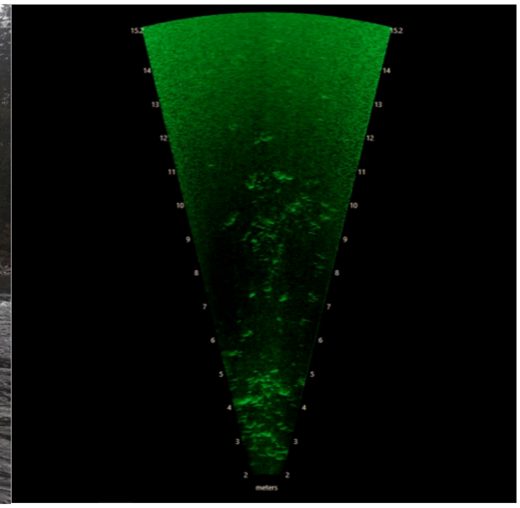

Enumeration of Quesnel Basin Interior Fraser Coho using Dual-frequency Identification Sonar

Interim Report: Yr-1
Prepared by: Upper Fraser Fisheries Conservation Alliance

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Acknowledgements

The UFFCA would like to thank all who were involved and supported this important project. Thank you to our key partners: Nothern Shuswap Tribal Council, Southern Endowment Fund, and DFO staff. We also acknowledge the Quesnel River Research Station, the land owner who allowed us to use their power and occupy their property at times.

Introduction

The Quesnel River is a significant producer of Pacific Salmon species including sockeye, Coho, and Chinook. This report documents the 2018 enumeration of Quesnel Basin Interior Fraser Coho (*Oncorhyncus kisutch*) using hydroacoustic duel-frequency identification. Since 2001, a single tributary annual enumeration program has been relied upon to generate Coho escapement estimates for the Quesnel system. The Northern Shuswap Tribal Council (NSTC) in partnership with the Department of Fisheries and Oceans (DFO) has annually deployed a temporary enumeration fence structure in the McKinley Creek tributary, as well as conducted boat, foot, and aerial counting methods in Quesnel Lake and Horsefly River tributaries. Although these methods are generally classified as medium to high precision approaches, in the Quesnel River watershed both fence and visual counting of Coho is difficult due to extreme weather events, season limitations (late fall, early winter), extended and multimodal migrations, defensive/cryptic nature of the animals, and its choice of small complex tributaries for spawning.

Due to the enumeration challenges, accuracy of the overall Quesnel system Coho estimate is a concern. The objective of adding the hydroacoustic element in the Quesnel River, is to develop an index between the Quesnel sonar result and the McKinley enumeration fence count in order to establish a system-wide escapement estimate (relationship) based on the McKinley counting fence. The project will collect and analyze 3-years of data (2018-2020).

This report is a summary of Yr-1.

Study Area

The project site is located on the Quesnel River, just south of the outflow into the river from Quesnel Lake. Quesnel Lake is located in central British Columbia in the eastern region of the Cariboo. The Quesnel River runs approximately 100km from its head waters originating at the southern end of Quesnel Lake near Likely, BC to its confluence which drains into the Fraser River near the city of Quesnel. Upper Fraser River region Coho return from the ocean via the Fraser River into the Quesnel River where they enter Quesnel Lake and split off into several tributaries including McKinley Creek to spawn (Figure 1).

The hydroacoustic installation area in the Quesnel River is approximately 55m in wetted width at the acoustic site with mean monthly discharges calculated from 2000 to 2013 ranging from $90m^3 s^{-1}$ (max 143 to min 50.1) to $96.5m^3 s^{-1}$ (max 129 to min 50.4) during the October to November migration period (Water Survey of Canada website accessed Nov 09, 2017). Water clarity at the site can be characterized as clear with a flow regime that is primarily unidirectional and turbulent, especially in the middle of the river. Less turbulent water with reduced velocity exists along each bank. The right-bank substrate is composed of large gravel, cobble and boulders over a low gradient (<5%) planar bottom descending to an approximate depth of 2m to 3m towards the centre of the channel. The left-bank substrate is composed of cobble and boulders and is relatively shallow and flat but descends gradually (<5% gradient) immediately beyond the weir. Mid-channel is composed predominately of boulders. Coho salmon migration behaviour at the sonar site is expected to be extremely shore orientated. As well, because the acoustic site is located a considerable distance below all Quesnel system spawning populations, downstream movement of Coho is expected to be minimal.

