissector put on a new pair of latex gloves followed by preparation of the table where a new mat was laid with 2 disinfected scissors and 2 disinfected scalpels placed on top. Second, a Coho from the holding bucket was euthanized by placing it into the bucket containing the lethal dose of TMS. Once the individual ceased operculum movement, signifying death, it was placed on the mat. The first tissue sample removed was a piece of muscle tissue which was extracted by cutting a small rectangle of flesh from the outside of the body using the designated "dirty" scalpel (the scalpel used only on the outside of the fish). Next, the "dirty" pair of scissors was used to remove the 3rd gill arch. The scissors were then inserted into the anus where a longitudinal incision was made anteriorly and ended just below the gills; exposing the internal organs. The "clean" scissors and scalpel were used only inside the body cavity of the specimen. Other than the brain and eye, each of the tissues mentioned previously were removed. Next, the eye was removed using the dirty pair of scissors and scalpel. Finally, the brain was removed by using the dirty scalpel to cut away part of the head, exposing the brain, followed by using the clean scalpel and scissors to remove the brain from the cavity.

Efficiency Tests

Efficiency tests using the VIE mark-recapture data was used to determine what proportion of the out-migrating salmon was being caught in the trap and what proportion was bypassing the trap. The trap efficiency over a given time period was calculated using the Peterson equation:

$$N_i = \frac{\hat{n}_i M_i}{m_i} = n_i \hat{e}_i^{-1}$$

N_i = estimated number of downstream migrants during period i

$\hat{n}_i$ = # fish captured during period i

$\hat{e}_i^{-1}$ = trap efficiency (m/M) during period i

m_i = total number of marked fish recaptured during period i

M_i = total number of fish marked during period i

Each period begins on the first day a batch of juveniles was tagged and continues until 3 consecutive days without tagging has been reached. For example, tagging that occurred on April 24 and 25 and not on the 26, 27 or 28 would result in the period being April 24 – 28. However, if no sampling occurred for some of the days following the last tagging date for a batch, the period would end during the last day sampling occurred. If no sampling occurred on April 27 and 28 in the above example, the period would instead be April 24 – 26. This period definition was chosen because the 2019 data showed that the latest a recapture occurred was 3 days following release. These periods will have separate trap efficiency estimates and separate total estimated number of downstream migrants. Due to the limited recapture data, we assumed the behavior of age 1+ Coho, age 0+ Coho and age 0+ Chinook was the same. The assumption being that when they're migrating past the trap, they're committed to entering the lower river and estuary and aren't holding upstream when released. Data from the 2017 Bedwell Chinook Out-Migration Assessment using Bismark Brown for marking also provides evidence suggesting this behavior for Age 1+ Coho as all recaptures except one occurred within 2 days of being tagged and released.

Estuary Sampling

All samples collected in Bedwell estuary was done at low tide using a beach seine that was 39 meters long, with a slight taper towards each end, with a depth of 2.6 meters. The outer mesh size was 10 millimeters with a centre mesh size of 4 millimeters. The seine net was borrowed from Cedarcoast Field Station (CFS). Seine sets were concentrated at our primary "Estuary Sample Site 2" (ESS2). This site and the surrounding area were targeted because sampling in previous years found that the juvenile Chinook prefer to congregate here. The coordinates of this site are 49°21' 21.3" and 125°46' 20.3" (Figure 7). Following each seine event, all the salmon captured were gathered and placed into 5 gallon buckets with a bait bucket aerator. The individual samples had their species, weight (when possible), length, number of sea lice attached, adipose fin-clip status, and condition recorded. Wind would often prevent accurate weights from being obtained. The width of the juveniles at the thickest portion of their body ("height") began to be recorded on May 14 to make up for the lack of weights. Following sampling, the juveniles were released live at the site.

Figure 7. The location of the primary beach seine site ESS2 (red star) and the general area focused when sampling the Bedwell estuary (yellow box).

On May 30th 2019, 30 age 0+ natural-origin Chinook captured near ESS2 using the beach seine were lethally sampled. The individuals were euthanized by a lethal blow to the top of their head. Using sterilized scissors, a piece of the gills was clipped and placed into separate vials containing RNAlater followed by the measuring of the individuals' length and height. The gill clips were sent to the PBS to undergo infectious agent profiling.

Near-Shore Marine Sampling

All samples collected outside of the estuary were done at beaches located within Bedwell Sound and as far as Buckle Bay on Vargas Island within Clayoquot Sound. The same net used in the estuary was used for sampling outside of the estuary. Following each seine event, all the salmon captured were gathered and placed into 5 gallon buckets with a bait bucket aerator. The individual samples had their species, weight (when possible), length, height, number of sea lice attached, adipose fin-clip status, and condition recorded. Following sampling, the juveniles were released live at the site.

On May 29th 2019, an ATS was conducted by the Huupacasath First Nation Fisheries department and Uu-a-thluk using external funding. A large midwater "3 x 7" beam trawl was towed behind the 7 meter Huupacasath Fisheries vessel at a speed of 1.3 knots. The trawl net was 18 m long with a 3 m wide by 7 m deep mouth opening

(Figure 8). The net was constructed with a graded series of meshes, decreasing in size from the mouth (10.2 cm stretch mesh) to codend (3 mm bobbin). A plastic PVC (75 mm diameter) tube was used to collect fish at the codend and was closed by a threaded perforated cap lined with plankton netting. The mouth was kept open by top and bottom spreader bars and two 22.7 kg lead balls hung from the ends of the bottom bar. To fish the surface of the water column (0 m – 7 m), 2 white boat bumper buoys were attached to each end of the upper spreader bar to prevent it from sinking. A total of 15 transects were completed within Bedwell Sound and around the Bedwell estuary. No salmon were captured along any transect. Only jellyfish were routinely captured.

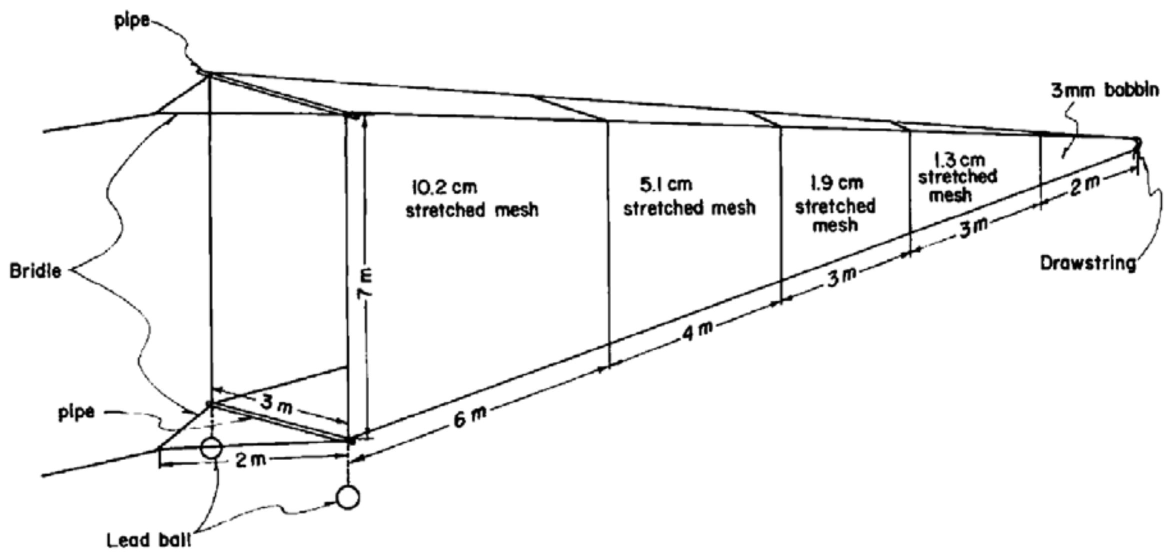

Figure 8. Schematic diagram of the single-net closing midwater trawl, showing the bridle attachment and net, used in the Acoustic Trawl Survey (ATS).

Starting at 6:30am, the first transects were completed just southeast of Bare Bluff along the eastern side of Bedwell Sound. Transects were done in both directions (NW to SE and SE to NW). 6 transects were completed at depths ranging from 0 m to a max of 50 m. The final 2 transects occurred in the centre of Bedwell Sound still south of Bare Bluff. Next, 6 transects were done adjacent to the Bedwell estuary. The first transect started offshore of the mouth of the Bedwell River where the net was towed from the west to the east parallel to the shoreline at a depth of 0 m – 7 m. The second transect was the reverse of the same transect but this time at a depth of 10 m – 17 m. The third estuary transect started at the same spot as the first estuary transect following the same route but halfway through the estuary the vessel veered south and continued the tow south through the centre of the estuary. This was at a depth of 2 m – 9 m. The following 2 transects occurred starting just NE from ESS2 and ended roughly halfway to Bare Bluff. The first transect occurred at a depth of 5 m – 12 m while the second transect in the opposite direction occurred at a depth of 15 m – 22 m. The final transect occurred starting also just NE of ESS2 and outwards to Bare Bluff at a depth of 23 m – 30 m. The final 3 transects occurred along the west side of Bedwell Sound from just south of Bare Bluff to Rant Point on the way back to Tofino. The first transect occurred at a depth of 3 m – 10 m from just south of Bare Bluff to halfway down Bedwell Sound. The final 2 transects were from halfway down Bedwell Sound to Rant Point. The first was in the southeast direction at a depth of 3 m – 10 m and the second transect followed the same path in the opposite direction but at a depth of 10 m – 17 m.

Results

In-River Sampling

The trap was installed and began fishing on March 15, 2019 and was operated until June 14, 2019 with a total of 46 days of sampling. A total of 2044 juvenile Chinook salmon were captured in the RST along with an additional 3801 juvenile Coho, 906 juvenile Chum and 144 Rainbow trout (Table 1; Figures 9 - 11). All juvenile Chinook captured were fry with the exception of alevin being occasionally captured. The Chinook fork-lengths ranged from 31 millimeters to a maximum of 80 millimeters with a mean length of 41.7 mm (Table 2; Figure 12). The weights ranged from 0.2 grams to a maximum of 2.3 grams with a mean weight of 0.54 g (Table 2; Figure 13). 0 Chinook were captured on March 16 following the first night the trap operated. The trap fished overnight again on March 20 yielding 76 Chinook fry. The peak catch occurred on April 4 with 223 Chinook fry captured. Following the peak, the catch remained relatively consistent until May 10 when it tapered off significantly. The tail-end of the run continued through to the end of May and was over on June 3.

The fork-lengths of all Coho juveniles captured ranged from 26 mm to 132 mm (Table 3 & 4; Figures 14 - 17). The weights of all Coho captured ranged from 0.1 g to 20.7 g (Table 3; Figure 15). There were 2 distinct size classes of Coho captured in the RST representing the age 0+ and age 1+ cohort's (Figure 14). 50 mm was chosen to be the fork-length threshold separating the age 0+ and age 1+ Coho. This was chosen because 100% of the Coho caught with a fork-length less than 50 mm were clearly very young fry and weighed much less than the Coho caught with fork-lengths greater than 49 mm. This threshold was particularly evident in 2018 where all the Coho under 50 mm weighed less than 1.02 g and were clearly young fry while all the Coho above 50 mm weighed at least 1.7 g and were visibly much larger parrs and smolts. Although the threshold is not as apparent in 2019, it serves the purpose of visualizing and characterizing the sizes for both the age 0+ and age 1+ juvenile Coho. The estimated average fork-length and weight for age 0+ Coho was respectively 37.2 mm and 0.45 g (Table 3). The estimated average fork-length and weight for age 1+ Coho was respectively 7.69 mm and 4.72 g (Table 4). 0 Coho were captured on March 16 following the first night the trap operated (Figure 10). The trap fished overnight again on March 20 yielding 94 Coho. The peak catch occurred on April 9 with 236 Coho captured. Following the peak, the catch remained relatively consistent until May 10 when it tapered off significantly. The tail-end of the run continued through to June 14 with the end of the run not captured as there were no days with 0 Coho captures.

