2018 Pelly River Chinook Salmon Sonar Program

Prepared For
Selkirk First Nation
PO Box 40
Pelly Crossing, YT Y0B 1N0

Prepared By
EDI Environmental Dynamics Inc.
2195 -2nd Avenue
Whitehorse, YT Y1A 3T8

EDI Contact
Pat Tobler
Sr. Biologist
867.393.4882

EDI Project
18Y0236
March 2019

EDI
ENVIRONMENTAL DYNAMICS INC.
Down to Earth Biology

This page is intentionally blank.

EXECUTIVE SUMMARY

In 2018, Selkirk First Nation conducted the third year of a Chinook salmon sonar enumeration program on the Pelly River at the Pelly River Chinook salmon sonar site located approximately 24 km downstream of the community of Pelly Crossing, Yukon.

The objectives of this project were to:

- Enumerate Chinook salmon in the lower Pelly River;
- Conduct test netting to confirm sonar counts between Chinook and other fish species;
- To collect age, sex, and length data from captured Chinook; and
- To build capacity for sonar and fisheries research projects in Pelly Crossing.

An ARIS Explorer 1200 multi-beam sonar system and an ARIS Explorer 1800 multi-beam sonar system were used to enumerate Chinook salmon passing the sonar site between July 10 and August 25, 2018. In conjunction with the sonar data collection, set netting was conducted near the sonar site to determine the extent of utilization of the sonar site by adult freshwater fish during the period of operation. Local Selkirk First Nation technicians assisted with the field work for this program and received technical training on operation of a sonar system, fisheries data management, and test netting.

A net raw[1] upstream total of 9,491 fish targets were counted during the period of operation of this program. Set netting between July 20 and August 8 captured a total of eight Chinook salmon and no chum salmon. Offshore drift netting was conducted on August 6 and August 8 with the goal of capturing any Chinook salmon that were moving through the non-ensonified section of the river due to the gap between the sonar beams; one Chinook salmon was captured. It is believed that no co-migrating chum salmon were present in the area during operation of the sonar program. Sonar data indicated that adult freshwater fish were present in small numbers relative to the amount of migrating Chinook salmon.

Post-season interpolation of missing data periods increased the net upstream Chinook salmon passage estimate to 9,678 for the period between July 10 and August 25. Run expansion of the Chinook sonar counts was conducted for pre- and post-program periods; an additional 67 Chinook salmon are estimated to have migrated past the sonar site before the field program operations, which began on July 10 and an additional six Chinook salmon are estimated to have migrated past the sonar site after operations ceased on August 25. Including run expansion data, a final interpolated estimate of 9,751 Chinook salmon migrated past the Pelly River sonar site in 2018.

[1] Raw total is the unprocessed field data total.

ACKNOWLEDGEMENTS

Funding for this project was provided by the Yukon River Panel Restoration and Enhancement Fund. Eugene Alfred and Ellie Marcotte of the Selkirk First Nation Government provided general project direction and assistance with logistics. Fisheries and Oceans Canada provided two ARIS Explorer sonar units in-kind to the project. Nathan Millar, Vesta Mather, Marina Milligan and Joel Harding (Fisheries and Oceans Canada) provided technical advice during this project.

AUTHORSHIP

This report was prepared by EDI Environmental Dynamics Inc. Staff who contributed to this project include:

Scott Cavasin ..... Primary Author

Ben Schonewille R.P.Bio ..... Report Editing

Pat Tobler, R.P.Bio ..... Senior Review

Lea Pigage, R.P.Bio, PMP ..... Report Review

Joel MacFabe and Scott Cavasin of EDI were the lead technicians for the field component of the project. Additional field assistants included Rowan Huggard (EDI), Devon O'Connor (EDI), Keifer Johnnie (SFN) and Thor Harper (SFN).

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

ACRONYMS AND UNITS

ADFG ..... Alaska Department of Fish and Game

ASL ..... Age, Sex, Length

APE ..... Average Percent Error

DFO ..... Department of Fisheries and Oceans Canada

EDI ..... Environmental Dynamics Inc.