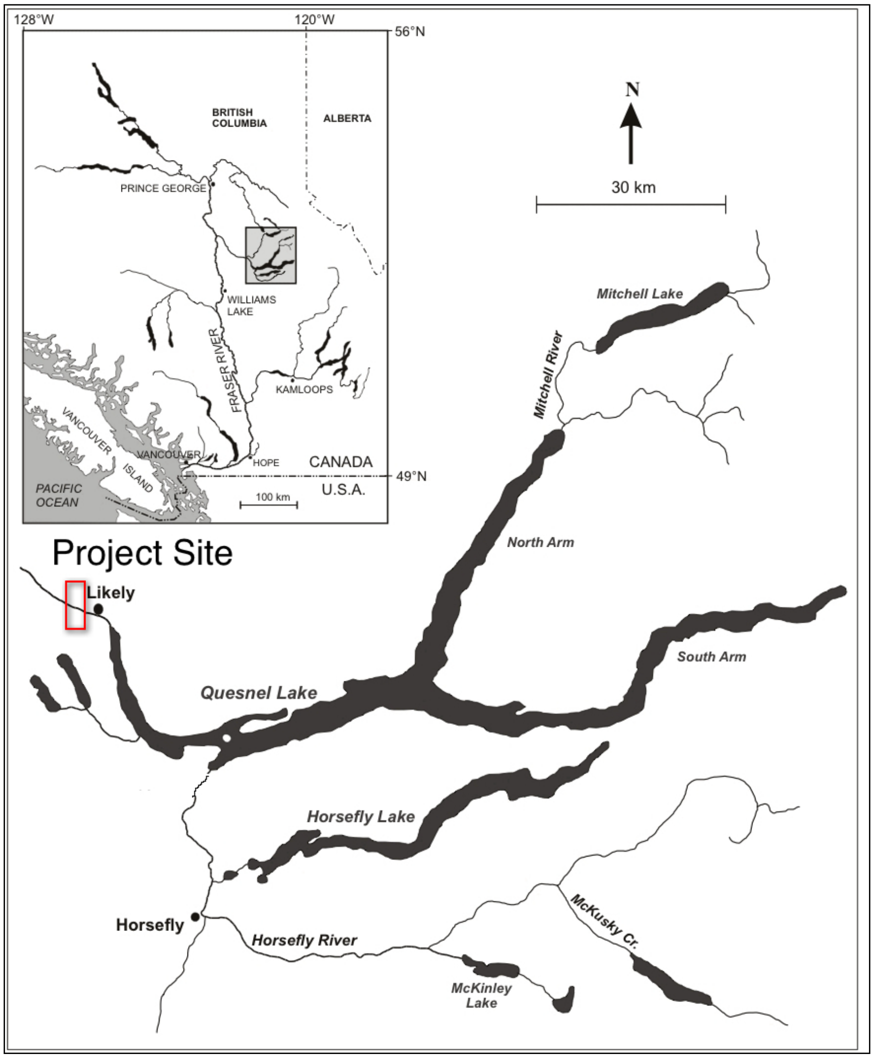

Figure 1. Map of Quesnel Basin and location of project site.

Methods and Materials

Project Timeframe

Logistical planning for the Quesnel Coho Hydroacoustic project was able to rely heavily on the experience of the existing Quesnel sockeye salmon hydroacoustic enumeration program which starts early August and typically runs until Sept 20th. In 2018, the same left and right bank setups from the sockeye enumeration will be used for Coho, with the only change being a swap of DIDSON systems (UFFCA in, DFO out) into the same setup on the left bank. The ARIS used in the Sockeye program will be utilized for the Coho program.

The DIDSON setup and monitoring was taken over by NSTC and UFFCA crew on Sept 26th 2018. Data collection commenced on Sept 28th 2018 and ran 24/7 until Oct 31th 2019.