All juvenile Chum captured were fry. The fork-lengths of Chum ranged from 29 mm to a maximum of 50 mm with a mean length of 40.0 mm (Table 5; Figures 18 & 19). The weights of the Chum ranged from 0.1 g to 0.7 g with a mean weight of 0.42 g (Table 5; Figure 19). 30 Chum were captured on March 16 following the first night the trap operated. The trap fished overnight again on March 20 yielding 38 Chum. The peak catch occurred on March 28 with 165 Chum captured. The run finished on May 10 as the final 2 Chum were captured on May 9.

Marking with VIE tags occurred on April 4, 10, 11, 12, 24, 25 and May 7 (Table 6). A combined total of 906 juvenile Chinook and Coho were marked with the VIE tags and released. Only 9 recaptures were observed producing trap efficiency estimates ranging from 0.8% to 7.4% for the separate periods (Table 6).

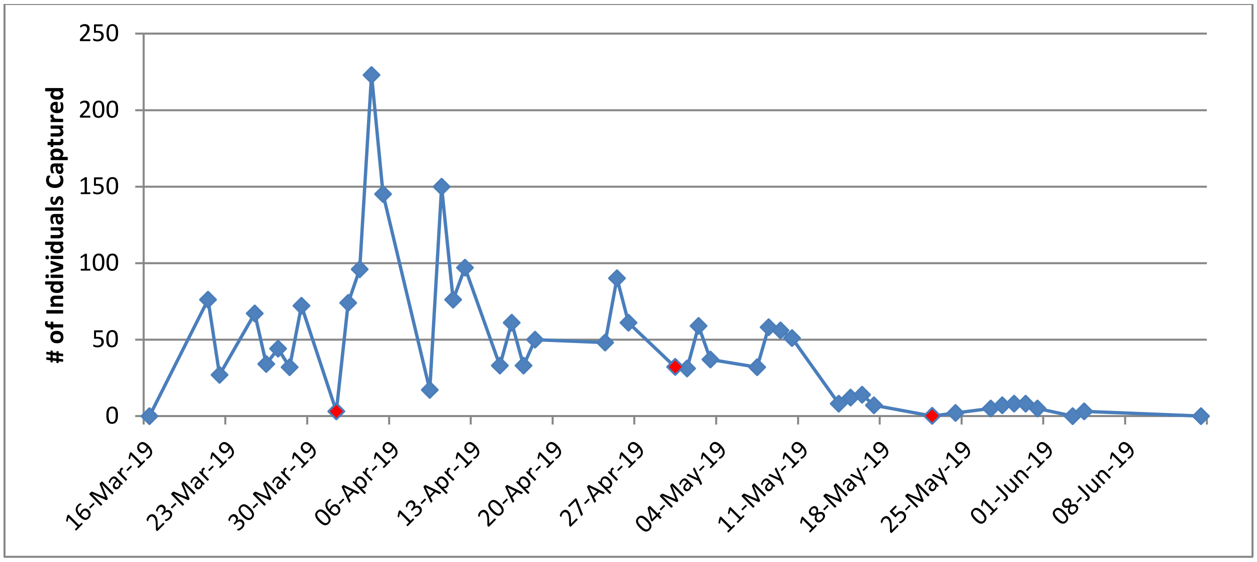

Figure 9. The daily number of juvenile Chinook caught in the Bedwell River RST in 2019. Note that on April 1, 30 and May 22 consist of samples that were only captured in the day and not overnight (red).

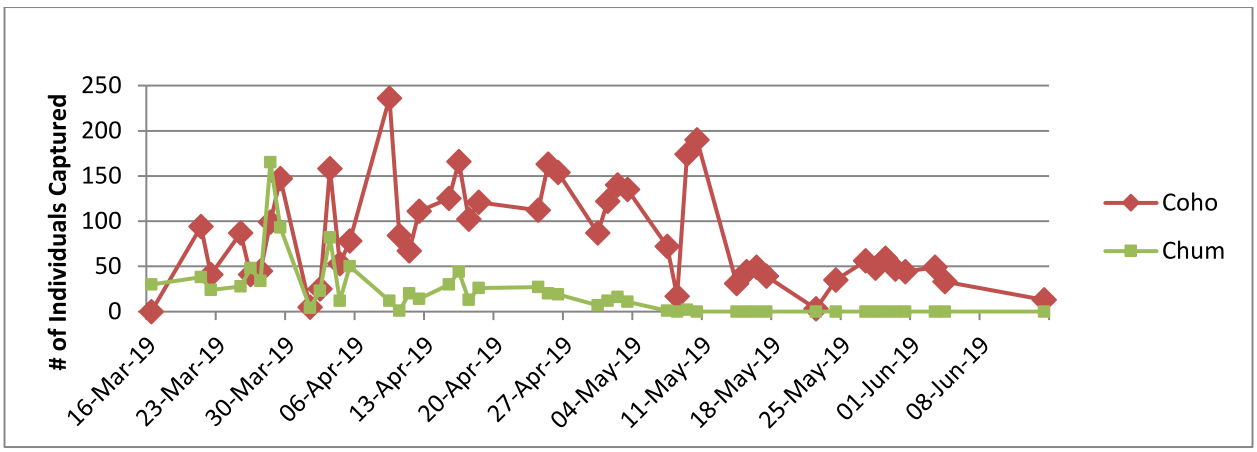

Figure 10. The daily number of juvenile Chum and Coho caught in the Bedwell River RST in 2019. Note that on April 1, 30 and May 22 consist of samples that were only captured in the day and not overnight.

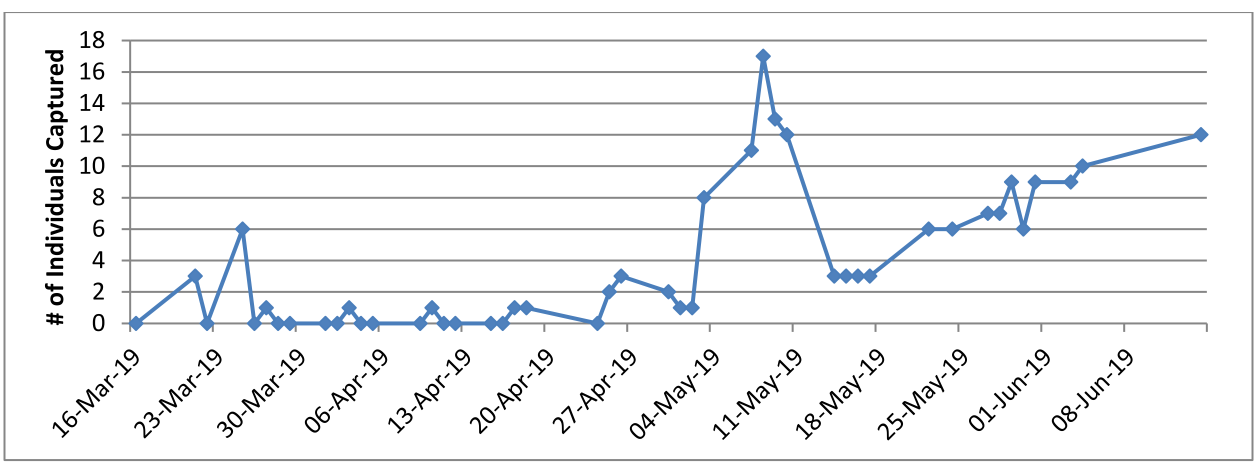

Figure 11. The daily number of Rainbow Trout caught in the Bedwell River RST in 2019. Note that on April 1, 30 and May 22 consist of samples that were only captured in the day and not overnight.

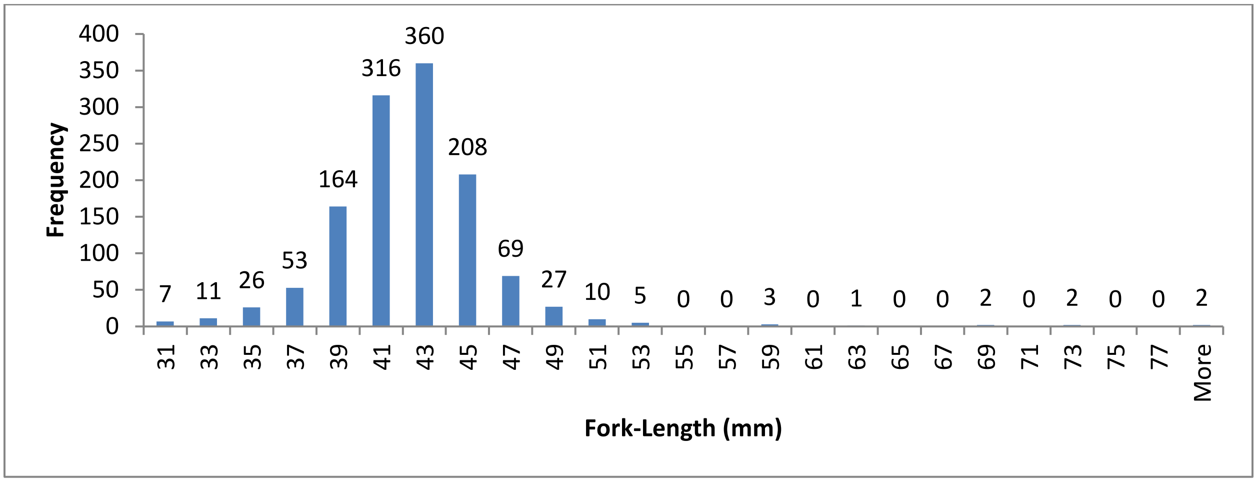

Figure 12. Fork-length histogram for juvenile Chinook salmon caught in the RST in the Bedwell River in 2019. The sizes within the bins decrease. For example, Fork-Length bin 35 includes juveniles both 35 mm and 34 mm.

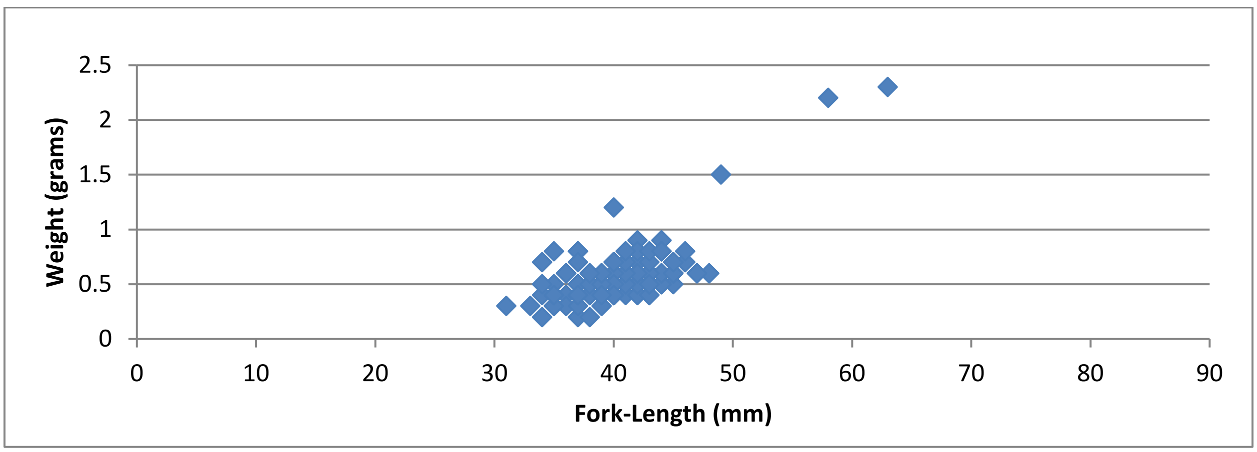

Figure 13. Weight Vs Length relationship for juvenile Chinook salmon collected from the Bedwell River RST in 2019.