NAS ..... Network-Attached Storage

SFN ..... Selkirk First Nation

TB ..... Terabyte

QA/QC ..... Quality Assurance/Quality Control

SYMBOLS

°C ..... degrees Celsius

in ..... inches

m ..... metres

cm ..... centimetres

1 INTRODUCTION

1.1 BACKGROUND

The Pelly River is a major tributary to the Yukon River and supports the Selkirk First Nation's (SFN) Chinook salmon (*Oncorhynchus tshawtychya*) fishery. This river is a large contributor of Canadian origin Yukon River Chinook salmon as determined from genetic sampling at the Eagle, Alaska sonar site just downstream of the Canada/U.S. border. Genetic samples collected at the border indicate that on average, 12.9% of the Chinook salmon entering the Canadian portion of the Yukon River are destined for spawning areas within the Pelly River[2] (JTC 2016).

The Chinook salmon enumeration weir on Blind Creek (near Faro, Yukon) provides an index of escapement on an important spawning tributary to the upper Pelly River. However, this weir is located approximately 350 km upstream of the community of Pelly Crossing and does not provide an in-season estimate of Chinook salmon in the lower Pelly River (vicinity of Pelly Crossing). Until the establishment of the Pelly River Chinook sonar program, there was no stock assessment of Chinook salmon in the lower Pelly River to gauge the accuracy of the estimate produced through genetic stock identification. The results of genetic analyses are not available until after the Chinook run has finished; therefore, this technique cannot be used to manage harvest in-season. Current in-season harvest management is dictated by the Canada/U.S. border escapement estimates. This system does not allow for localized management of specific salmon stocks that may have higher or lower returns than what is indicated by the border estimates.

SFN has taken an active role in the management and conservation of Chinook salmon in the Pelly River through a locally developed Salmon Management Plan. A significant component of the plan includes developing an SFN operated stock assessment program for Chinook salmon on the Pelly River. In support of this goal, SFN located a candidate site in 2015 and completed the first season of sonar enumeration for Chinook salmon. The first enumeration was run between July 1 and August 3, 2016 with a final Chinook salmon passage estimate of 5,807. A second season of sonar enumeration was completed between July 1 and August 15, 2017 with an estimated 9,081 Chinook salmon migrating passed the sonar site. The 2018 enumeration was the third year of this program was completed between July 7 and August 25, 2018.

1.2 OBJECTIVES

SFN is committed to improving the management capacity for Chinook salmon in the Pelly River. SFN were recipients of funding from the Yukon River Panel's Restoration and Enhancement Fund to complete the 2018 Chinook salmon sonar enumeration program. The field portion of this program included up to eight weeks

[2] Proportion of Canadian origin Chinook salmon destined for the Pelly River averaged 12.9% from 2008 to 2014; the minimum and maximum range was 9.3% to 23.9%, respectively, since 2005; and was 18.2% in 2015 (JTC 2016).

completed between the beginning of July and end of August. The primary objectives of the 2018 Pelly River Chinook salmon sonar program were to:

- Develop an accurate, in-season stock assessment tool to estimate the annual passage rates for Chinook salmon in the Pelly River;
- Foster a stronger understanding of the Chinook salmon run in the community through community engagement; and
- Build local capacity, through technical training and full-time employment for local SFN citizens throughout the program.