Project Personnel

Project management was provided by UFFCA Senior Biologist, Pete Nicklin. Management included general project logistics, budget management, and coordination of technicians. UFFCA Biologist, Shamus Curtis provided technical direction, material maintenance, site set up and dismantle, and in-season and post-season data processing and analysis. NSTC Fisheries Technicians Cheryl Meshue and Sara Hood were responsible for daily monitoring and maintenance of DIDSON and project site, observational data collection, and in-season data processing.

Materials and Equipment

Materials to support the project site and operation of the DIDSON were as follows:

1. 2 x Laptop Computers to run the Aris and DIDSON
2. 2x Laptop Computers to view and count files
3. 3x 4TB hard drives to store DIDSON and Aris files on at the site.
4. 2x 4TB hard drives to store backups of the files and provide for counting of files
5. 2 computer monitors (for ease of onsite viewing and set up)
6. 2x 400ft extension cords to run power on both banks of the river from shore power at the house on river right and the QRRC on river left
7. Spot satellite phone
8. Waterproof handheld radios
9. Residence provided by Quesnel River Research facility
10. 3x Power bars and extension cords
11. 2x Tables and chairs for on-site computer huts
12. 2x Rubbermaid sheds for on-site computer huts
13. Two Honda Generators (model 2000) for back up power in case of prolonged outages.

14. Jerry cans and fuel for generators
15. Deflection Weir (Donated by DFO)
16. Construction tools (sledgehammer, drills, saws, socket sets…)
17. 2x Tripod mount for both the Aris and DIDSON.
18. High-Frequency long-range DIDSON unit River Left site
19. High-Frequency short-range Aris unit (main unit on River Right)
20. 2x 150’ standard DIDSON data & power cable
21. 4x Handheld tally counter

Methods

DIDSON and ARIS installation

Left Bank DIDSON Installation

The sonar site, having been used for the sockeye program right up till the start of the Coho project, required little work as the deflection weir and tri-pod mount were already in place. The installation of the UFFCA DIDSON was a simple swap out as the DFO DIDSON was sent back with the sockeye crew. The DIDSON viewing window was set using the best possible view and maintaining an angle of 6 degrees that provided the best view of the bottom while maintaining a clear view out to 20 meters. The use of a telescopic deflection weir is a standard approach used by the UFFCA DIDSON projects as it allows for easier movement to follow water level drops and reduce downtime. The weir was extended to an adjustable distance of approximately 5 to 8 meters into the river, allowing for extension as the water fluctuated throughout the field operations.

The DIDSON unit was installed on the upstream side of the deflection weir and protected from upstream debris by a natural pool and rock rise in the riverbed situated 2 meters upstream from the tri-pod mount (Figure 2). This natural feature also helped in slowing the waters and reducing turbulence around the DIDSON unit itself.

For this project, a compact specialized tri-pod mount that was maneuverable and infinitely adjustable was utilized. This provided a great stable platform for both the DIDSON and ARIS sonar systems. Further aiming adjustments could be fine-tuned via the ball clamp style bracket situated directly above the sonar mounting plate. This mount was a major improvement in utility and function compared to the traditional ladder and box mounts.


Figure 2. Left bank DIDSON set up.

Right Bank ARIS Installation

The Aris set up was conducted similar to the left bank DIDSON. The right bank had been previously used by the Sockeye program and in this case, it was not necessary to swap out any equipment as the ARIS was being used for both projects. However, the weir and tripod mount needed only slight adjustment due to water level drop. The weir on this bank was not a telescoping weir as on the left but a walkway or scaffolding weir. This style of weir, though not as easy to move with the water level provided a superior platform for viewing the passage of fish. The ARIS viewing window was set using best possible view and maintaining an angle of between 4-8 degrees that provided the best view of the bottom while maintaining a clear view out to 20 meters.

The ARIS was set up upstream of the weir but was protected by a rock wall made on a natural rise in the river bottom that deflected most of the flow out past the ARIS. Without these protective barriers, the sonar units would have needed protection from debris (Figure 3).

Figure 3. Right bank ARIS set up with UFFCA Biologist Shamus Curtis.