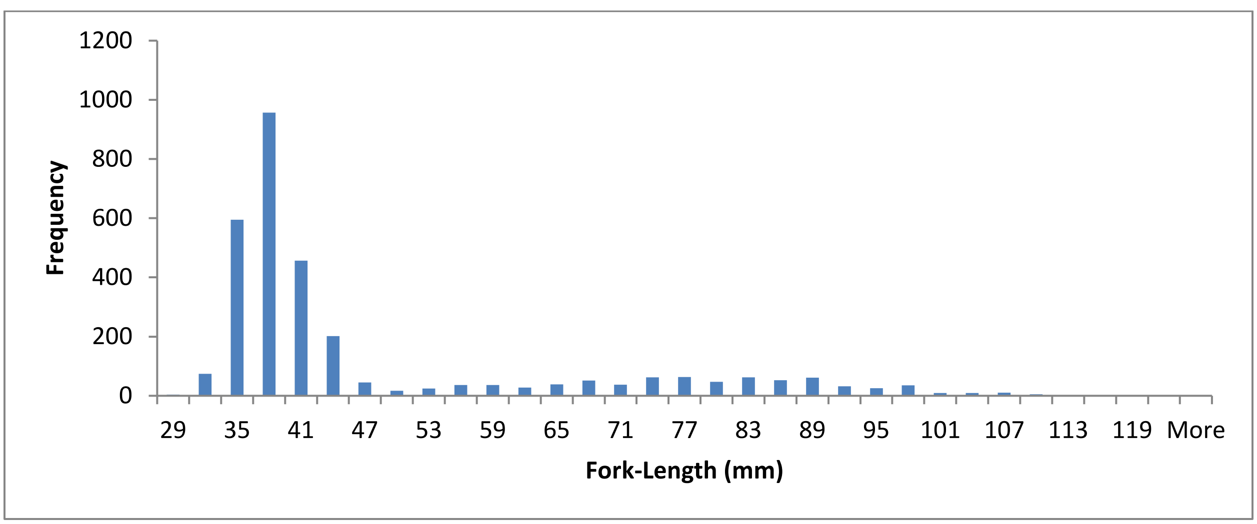

Figure 14. Fork-length histogram for juvenile Coho salmon caught in the Bedwell River RST in 2019.

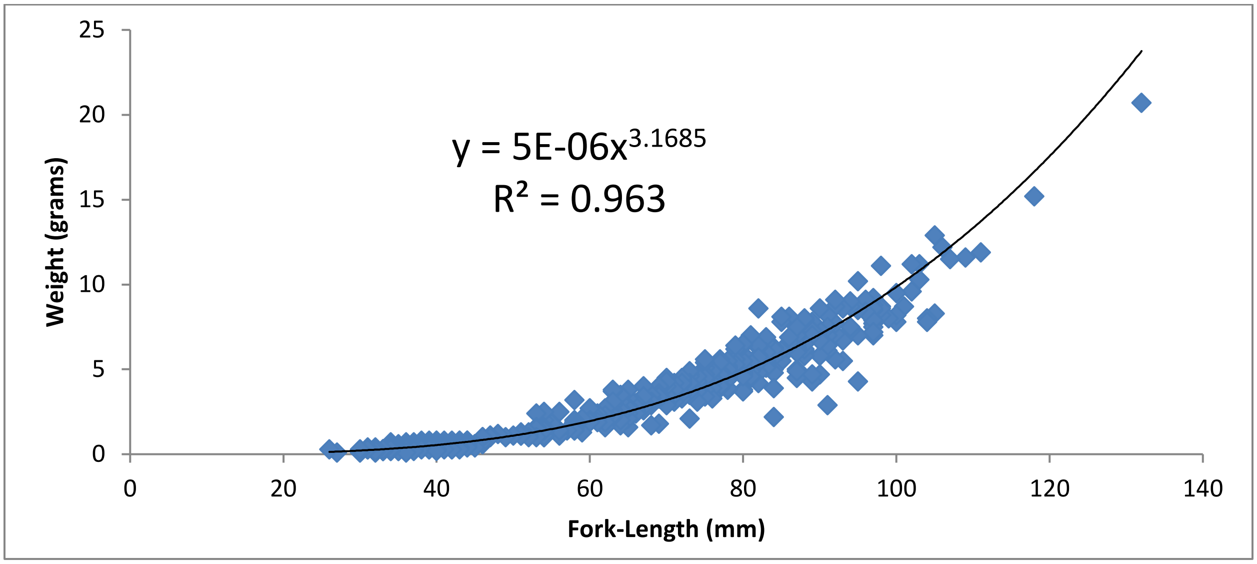

Figure 15. Weight Vs Length relationship for juvenile Coho salmon collected from the Bedwell River RST in 2019.

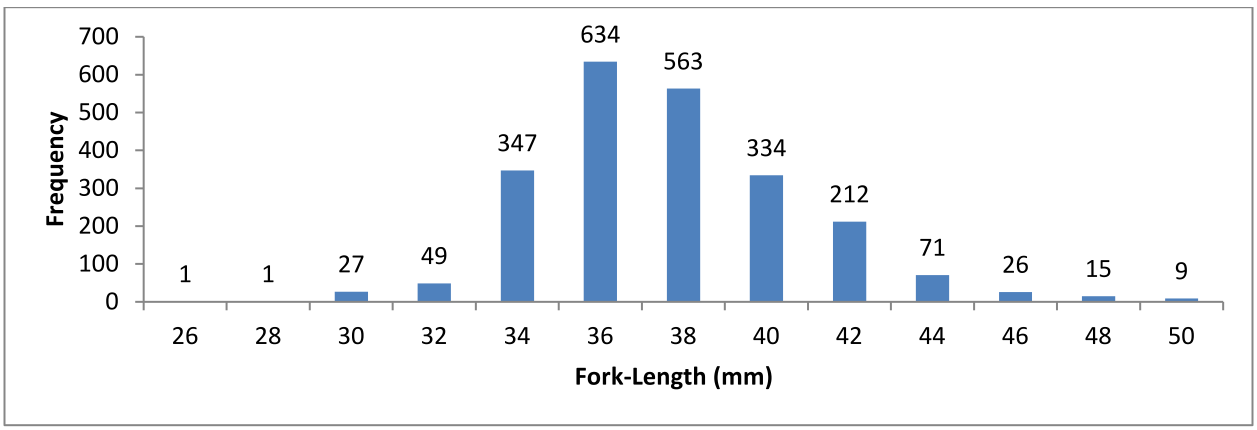

Figure 16. Fork-length histogram for assumed age 0+ Coho salmon caught in the Bedwell River RST in 2019.

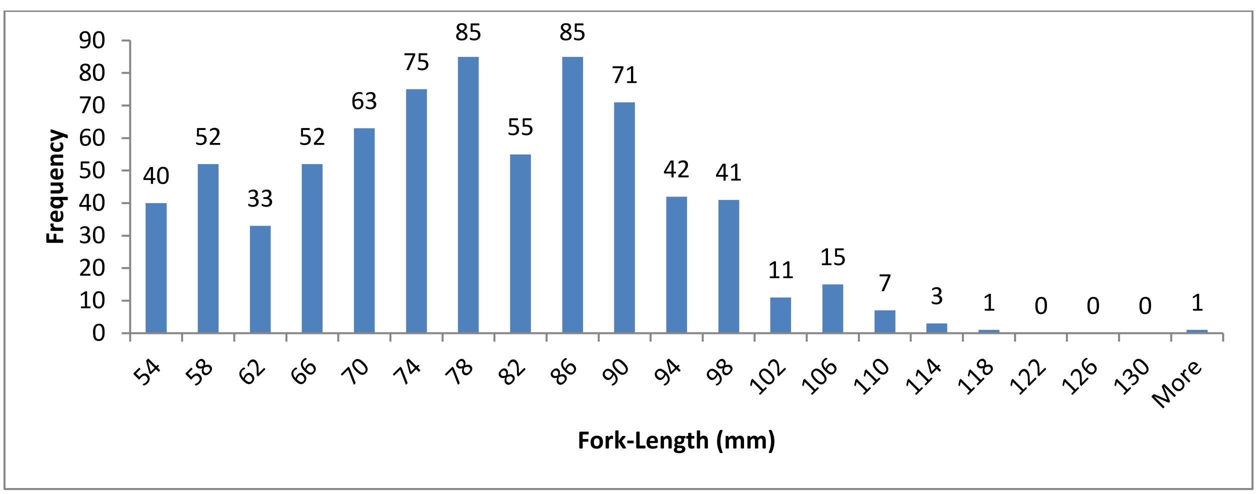

Figure 17. Fork-length histogram for assumed age 1+ Coho salmon caught in the Bedwell River RST in 2019.

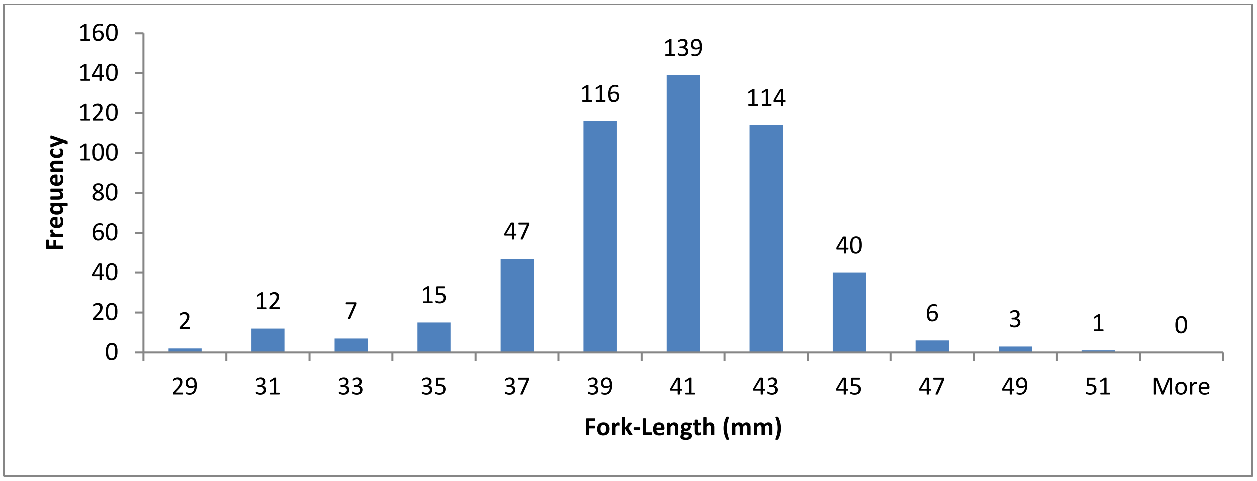

Figure 18. Fork-length histogram for Chum salmon caught in the Bedwell River RST in 2019.

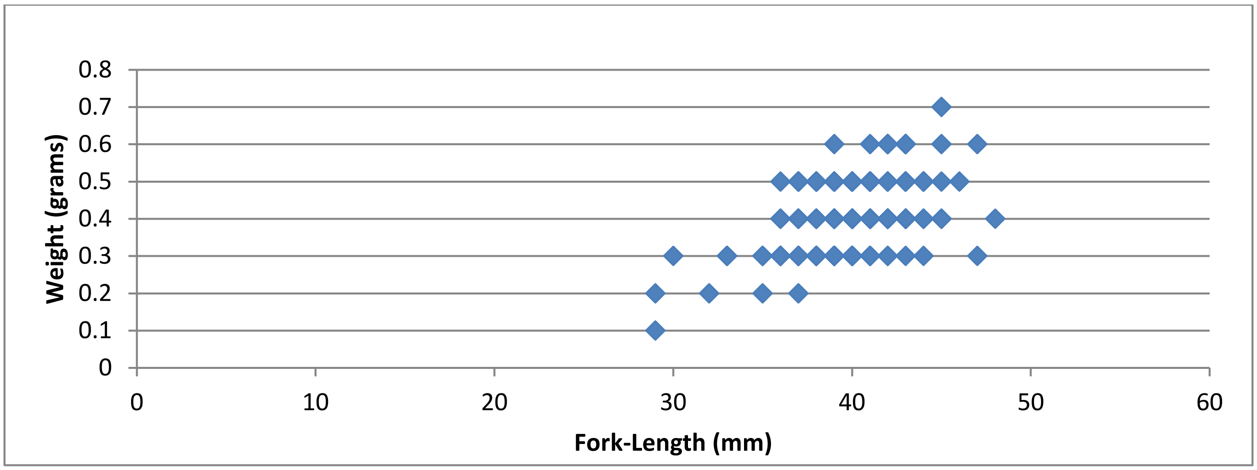

Figure 19. Weight Vs Length relationship for juvenile Chum salmon collected from the Bedwell River RST in 2019.