Both the low frequency long range DIDSON unit on the left bank and the ARIS on the right bank were aimed according to procedures outlined by Xie *et al* (2002) (Figure 4):

- The sonars were attached to the tri-pod mounts and these were lowered till the front of the unit was level with the water and the back about 2cm above the water line.
- The sonars were aimed at a downward angle of approximately -6 degrees with the view incorporating the very edge of the diversion fence within the lower right portion of the viewing window, approximately at the 2m mark on the DIDSON view.
- The DIDSON was angled 15 degrees downstream to prevent feedback from the rock directly in front of the weir.
- The ARIS was angled 18 degrees upstream to avoid a deep hollow that made a blank in the original sonar window directly in front of the left bank weir.
- Using these aiming settings, the sonar beams could ensonified the entire area within the 20m window length in front of each unit.
- The viewing window for the DIDSON was set at 12 meters and recorded a full 60 minutes, in 20-minute files from 14:40 Sept 28th, 2018 till 12:40 October 9th, 2018 when the fence was moved out and the unit repositioned. The decision was made to extend the window out to 20m while keeping the full 60-minute recordings at 20-minute increments.
- The viewing window of the ARIS unit was set at 20 meters and the recordings were set to cover full 60 minutes divided into 20-minute file to record a full 24hrs a day.
- The DIDSON on the left bank was powered by a 200ft power cable attached to the Quesnel River Research centers main power and the Aris on the right bank was powered

through the use of a local residence main household power also connected by a 200ft power cable

- Both sonars were linked via 150ft sonar cable to their own topside box and laptop/recording hard drives, stored in separate computer huts to protect the equipment from the weather and any other external forces.

Figure 4. Left bank DIDSON and Right bank ARIS setup.

The laptop computers controlling the acoustic systems were housed in two dedicated site offices, one on each bank of the river. This office was constructed as a large one room Rubbermaid shed. These structures were built each with locking doors and situated away from the river shore. Additional laptops were used as a dedicated file review stations, along with external hard drives for complete backups of all recorded files. Power for the DIDSON and the recordings was provided by the Quesnel River Research Center, on the left bank, and with permission from the property owner on the right bank.

Acoustic Data Collection

The low frequency long range DIDSON unit was used on the left bank and an ARIS was used on the right bank for data collection. The units were operating at a 20m window with a start length between 1m and 2m and a frame rate of 8 frames per second in high frequency mode (1.2 MHz for DIDSON and 1.8MHz for ARIS) on a continual recording schedule. The files were recorded in 20-minute long intervals for each of the 24 hours a day. Each 20-minute recording consisted of approximately 1.2 gigabytes of data for the ARIS and 600 megabytes for the

DIDSON files. The file recording processes is well suited for low salmon passage rates as it removes any time related bias from the calculations if a sample of each hour was to be recorded instead. The 20m window was used to verify that salmon migrating in the center of the river would not be missed in the recordings. Figures 5 and 6 show example of file image outputs from the DIDSON and ARIS.

The sonars were programed to create new files every 20 minutes (time and date stamped) for each recording, this generated 3 files for every hour; the first starting at the start of every hour (XX:00), the second file (XX:20) started at the 20 minute mark, and the third (XX:40) and carried on for the full 24 hours of every day until project completion. All DIDSON recordings, programming and post-processing of fish counts, were conducted using version 5.26.25 of the DIDSON Operating System Software (Sound Metrics Corporation 2018). The ARIS files were recorded and programed using ARIscope version 2.6.3 and the post-processing and fish counts were conducted using ARIS fish version 2.6.3 (Sound Metrics 2018). Due to the number and size of files being created the data were recorded directly to an “always on and always connected” 4Tb external hard drive. To ensure data security, a system was set in place to back up all the recordings on a daily basis to a second 4Tb external drive every morning. This was done for each bank and ensured that minimal data would be lost if the connection to the hard drive were disrupted or the hard drive failed.