Table 1. Number of fish captured in the Bedwell River RST during each of the 46 days sampled in 2019.

Date	Chinook	Coho	Chum	RB	Comments
16-Mar-19	0	0	30	0	
21-Mar-19	76	94	38	3	
22-Mar-19	27	41	24	0	
25-Mar-19	67	87	28	6	
26-Mar-19	34	41	48	0	
27-Mar-19	44	45	34	1	
28-Mar-19	32	99	165	0	
29-Mar-19	72	147	93	0	
01-Apr-19	3	5	4	0	Morning/Afternoon only
02-Apr-19	74	25	23	0	
03-Apr-19	96	158	82	1	
04-Apr-19	223	53	12	0	
05-Apr-19	145	78	50	0	

09-Apr-19	17	236	12	0	
10-Apr-19	150	84	1	1	
11-Apr-19	76	67	20	0	
12-Apr-19	97	111	14	0	
15-Apr-19	33	125	30	0	
16-Apr-19	61	166	44	0	
17-Apr-19	33	102	13	1	
18-Apr-19	50	121	26	1	
24-Apr-19	48	112	27	0	
25-Apr-19	90	163	20	2	
26-Apr-19	61	154	19	3	
30-Apr-19	32	87	7	2	Morning/Afternoon only
01-May-19	31	122	12	1	
02-May-19	59	140	16	1	
03-May-19	37	135	11	8	
07-May-19	32	72	1	11	
08-May-19	58	17	0	17	
09-May-19	56	174	2	13	
10-May-19	51	190	0	12	
14-May-19	8	31	0	3	
15-May-19	12	44	0	3	
16-May-19	14	49	0	3	
17-May-19	7	39	0	3	
22-May-19	0	3	0	6	Morning/Afternoon Only
24-May-19	2	35	0	6	
27-May-19	5	56	0	7	
28-May-19	7	48	0	7	
29-May-19	8	59	0	9	
30-May-19	8	47	0	6	
31-May-19	5	44	0	9	
03-Jun-19	0	49	0	9	
04-Jun-19	3	33	0	10	
14-Jun-19	0	13	0	12	
TOTAL	**2044**	**3801**	**906**	**177**	

Table 2. Descriptive statistics for **Age 0+ Chinook** captured in the RST in 2019.

	Fork Length (mm)	Weight (grams)
Mean	41.7	0.54
Standard Error	0.1	0.01
Median	42	0.5

Mode	43	0.5
Standard Deviation	3.15	0.14
Minimum	31	0.2
Maximum	53	1.5
Sample Count	1256	235

Table 3. Descriptive statistics for **Age 0+ Coho** captured in the RST in 2019.

	Fork Length (mm)	**Weight (grams)**
Mean	37.2	0.45
Standard Error	0.1	0.01
Median	37	0.4
Mode	36	0.4
Standard Deviation	3.1	0.17
Minimum	26	0.1
Maximum	49	1.2
Sample Count	2285	423

Table 4. Descriptive statistics for **Age 1+ Coho** captured in the RST in 2019.

	Fork Length (mm)	**Weight (grams)**
Mean	76.9	4.72
Standard Error	0.5	0.14
Median	77	4.3
Mode	83	3.1
Standard Deviation	14.0	2.63
Minimum	50	1
Maximum	132	20.7
Sample Count	736	349

Table 5. Descriptive statistics for **Age 0+ Chum** captured in the RST in 2019.

	Fork Length (mm)	**Weight (grams)**
Mean	40.0	0.42
Standard Error	0.1	0.01
Median	40	0.4
Mode	39	0.4
Standard Deviation	3.2	0.09
Minimum	29	0.1
Maximum	50	0.7
Sample Count	502	246

Table 6. Mark-Recapture results using Visible Implant Elastomer (VIE) tags on Chinook and Coho. The unadjusted and adjusted total out-migrants are for age 0+ Chinook only.

Mark Day(s)	Period	# Marked	# Recaptured	Trap Efficiency	Unadjusted	Adjusted
April 4	April 4 - 5	63	1	0.016	509	32,067
April 10, 11, 12	April 10 – 15	363	3	0.008	398	48,158
May 7	May 7 – 10	68	5	0.074	197	2,679
April 24, 25	April 24 – 26	412	0	n/a	n/a	n/a

Estuary Sampling

Semi-regular sampling with a beach seine net within the Bedwell estuary began on March 1, 2019 and ceased on August 14, 2019 for a total of 15 days sampled. All of the salmon caught were identified to species. Although not recorded due to time restraints, our sets would often yield starry flounders (*Platichthys stellatus*), pacific sanddabs (*Citharichthys sordidus*), sculpins, shiner perch (*Cymatogaster aggregate*), gunnels, pipefish, tubesnouts and juvenile lingcod (*Ophiodon elongates*). The invasive European Green Crab (*Carcinus maeas*) was also captured on several occasions.

In total, 265 Chinook, 54 Coho and 313 Chum were caught within the estuary (Figures 12 – 23; Tables 6 – 8). Of the 265 Chinook sampled, 191 were of natural-origin while the remaining 74 were of hatchery-origin from the May hatchery releases. Although the average weight and lengths of the natural-origin Chinook caught were on average larger in May than in previous months, they were still much smaller than the captured hatchery-origin Chinook caught the same day (Figure 16; Table 7). The hatchery smolts remained significantly larger than the wild smolts in June (Figure 17; Table 7 & 8). The fork-lengths of hatchery smolts captured in June was significantly larger than the fork-lengths of the hatchery smolts caught in May (Table 8).

Both the natural-origin Chinook and Chum captured in March and April in the Bedwell estuary were a similar size to the individuals captured in the RST. No Chinook or Chum were captured during the first estuary sampling event on March 1st. 1 Chinook, 29 Chum, and 0 Coho were captured during the following sampling event on March 5th. All three species where regularly caught thereafter. In May, there was an increased number of larger Chum and Chinook juveniles which is reflected in the increased average fork-lengths, weights and heights (Figure 12; Figure 13; Figures 15 – 18; Figure 20). The increase in average fork-lengths, weights and heights from increasingly larger juveniles caught continued through into June and appeared to plateau through June and into July. In late May the average fork-lengths were 65.5 mm and 66.8 mm for Chinook and Chum respectively whereas in June through July the average fork-lengths of the Chinook ranged from 76 mm to 72.6 mm (Figure 12) and for Chum was only 69.5 mm in June (Figure 17). No Chum were caught in the July sample. The progression of growth over the months is visualized in figures 23, 24, 25, and 29.

Within the estuary a mix of both age 1+ and age 0+ Coho were repeatedly caught within the same beach seine sets. During the very first estuary sampling event on March 1, 2019 only 2 large Age 1+ Coho juveniles were captured. During the second sampling event on March 15th and thereafter, very small age 0+ Coho fry were also captured alongside the age 1+ Coho. This mixing of Coho cohorts created difficulties monitoring the changes in the average fork-lengths, weights and heights for these cohorts within the estuary. As shown in Figures 30 and 31, we don't see the trend of an average increase in fork-lengths, weights and heights over time as observed in the Chum and Chinook (Figures 12 & 13; Figures 15-18; Figure 20). This is due to changes in the proportion of age 1+ versus age 0+ Coho juveniles captured each day.

On May 29th 2019, 30 natural-origin Chinook captured in the Bedwell estuary with the beach seine underwent additional sampling where that after having their lengths and height measurements recorded, they were euthanized with a blow to the head followed by having their gills clipped and stored in separate vials containing RNAlater. The samples were sent to the PBS to undergo infections agent profiling. All of the infectious agent results were not available during the time this report was written and will be provided in an updated report once they're received by Uu-a-thluk and Ahousaht Fisheries.

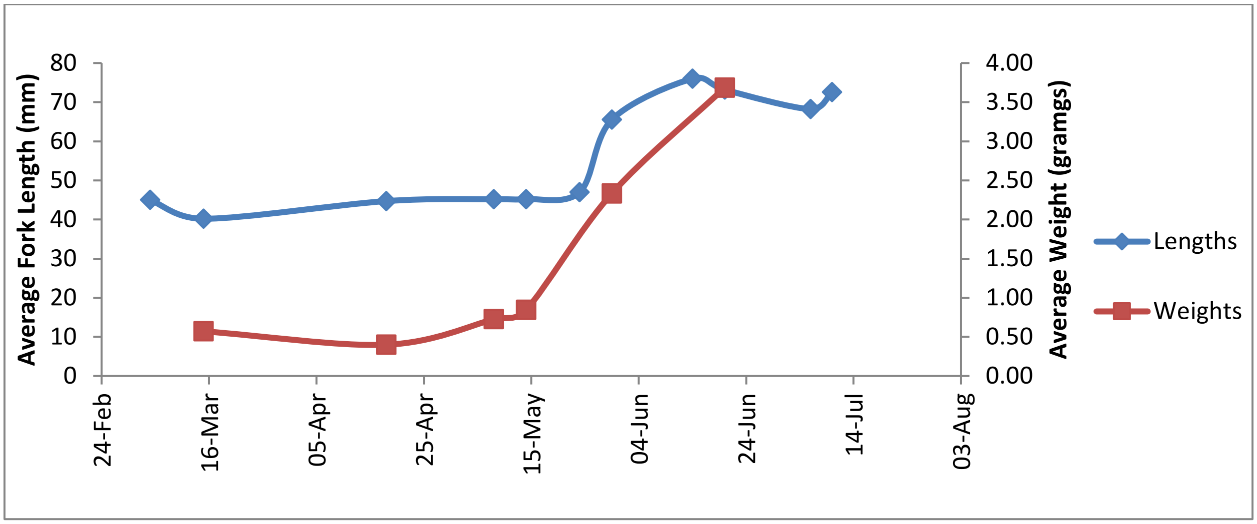

Figure 20. Average fork-lengths and weights of natural-origin juvenile Bedwell Chinook caught in the Bedwell estuary in 2019.

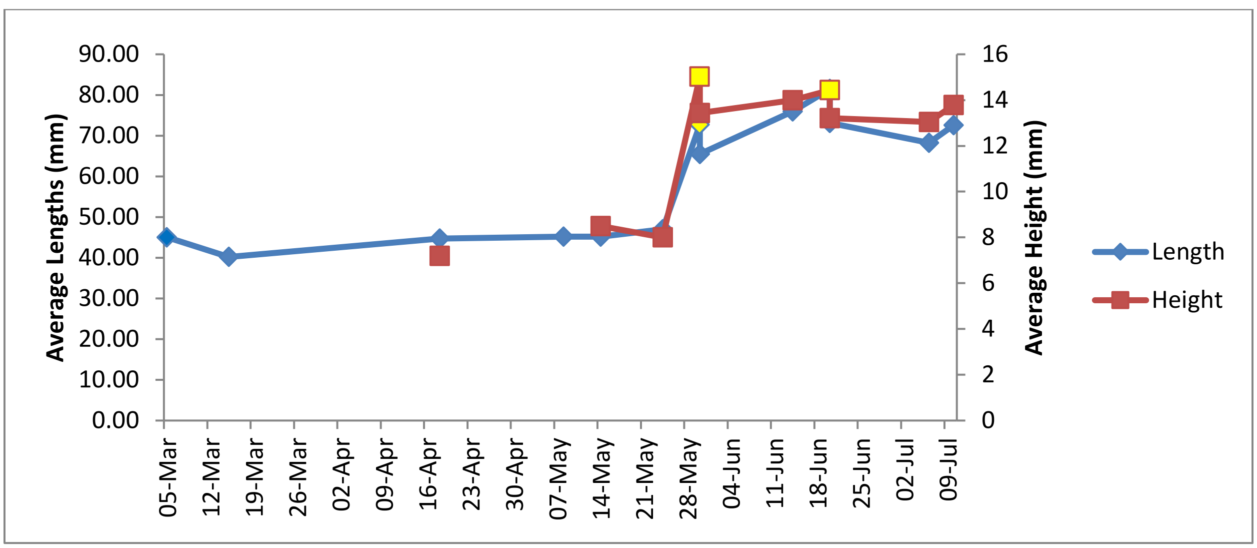

Figure 21. Average fork-lengths and heights of natural-origin and hatchery-origin (yellow) juvenile Bedwell Chinook caught in the Bedwell estuary in 2019.

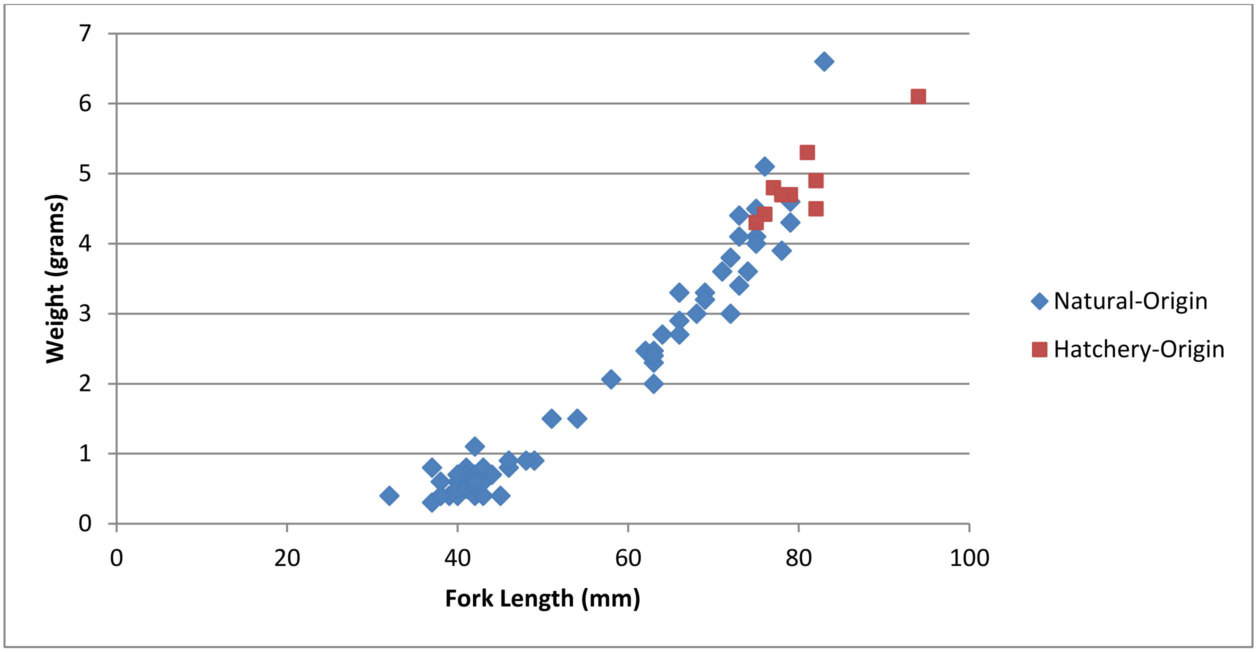

Figure 22. Weight Vs Length relationship for juvenile Chinook caught in the Bedwell estuary in 2019.

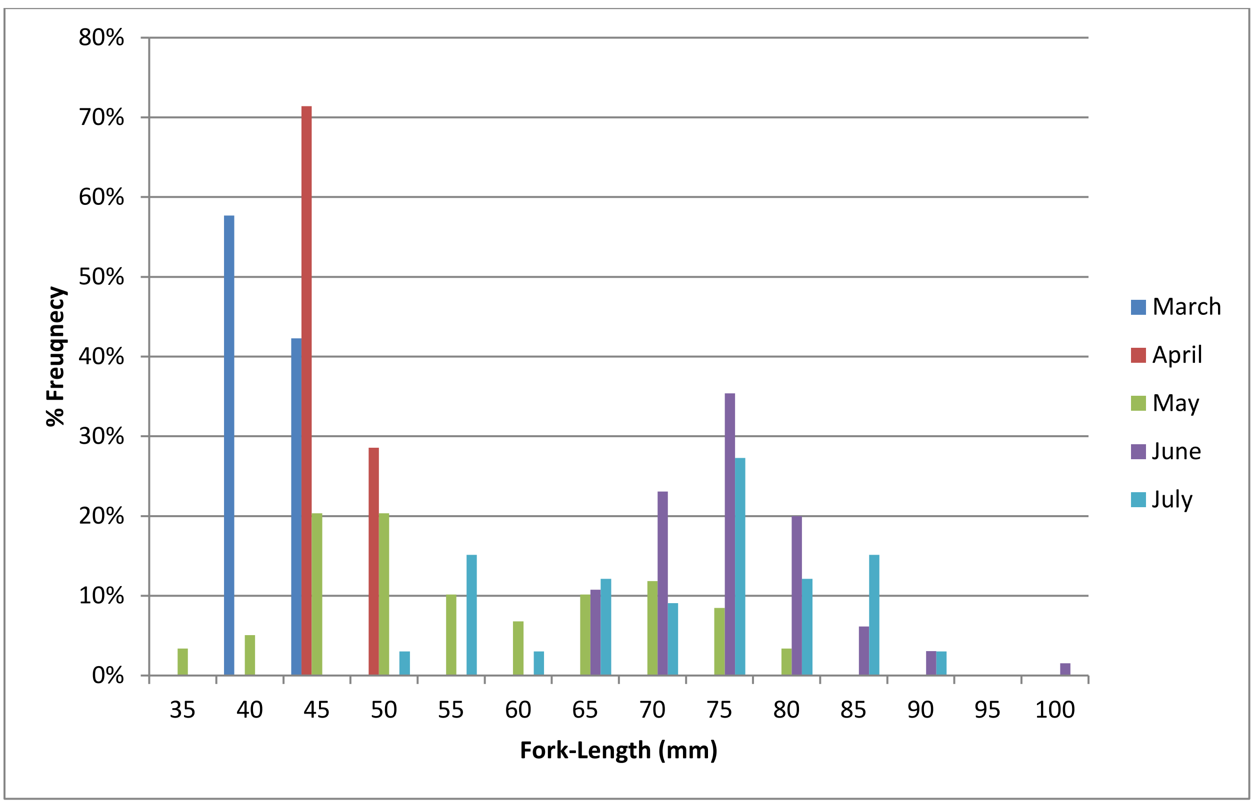

Figure 23. Monthly % frequency distribution of natural-origin juvenile Chinook fork lengths captured in the Bedwell estuary in 2019.

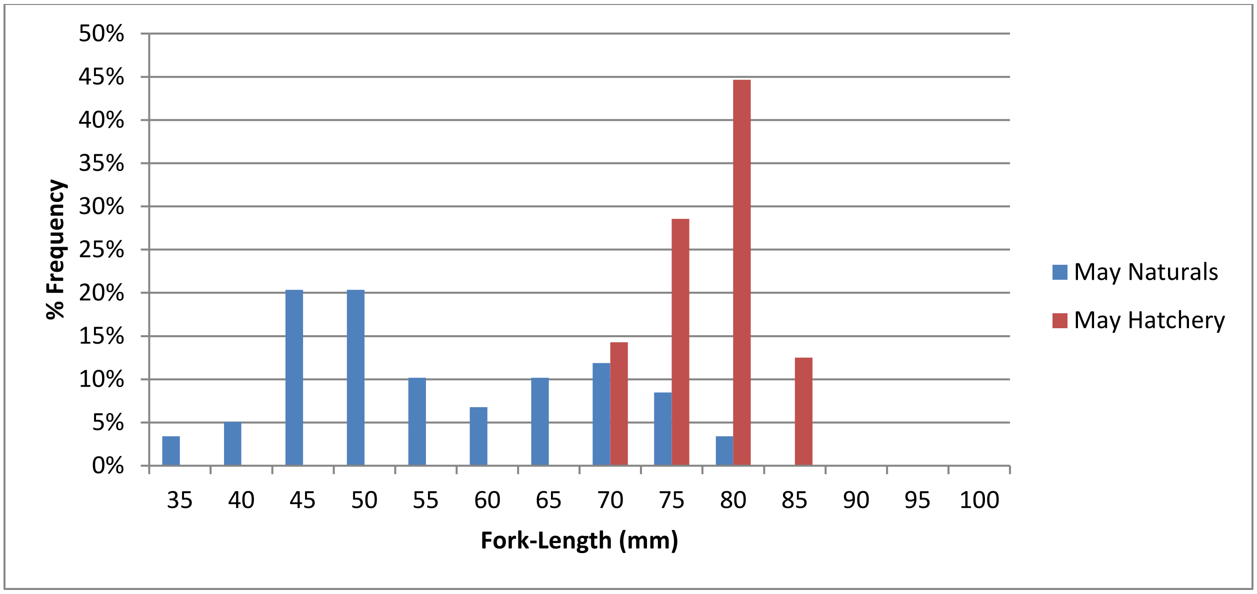

Figure 24. Fork-length % frequency distribution of natural-origin and hatchery-origin juvenile Chinook captured in the Bedwell estuary in May 2019.

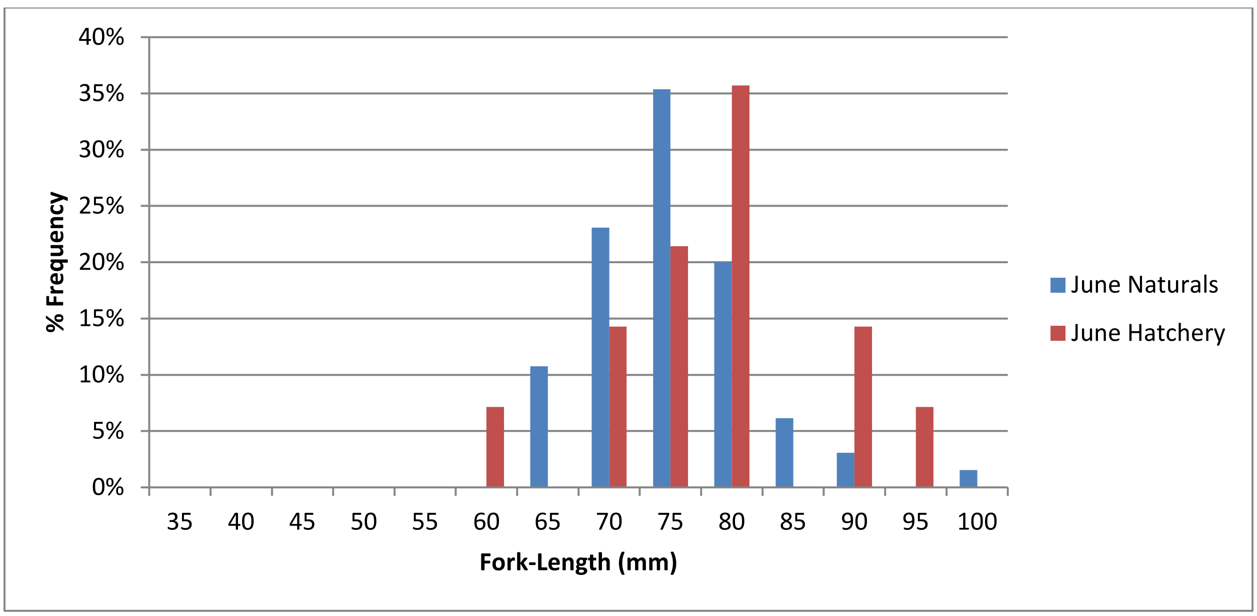

Figure 25. Fork-length % frequency distribution of natural-origin and hatchery-origin juvenile Chinook captured in the Bedwell estuary in June 2019.