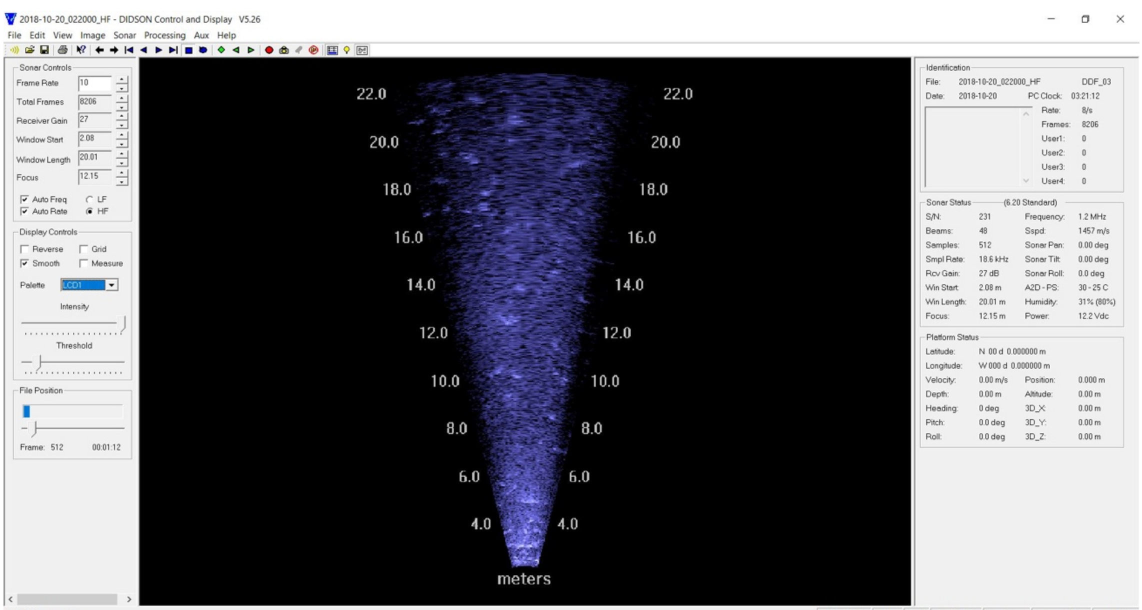

Figure 5. Example of DIDSON image file from project.

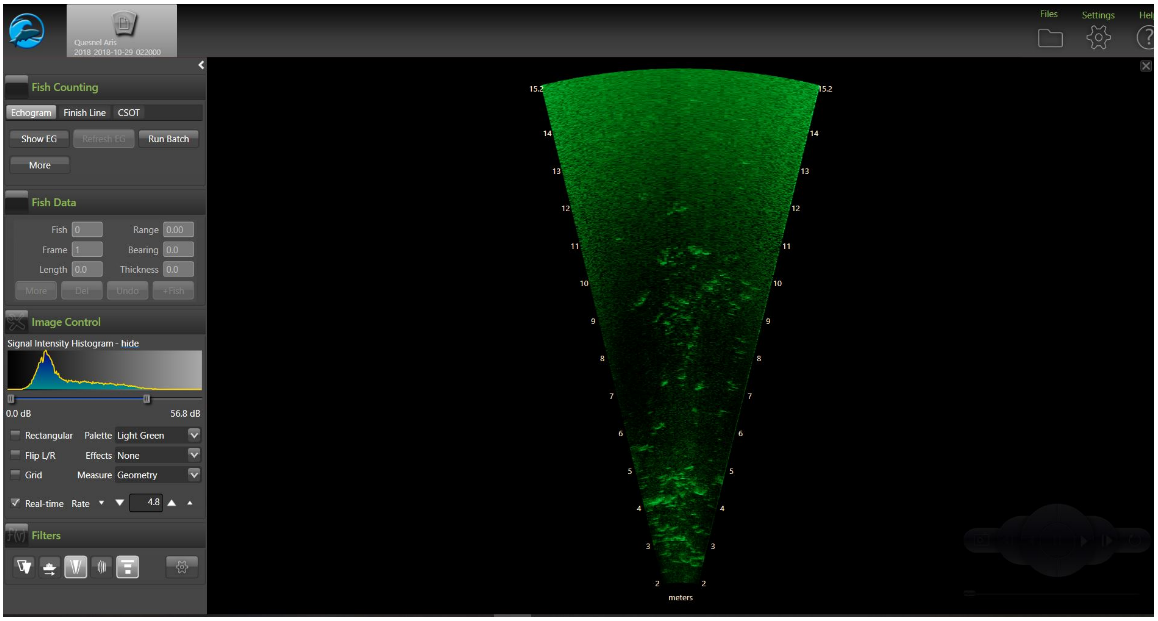

Figure 6. Example of Aris image file from project.