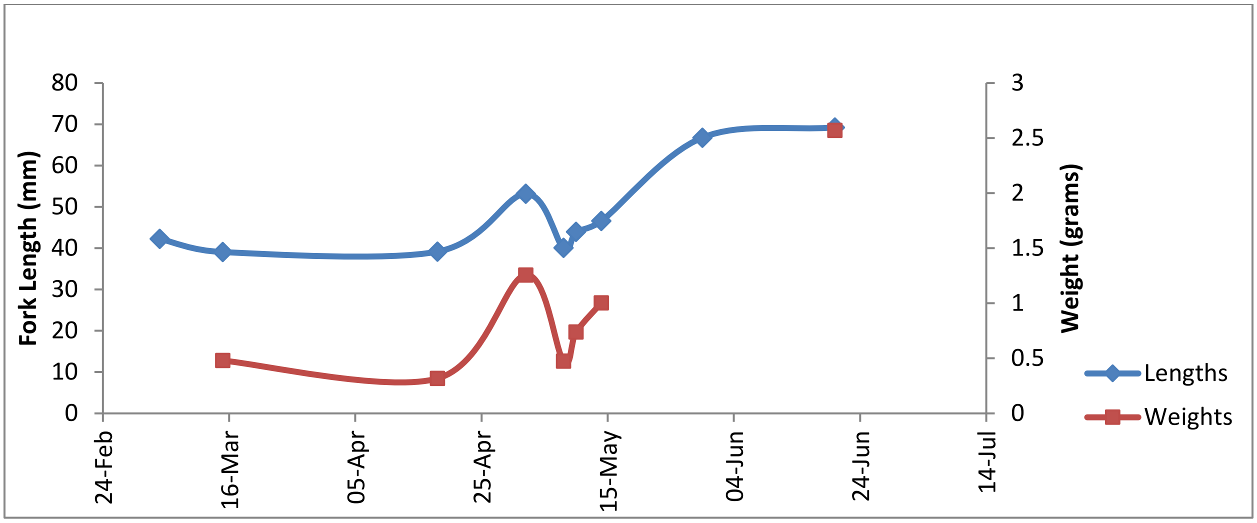

Figure 26. Average fork-lengths and weights Bedwell Chum caught in the Bedwell estuary in 2019

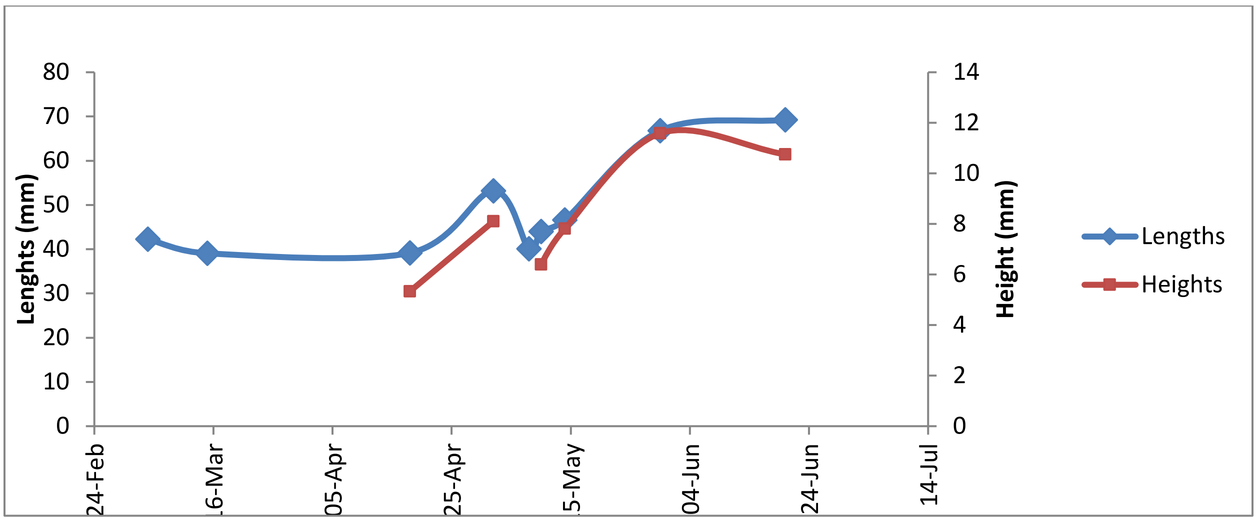

Figure 27. Average fork-lengths and heights juvenile Bedwell Chum caught in the Bedwell estuary in 2019.

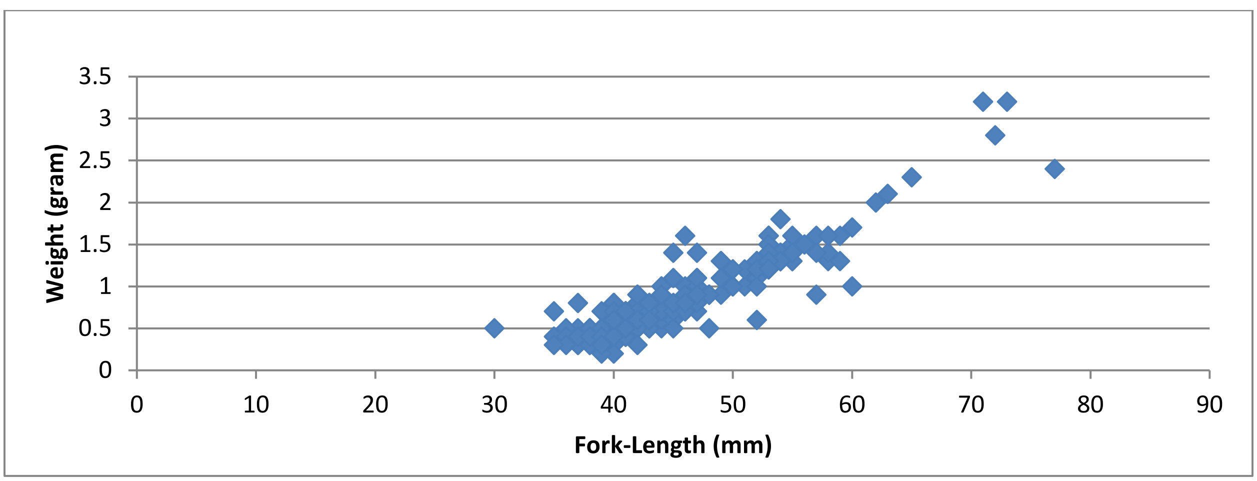

Figure 28. Weight Vs Length relationship for juvenile Chum caught in the Bedwell estuary in 2019.

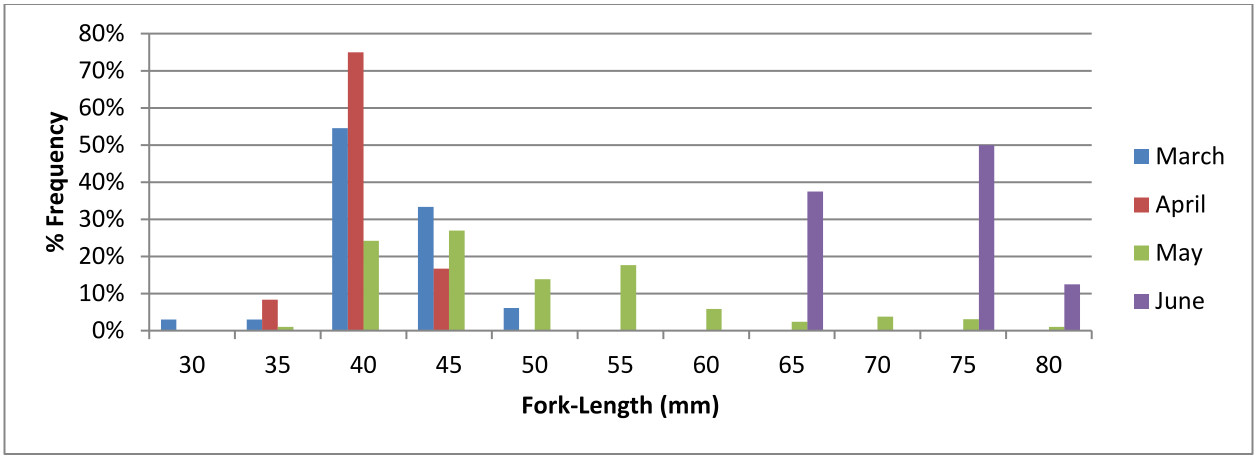

Figure 29. Monthly % frequency distribution of fork-lengths for juvenile Bedwell Chum captured in the Bedwell estuary in 2019.

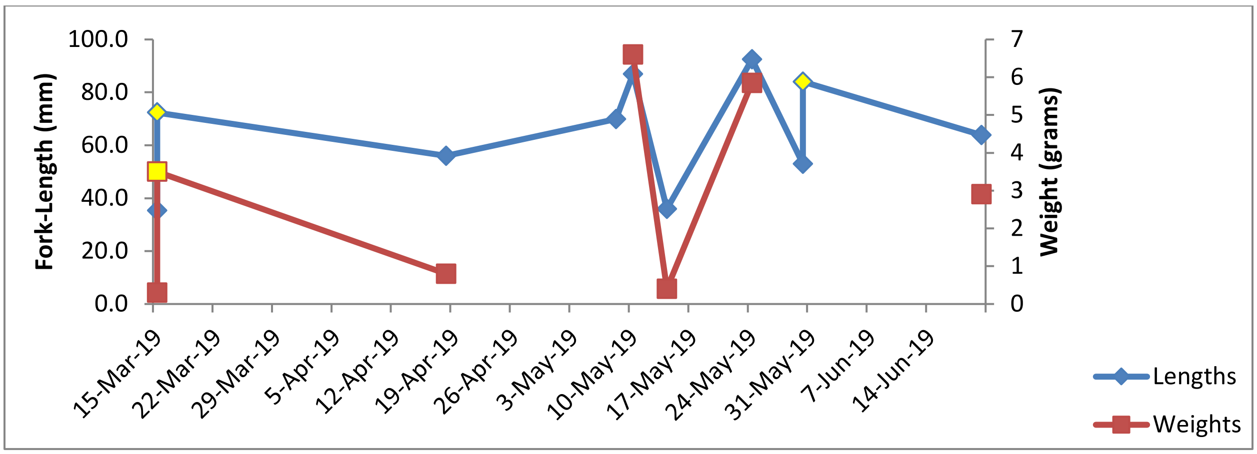

Figure 30. Average lengths and weights of juvenile Coho captured in the Bedwell estuay in 2019. May 10th and May 14th "averages" are derived from only one Coho captured during these sampling events.

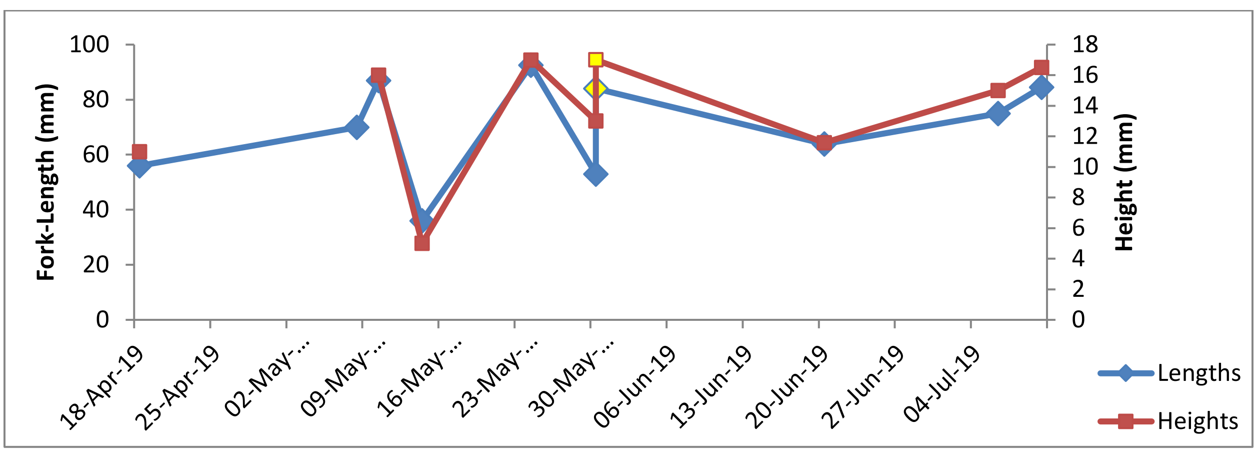

Figure 31. Average lengths and heights of juvenile Coho captured in the Bedwell estuay in 2019. May 10th and May 14th "averages" are derived from only one Coho captured during these sampling events.

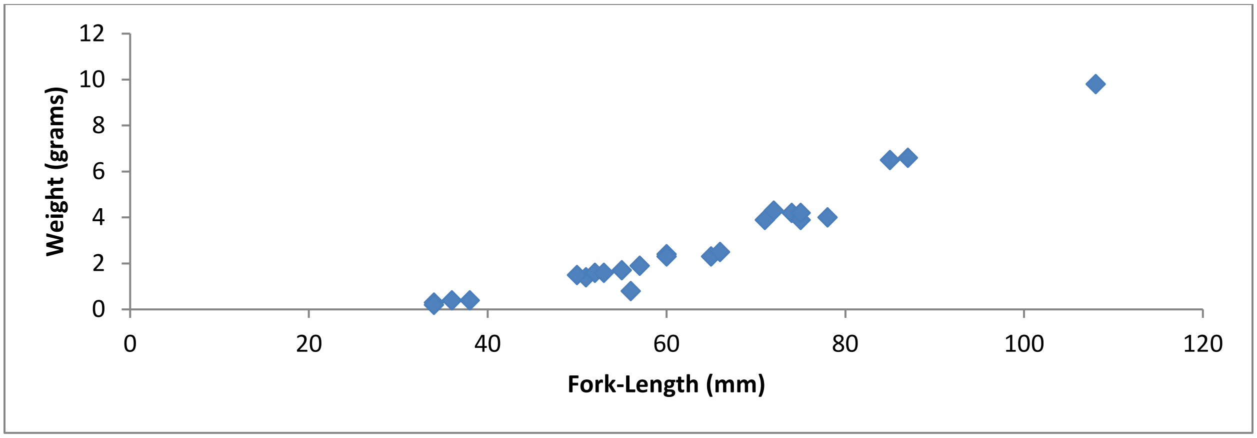

Figure 32. Weight vs Length for juvenile Coho captured in the Bedwell estuary in 2019.

Table 7. The average fork-lengths (mm), weights (g) and heights (mm) of both natural and hatchery-origin juvenile Chinook captured in the Bedwell estuary in 2019.

Origin	Date	Average Length	Average Height	Average Weight
Natural	05-Mar	45		
Natural	15-Mar	40.2		0.57
Natural	18-Apr	44.7	7.2	0.4
Natural	08-May	45.12		0.73
Natural	14-May	45.2	8.5	0.84
Natural	24-May	47	8	
Hatchery	30-May	72.7	15.0	4.42
Natural	30-May	65.5	13.4	2.33
Natural	14-Jun	76	14	
Hatchery	20-Jun	81.4	14.4	4.91
Natural	20-Jun	73.2	13.2	3.68
Natural	06-Jul	68.2	13.0	
Natural	10-Jul	72.6	13.8	

Table 8. Comparisons of lengths and weights between hatchery-origin and natural-origin Bedwell juvenile Chinook captured in the Bedwell estuary in 2019. Weight was measured in grams and length was measured in millimeters.

Origin	Month	Measurement	Average	Variance	Stat. Sign. Diff?	T-Test p-value
Natural	May	Fork-Length	65.52	63.59	Yes	1.42×10^{-6}
Hatchery	May	Fork-Length	75.60	16.13		
Natural	June	Fork-Length	73.17	41.64	Yes	9.85×10^{-5}
Hatchery	June	Fork-Length	81.42	70.73		
Natural	June	Weight	3.68	1.03	Yes	2.44×10^{-5}
Hatchery	June	Weight	4.91	0.32		
Hatchery	May	Fork-Length	75.61	16.13	Yes	0.024
Hatchery	June	Fork-Length	81.43	70.73		

Near-shore Marine Sampling

Sampling outside of the Bedwell estuary occurred on 5 separate occasions in 2019: April 25, May 2, 15, 22 and July 26. A total of 7 Chinook smolts (Table 9), 79 Coho smolts and 329 Chum smolts were captured (Table 10). The ATS that was conducted on May 29 was unsuccessful at capturing juvenile salmon or any other species of fish. Only jellyfish or nothing at all was captured during each transect. A total of 15 transects throughout Bedwell Sound and within close proximity to the Bedwell estuary occurred at depths ranging from 0 meters to 50 meters.

Table 9. Measurements and location of juvenile Chinook captured outside of the Bedwell estuary during spring 2019.

Date	Capture Location	Fork-Length (mm)	Height (mm)
April 25	Cypre River Estuary	92	18
May 15	Cypre River Estuary	61	13
May 15	Cypre River Estuary	53	11
May 15	Cypre River Estuary	62	12
May 15	Cypre River Estuary	57	10
May 15	Cypre River Estuary	57	11
May 22	Cypre River Estuary	87	17

Table 10. Data for the juvenile Chum and Coho caught within near-shore marine environment.

Date	Capture Locations	# Chum	Avg. Fork-Length (mm)	Avg. Height (mm)	# Coho	Avg. Fork-Length (mm)	Avg. Height (mm)
April 25	Cypre, Ritchie, Buckle	132	51.1	7.7	50	91.8	18.0
May 2	Bedwell Sound	48	47.3	7.5	2	83.0	17.0
May 15	Cypre, Ritchie, Buckle	74	60.2	10.0	3	84.7	15.7
May 22	Cypre, Ritchie, Buckle	59	66.5	11.5	23	99.7	18.5
July 26	Cypre, Ritchie, Buckle	18	122.2	-	1	118	-

Discussion

Estimating the total number of juvenile Chinook out-migrating from the river into the estuary using a RST requires a mark-recapture component to estimate the trap's efficiency. Bismarck Brown was used at Bedwell in 2017 to dye captured individuals prior to release upstream. However, concerns arose that the marked juveniles may be residing upstream long enough for the dye to disappear resulting in recaptured individuals being misidentified as new, unmarked captures. This concern was addressed by marking the individuals with Visible Implant Elastomer (VIE) tags that does not disappear in such a short period of time. Although very few occurred, 8 of the 9 recaptures were within 2 days of being released with the latest recapture occurring only 3 days after release. The results suggest that once the juveniles migrate past the trap they're committed to entering the lower reaches of the river and the estuary and will not reside upstream for very long. The mark-recapture data from 2017 suggests the same behavior as all but one of the recaptured juveniles occurred within 2 days of being released. In 2017, the RST was checked both once in the morning and once in the evening with little to no fish captured when fishing during the day. This signalled that the majority of the fish move at night and justified only checking the trap once in the morning. Further to this point, there would be occasions where marked juveniles from the morning sampling would be recaptured in the evening of the same day which provides further evidence to the juvenile's commitment to downstream migration. With Bedwell River being a relatively small Chinook system with limited rearing habitat, exacerbated by degraded riparian zones and side-channels (i.e. Penny Creek), it's understandable that the Chinook fry migrate to the estuary quickly seeking food: emphasizing the importance of the estuary to Bedwell Chinook production.

The low number of recaptured juveniles marked with VIE tags produced very low trap efficiency estimates that are much lower than the trap efficiencies estimated in 2017. The 2017 estimates ranged from 4.5% to 26.9% compared to the 2019 VIE estimates that ranged from 0.8% to 7.4%. 2 of the 4 marking periods had 0 recaptures resulting in no trap efficiency or total abundance estimates. Consequently, the total number of out-migrating juvenile Chinook leaving Bedwell River could not be estimated. The low recapture rate of VIE-marked fish may be attributed to the VIE marking procedure being much more invasive and stressful compared to dying with Bismarck Brown. Furthermore, the elastomers used were bright and fluorescent to allow for easy identification when recaptured which likely caused the VIE-tagged juveniles to be much more visible to predation (i.e. trout and age 1+ Coho). The combination of being stressed, the potential harm from the marking procedure and increased visibility to predators may have increased the predation on the VIE-tagged juveniles. Fortunately, the VIE recapture data supports using the less invasive and much cheaper Bismarck Brown for marking since it is unlikely the dyed juveniles will reside upstream and have the dye wear off. Future comparisons between the two marking methods and resulting trap efficiencies should be investigated by marking half the individuals with Bismarck and the other half with VIE tags during each tagging event. Overall, increased mark-recapture and run-timing data will be required to create an estimate of the total number of juvenile Chinook out-migrating from Bedwell River. The increased data may allow for retroactive estimates to be produced with previous years' data, including the 2019 data.

The run timing of out-migrating Chinook leaving Bedwell River was generally understood to occur in April and May with little knowledge of the detailed characteristics of the run. For example, the time and duration of the peak of the run, along with the duration of the run in general, was not known. To be confident that the entirety of the run has been captured requires zero Chinook captures in the RST at both the beginning and the end of the in-river sampling. In previous years, the RST was installed around the beginning of April and would cease operation in May with juvenile Chinook captured both on the first and last day of trap operation. This signalled that the run began earlier and ended later than initially thought and thus provided justification to install the trap at the beginning of March and continue operating through June until there were multiple occasions of zero Chinook captures. The RST was installed and began operating on March 15 2019 with zero Chinook captured during the first night of operation. The trap began fishing again on March 20 with 76 Chinook fry captured by the morning of March 21. The RST captures suggest that the Chinook out-migration began sometime between March 15 and March 20. However, the capture of juvenile Chinook in the estuary conflicts with this timing as there was 1 juvenile Chinook captured on March 5 and 25 captured on March 15 when beach seining the estuary. Thus, the run must have started very slowly at the beginning of March or at the end of February and provides justification to install the trap in February if research is to continue. Fortunately, the end of the out-migration was clearly captured with zero Chinook captured on the final 3 days of RST operation on June 3, 4 and 14.

The size of the Chinook fry captured in the RST remained small throughout the entire out-migration period (Figure 12). The consistent small size provides further evidence that Chinook are not rearing in the river and are migrating quickly into the estuary. This is confirmed by the size of the Chinook captured in the estuary beach seines in March and April that are similar in size (Figure 23). Juvenile Chinook of this size continued to be captured in the estuary in May but were a much smaller component compared to previous months. By June and July there are no juvenile Chinook captured that are less than 46 mm which can be attributed to their growth in the estuary. This growth can be visualized through changes in the daily averages of the lengths, weights and heights of captured individuals (Figures 20 & 21). From March to the beginning of May the average lengths, weights and heights remained relatively consistent. Starting in May, these daily averages quickly increased and appear to plateau by mid-June and July. The drastic change in size starting in May was observed in the Chum as well (Figures 26 & 27). The data suggests that perhaps the juveniles faced limited food items during March and April in the estuary with an increase in available groceries starting in May. The increase in food items may be a result of increased zooplankton and insect production from spring plankton blooms and hatching insects. With estuary residence appearing to be a significant component of the early life-stages for juvenile salmon, future research on the diet and available food items should be conducted.