Acoustic Fish Counting

The files were counted manually by two individuals and the number of fish and directional migration were recorded on a spreadsheet. A sub-sample of files were counted were double counted (by each individual) for quality assurance and to assess the error between results. The error between the individual counters was 3 Coho out of 86.5 total counted in the double count files resulting in an error of +/- 0.9%.

Downstream Moving Fish and the Flux Model

The hourly count data obtained with the DIDSON system were used in a simple model (Xie *et al*, 2002) to estimate the net upstream flux (fish per unit time) of salmon passing through the acoustic site. This model is:

N = U – D
(Where N = the net upstream flux, U = the upstream actively migrating fish and D = the downstream actively migrating fish).

Overall, because the DIDSON site is located a considerable distance below all Quesnel system spawning populations and the characteristics of the river at this site, downstream movement of Coho is estimated to be zero. This estimation on migration is based on the idea that throughout the project no downstream migration of Coho was observed on the recordings. Milling in this

site is also negligible for Coho but was a note of concern for Sockeye but could be better mitigated with a slight adjustment to site location, 2-3 meter further upstream.
The right bank showed similar results with zero downstream Coho migration. Milling at this site was not noticed And Coho migration was further out into the river but still stratified between the three salmon species present during the feasibility study.

Species Identification

The location used in the 2018 Coho study demonstrated its usefulness for documenting the migration of sockeye, Chinook and Coho. The site, as it was set, was originally designed with higher water and sockeye enumeration by sonar in mind. Where the weir was placed originally lead to a higher than anticipated volume of sockeye milling in the lower velocity waters that were formed by the low water levels of the fall season. Sockeye were observed milling in the vicinity of the Aris, right bank, up till the 26th of October. This milling could have been a problem for the project if the water was not crystal clear as it is. A short observation period once every few days helped in determining the passage of sockeye was entirely within the first 4 meters and the Coho rarely passed the Aris any closer than 4 meters. This along with swim behaviour and size classification helped to identify the two different species as they migrated past the Aris and DIDSON.

The location also has a significant population of resident rainbow trout. But their general size, and "rock hop" swim pattern makes them easy to separate from all salmon migration. This location does not hold any questions as to if a Coho sonar can be run here but does pose the question as to how we can improve and develop a better site. With a modification to fence positioning, on both banks, the site could be further improved for the Coho project.

Results

The analytical procedures followed to assess the precision of the DIDSON counts among individuals using the coefficient of variation (CV) and average percent error (APE) are outlined in Holmes *et al*, 2005. The estimate of total variance for the upstream escapement estimate is the variance between individual counts and expressed as the standard deviation for the total count (SDTotalCount). The 95% confidence interval is calculated by multiplying the standard deviation by ± 1.96 for normally distributed data (Pagano, 1981). Results of analyses in Table 1.

Table 1. Coefficient of variation (CV) and average percent error (APE). for both Left (DIDSON and Right (Aris) banks as a comparison between the two enumerators observations of the files.

System	Number of Coho in total double counts	Average CV	APE (%)
ARIS	29	0.00	0.00
DIDSON	57.5	1.272030147	0.90

A total of 5,236 20-minute files were distributed over the entire migration period, were counted by multiple observers. Upstream passage rates from these files ranged from 0 to approximately 23 Coho per file. Based on the APE from these data, repeated independent counts of the DIDSON data sets would be expected to produce the same count 98.1% of the time (0.90% APE) for the net upstream travelling fish. At no time during the file counting was precision jeopardized and accuracy reduced due to high passage rates (saturation).

The 2019 Coho salmon migration past the ARIS and DIDSON was 1,454 +/- 0.9%. The migration of Coho into the Quesnel system would have started before the project's September 28th start date as the numbers for the first 2-days were over 20. The bulk of the run had concluded its migration past the Sonar site as of October 20th as the number for total daily migration after that is less than 10 fish. The maximum daily migration occurred on October 2nd with 135 fish. The mid-point in the project occurred on October 7th where 50% (727) of the estimated total Coho had passed the site. Figures 6 and 7 display the daily and cumulative Coho salmon escapement for the Quesnel River in 2019.