In addition to diet and food availability, information on juvenile Bedwell Chinook habitat usage and the duration spent in the Bedwell estuary is limited. Previous sampling had identified sample site ESS2 at the far southeast corner of the Bedwell estuary as potentially preferred habitat for Chinook as it had the largest Chinook catch-per-unit-effort (CPUE) compared to all the other sites within the estuary: especially at low tide where sets occurred off the drop-off. The substrate here is largely made up of gravel and cobble compared to other parts of the estuary that are sandy, muddy or also rocky. It was previously thought that the juvenile Chinook no longer reside in the estuary by June and July but sampling in 2019 captured Chinook smolts as late as July 20 although in a much smaller abundance. Only 14 Chinook were caught in 4 sets on July 20. Sampling on August 15 2019 resulted in zero juvenile salmon being caught and signalled that all of the juvenile salmon have migrated outwards into the near-shore marine environment. Another interesting observation was the apparent plateauing of the lengths and heights of the Chinook smolts in the estuary in June and July. The upper tail-end of the fork-length frequency distribution for June and July (Figure 23) were also very similar. There were no natural-origin Chinook caught in July that had a fork-length greater than 90 mm and only 1 of this size caught in June. Similarly, there were no hatchery-origin Chinook smolts larger than 95 mm caught in May or June (Figures 24 & 25). The similar fork-length frequency distributions, the appearance of a plateau in length and heights and lack of smolts greater than 100 mm may be indicating that there is a size threshold that queues the smolts to leave the estuary. Perhaps the food items available to them in the estuary are no longer sufficient to sustain continued growth at these larger sizes. Future mark-recapture research in the estuary is recommended to identify the proportion of new fish captured during each beach seine sample and provide further details on estuary residence. It's also recommended that snorkel surveys are trialed, both in the day and the night, within the Bedwell estuary and lower Bedwell River to identify habitats utilized by the juvenile salmon. Mark-recapture/mark-resight when snorkelling may be beneficial for identifying preference and movement between the different habitat types and areas within the estuary.

Hatcheries are often used as a tool to increase production in an attempt to restore wild Chinook populations following a collapse or years of low production. However, little is known about the interactions and potential competition in both the estuary and near-shore marine environment between juvenile Chinook originating from these hatcheries and those originating naturally from their natal spawning grounds. This data gap exists for the Bedwell Chinook population. Conventional hatchery practices along the WCVI involves raising juvenile Chinook to a large size (5 – 11 grams) to promote increased survival as increased size at release correlates with increased marine survival. The TES employs this strategy and in 2019 released 38,000 adipose-clipped juvenile

Chinook in 2 batches with the average weights of 5.3 grams and 5.8 grams. These hatchery Chinook began to immediately show in the estuary beach seine samples and allowed for a comparison to the sizes of the natural-origin Chinook inhabiting the estuary around the time of release. The difference in the fork-lengths between the hatchery-origin and natural-origin Chinook was statistically significant on May 30 and June 20 as well as for weight on June 20 (Table 8). The difference in the distribution of sizes is clearly illustrated in figures 24 and 25 with the hatchery juveniles being visibly larger. It is generally understood that the Bedwell hatchery-origin juveniles do not spend much time in the estuary and quickly move outwards into the near-shore marine environment and other estuaries (i.e. Cypre River). However, there were a number of hatchery-origin Chinook still residing in the estuary that were captured on June 20. When then compared to the hatchery juveniles captured in May, the difference in the average fork-lengths was statistically significant (Table 8). This suggests that a number of released hatchery Chinook resided in the estuary and grew. When conducting the previously recommended research on diet and food availability within the Bedwell estuary, a sampling strategy should be designed to allow for comparison between the diets of hatchery-origin versus natural-origin Bedwell Chinook.

New science and research has emerged investigating the impacts of hatchery-origin Chinook on the wild populations they're interacting and interbreeding with. In light of this information, DFO's Salmonid Enhancement Program (SEP) has begun a reform process to review their hatchery practices. The Nitinaht River hatchery has begun investigating and experimenting with alternative rearing strategies with the goal of producing hatchery fish that more closely mimic the morphology, physiology, behaviour, genetics and age at maturity of their wild counterparts (Doherty and Cox, 2018). Such work stems from research that showed conventional rearing strategies producing large smolts may reduce the average age of returning adults and increase the rate of jacking. Starting in 2005, the Nitinat River hatchery began an experimental semi-natural wild-type rearing strategy for their Chinook salmon to evaluate whether producing smolts of a much smaller size (2 – 3.3 grams) will result in the semi-natural and wild fish having more similar maturation schedules and age-compositions compared to conventional hatchery-raised fish (Doherty and Cox, 2018). This rearing strategy involves reducing the daily food rations and the feeding frequency once the juveniles reach a size 0.85 grams whereas the conventional rearing strategy doesn't change food rations or frequency and maintains rationing food at a rate of 1.8% body weight per day 7 days a week (Doherty and Cox, 2018). In 2010 they began using shade cloth to mimic shade cover followed by the introduction of in-stream structures, predator simulation with a dip net in 2012 and introduction to subsurface krill feeding in addition to pellet diet 2 or 3 weeks prior to release. The results from returning adults showed strong evidence that there is a difference in the average age of returning adults between the conventional treatment and wild fish, as well as between the conventional treatment and semi-natural treatment. Furthermore, there is no evidence of a difference in the average age of adult returns between wild fish and the semi-natural treatment (Doherty and Cox, 2018). Overall, the conventional treatment on average produces younger adult-returns with the semi-natural treatment on average producing a smaller proportion of jacks and a greater proportion of age-5 fish (Doherty and Cox, 2018). These results did come at the cost of reduced marine survival by the semi-natural smolts. The average marine survival rates for the conventional treatment are 2.4 times greater than those from the semi-natural treatment (Doherty and Cox, 2018). This suggests that more hatchery releases will be needed under the semi-natural treatment to achieve similar return numbers to the conventional treatment (Doherty and Cox, 2018). This information is applicable to Bedwell because around the time of the hatchery release, the natural-origin Bedwell Chinook residing in the estuary are of a similar size to the semi-natural hatchery Chinook discussed above. The objective of the Bedwell enhancement is conservation and restoration of the wild Bedwell Chinook population with the ultimate goal of ceasing hatchery input while the wild population remains viable and self-sufficient. Under this objective, using the semi-natural rearing strategy for Bedwell Chinook may be beneficial in that the returning adults would be more similar to their wild counterparts they will be interbreeding with and influencing. It is recommended that research is extended to assess the differences in behavior and diet in the Bedwell estuary not only between the natural-origin Chinook and the conventional Bedwell hatchery Chinook, but also between these 2 groups and a group of semi-natural Bedwell hatchery Chinook.

Once the Chinook smolts continue their outward migration into the near-shore marine environment of Clayoquot Sound, very little is known about their diet, distribution, residence time, growth and interactions with the salmon aquaculture facilities located along their migratory route. Genetic stock identification (GSI) data from the DFO trawl surveys that occurred in Clayoquot Sound from October 15 – 16 2015 showed that all of the 94 age 0+ Chinook captured originated from rivers outside of Clayoquot Sound (Neville & Trudel, 2016). Many of the Chinook captured originated from Robertson, Nitinat, Thorton and Puget Sound stocks (Neville & Trudel, 2016). Previous attempts by Ahousaht Fisheries and Uu-a-thluk to capture these smolts occurred within Bedwell Sound using a beach seine although the catch consisted of primarily Chum with some Coho and very rarely Chinook. In 2019, Uu-a-thluk and Ahousaht Fisheries partnered with the Cedarcoast Field Station (CFS) and assisted with their beach seine sampling that focused on shallower areas outside of the Bedwell Sound fjord. The catch in this area consisted of primarily Chum as well. Interestingly, the only Chinook captured by Uu-a-thluk and CFS outside of Bedwell estuary occurred within the Cypre River estuary. The captured individuals did not undergo GSI and so origin was not determined and can't be confirmed as Bedwell Chinook since Cypre River also hosts a collapsed Chinook population. Out-migrating juvenile smolts are known to utilize the estuaries of other rivers and there is evidence of this occurring through the capture of clipped juvenile Chinook by CFS within the Cypre estuary in late May and June 2019 that would have been from the late May release of 38,000 age 0+ Chinook. It's important to note that CFS has occasionally captured Chinook smolts at Ritchie Bay but in very low abundances. When beach seining within these areas, dimpling along the waters' surface is often observed away from shore and out of range of the beach seine. One hypothesis is that the Chinook smolts do not utilize the shallow beach habitats outside of estuaries, since they're rarely caught in these areas, and may inhabit these areas more offshore since the dimpling observed may be Chinook smolts.

To test this hypothesis, an ATS was trialed in Bedwell Sound and around the Bedwell estuary but was unsuccessful at capturing salmon smolts. The acoustic data did not provide any tangible information since there were many sonar reflections detected and there has been little work done on differentiating these signals within the marine environment. One possible explanation for this is from the ATS occurring in the day. These surveys are usually conducted within sockeye-bearing lakes at night to provide an estimate of juvenile sockeye abundance and over-winter survival. They occur at night because the sockeye undergo diel vertical migration and move upward in the water column and spread out at night (allowing for easier counting with the sonar data) and the lack of light reduces their ability to see and avoid the net coming towards them. It's recommended that a future ATS within Bedwell Sound and the surrounding area occurs at night. Although not trialed this year, microtrolling using modified recreational fishing gear to capture Bedwell Chinook smolts within the near-shore marine environment is recommended. Previous work done in the Strait of Georgia demonstrated the success of this method (Duguid and Juanes, 2017). However, the smallest Chinook caught had a fork-length of 116 mm yet there were smaller Chinook captured within the same time and area through seining and trawling: suggesting a minimum size threshold for capture by hook-and-line sampling (Duguid and Juanes, 2017). Although there are no Chinook smolts of this size observed in the Bedwell estuary or yet to be observed in the near-shore marine environment, there are some approaching that size in June and July (Figure 23) and so there's potential they'll be above the perceived minimum size threshold for hook-and-line capture not long after leaving the estuary. In March 2020, DFO staff from the PBS will be conducting microtrolling within Clayoquot Sound targeting overwintering age 1 Chinook and will be providing microtrolling training to CFS and Uu-a-thluk staff. Following training, Uu-a-thluk, CFS, and Ahousaht Fisheries will trial microtrolling for age 0+ Bedwell Chinook during the 2020 spring out-migration.

The high density of open net-pen Atlantic salmon farms that Bedwell Chinook smolts must migrate past has raised concerns about the potential transfer of infectious agents and sea-lice from the farms to the smolts. To address these concerns, samples of natural-origin juvenile Bedwell Chinook from both the river and the estuary were sent to the PBS to undergo infectious agent profiling to begin developing a baseline of which infectious agents (i.e. pathogens) are present in the population during these early stages of development. It is recommended that juvenile Bedwell Chinook captured within the near-shore marine environment also undergo infectious agent profiling to compare to the profiles from Chinook smolts residing in the river and estuary. With regards to sea-lice, all the juvenile salmon that were captured in the estuary and near-shore marine environment that had their measurements taken (i.e. lengths and heights), had the number of sea-lice attached enumerated. This sea-lice information can be found in the report produced by Bartlett (2020). The louse infection rates on juvenile salmon in Clayoquot Sound is important to monitor as high lice loads may induce mortality or result in sub-lethal impacts such as a reduced ability to forage. This is especially important because in 2018 a *L. salmonis* population that developed a resistance to SLICE (emamectin benzoate), the main delousing chemical administered through the feed, began to propagate uncontrollably and spread to every active Atlantic salmon farm in Clayoquot Sound. The outbreak resulted in every active farm, but one, to be harvested as they could not maintain lice-loads below the allowable threshold of 3 motiles/fish. It’s recommended that future monitoring of sea lice loads on out-migrating smolts continue as the farms employ alternative de-lousing measures that have reduced efficacy compared to SLICE.

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