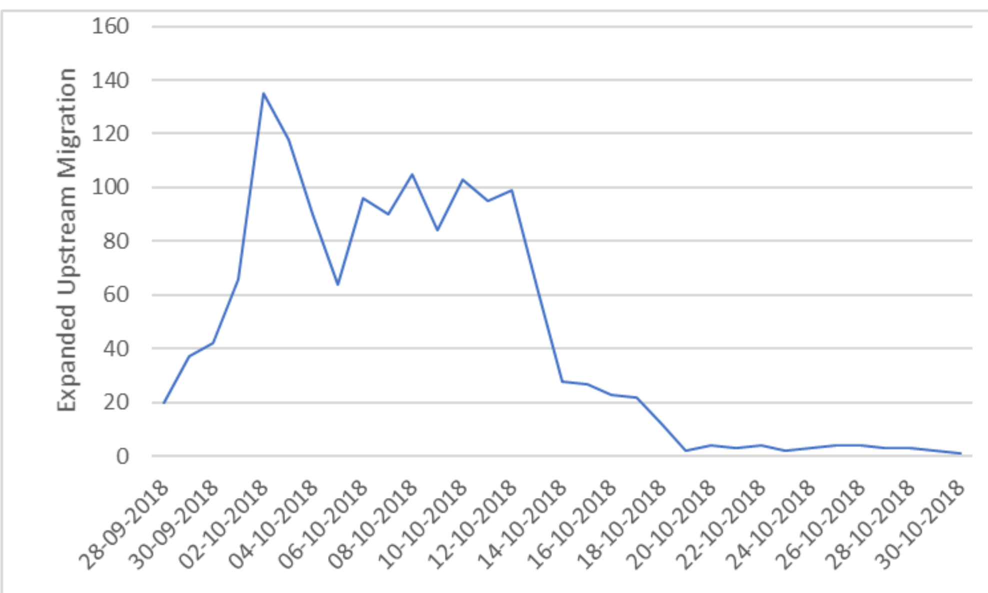

Figure 6. Daily net upstream migration of Coho past the sonar site on the Quesnel River 2019.

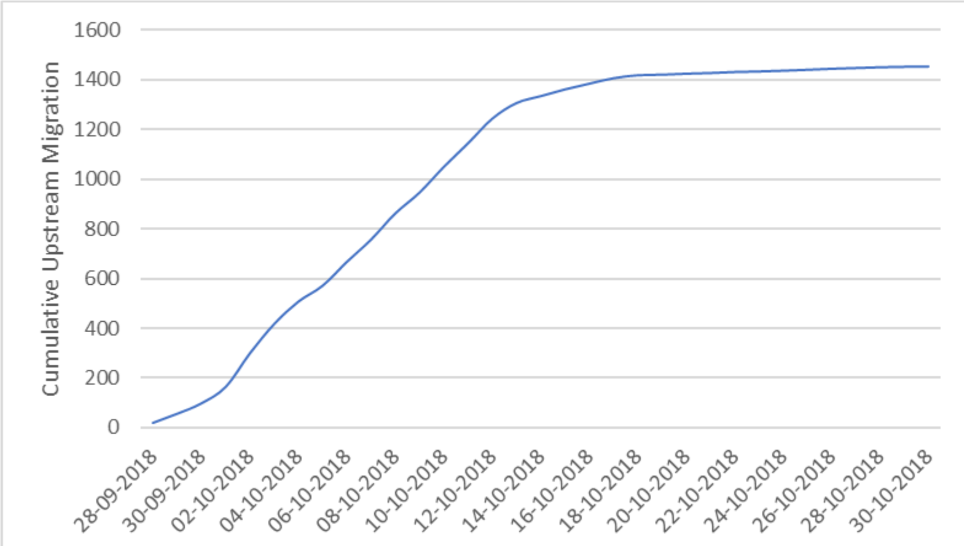

Figure 7. Cumulative daily net upstream migration past the sonar site for 2019.

The files were counted by 2 individuals and the counts were identical on all double count files the error between them was a 3 Coho out of the 86.5 total Coho counted in the double counts. Making for an error of +/- 0.9%. Files counted were conducted in 20-minute increments but in all cases full hours for 24 hours a day were counted. This was done to eliminate error incurred by temporal variance and to get a better idea as to timing with Coho in low number migration. The majority (80%) of the Coho migration occurred during day light hours, between 7am and 7pm with the two peaks at 8am and 6pm (Figure 8). Of that the majority (71%) of the Coho passing on the left riverbank (Figure 9).

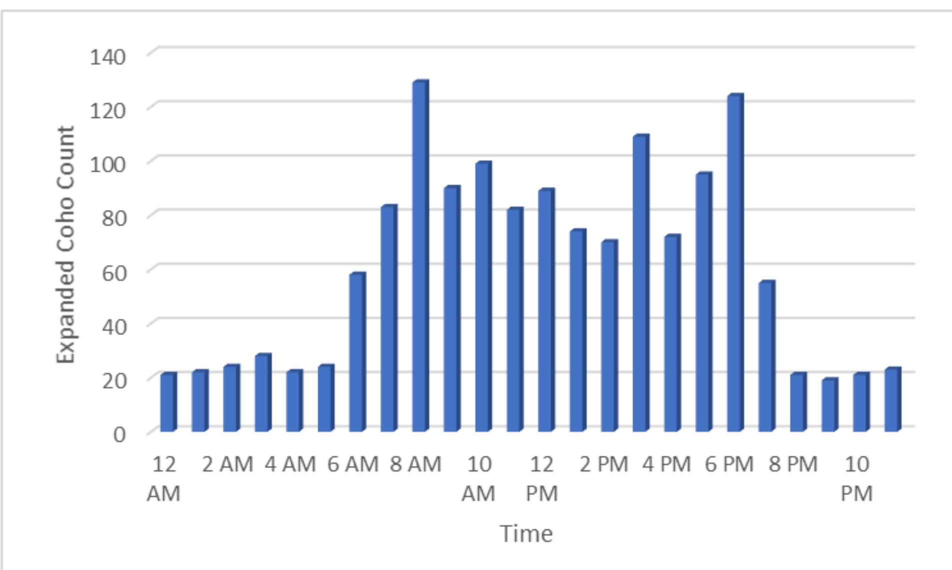

Figure 8. Total hourly Coho migration past the sonar site.

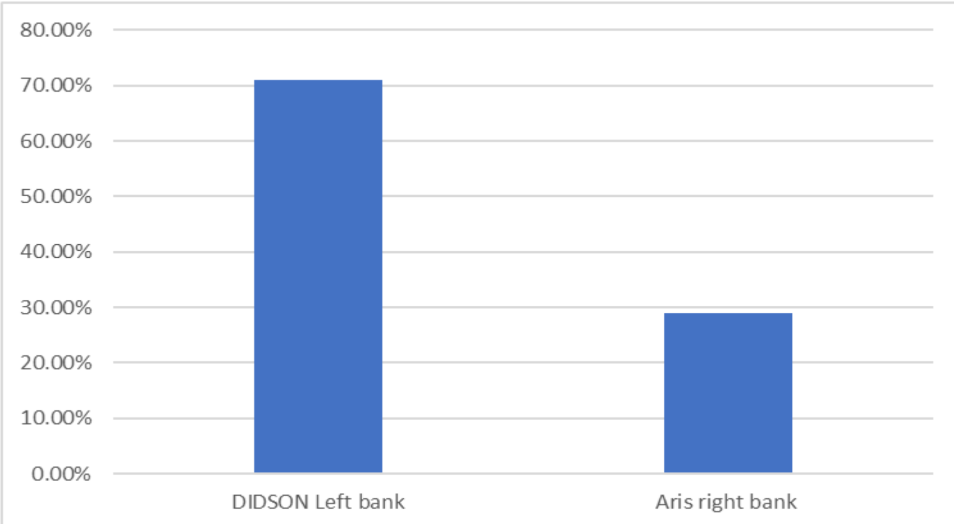

Figure 9. Total expanded migration of Coho counted past the right and left banks.

The results of adding the hydroacoustic element in the Quesnel River will be compared and developed into an index between the Quesnel sonar result and the McKinley enumeration fence count in 3rd and final year of the project.

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