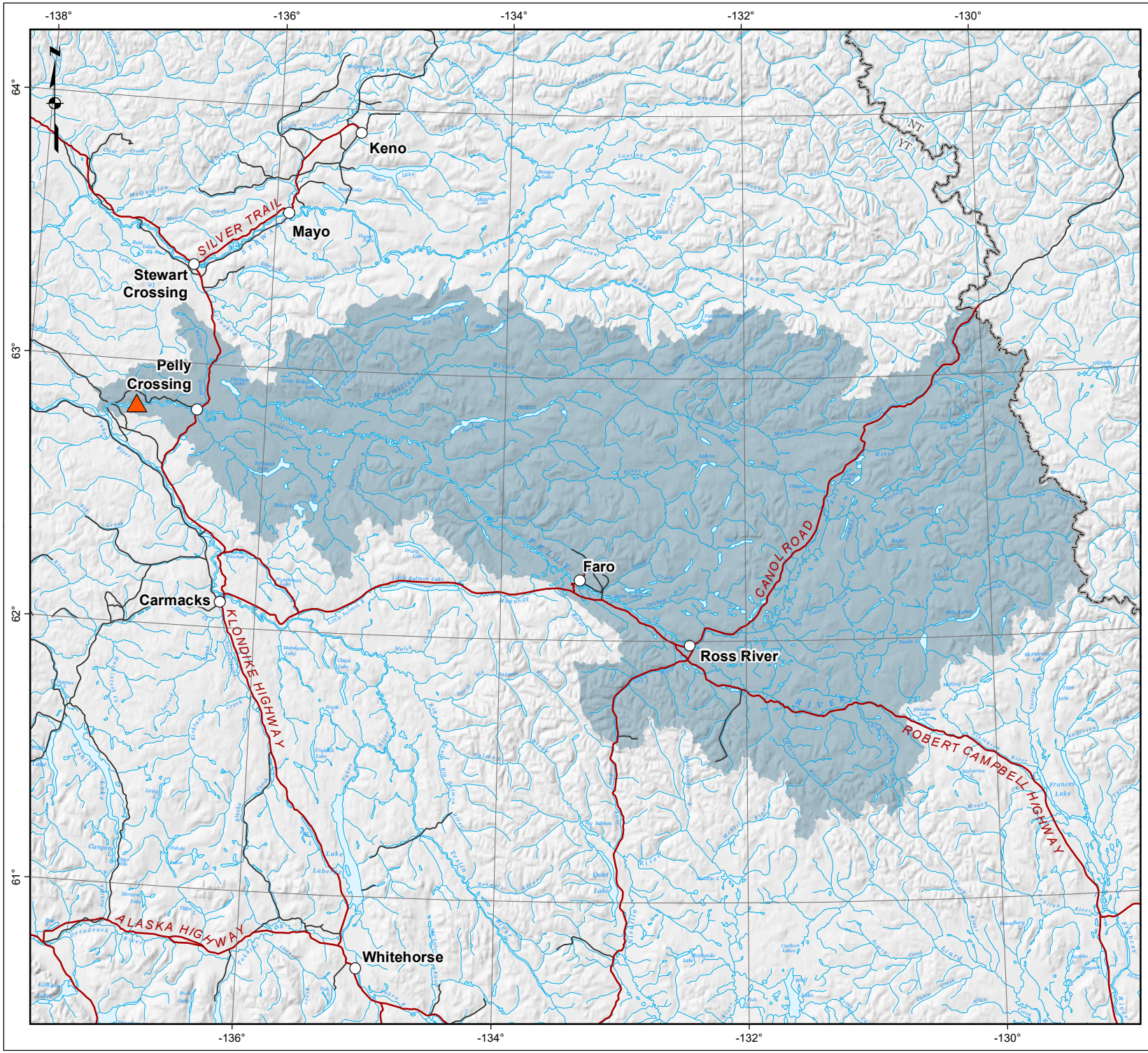
Additional objectives of the project include:

- Conduct test netting to confirm species in the sonar count data between Chinook salmon and all other fish species (including chum salmon (*Oncorhynchus keta*) and larger freshwater fish species); and
- Age, sex and length (ASL) data from Chinook salmon that are captured in the test fishery.

1.3 STUDY AREA

The Pelly River is a large tributary in the Yukon River watershed (Map 1). It joins the Yukon River just upstream of the settlement of Fort Selkirk, Yukon. The Pelly River has a number of large tributaries, including the Macmillan, Tay, Lapie, and Ross Rivers. Communities located within the Pelly River watershed include Pelly Crossing, Faro, and Ross River. Pelly Crossing has a population of approximately 300 people, the majority of which are SFN citizens.

The Pelly River Chinook salmon sonar site (Pelly River sonar site) is located on the lower Pelly River approximately 24 km downstream of the community of Pelly Crossing and 24 km upstream from the confluence of the Pelly and Yukon Rivers (Map 1). This location was selected following a 2015 study that evaluated a number of potential sonar sites in the lower Pelly River (EDI 2015). Cross-sectional bathymetry data showed that the site was suitable for the operation of sonar, with a shallow and even sloped river bottom on both the right and left banks of the site.



Legend

- Pelly River Chinook Salmon Sonar Location
- Pelly Watershed

Overview of the Pelly Watershed

Data Sources
1:50,000 and 1:2,000,000 Topographic Spatial Data courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Digital Elevation Model and 1:50,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2018) was obtained using Garmin GPS technology.

Disclaimer
This document is not an official land survey and the spatial data presented is subject to change.

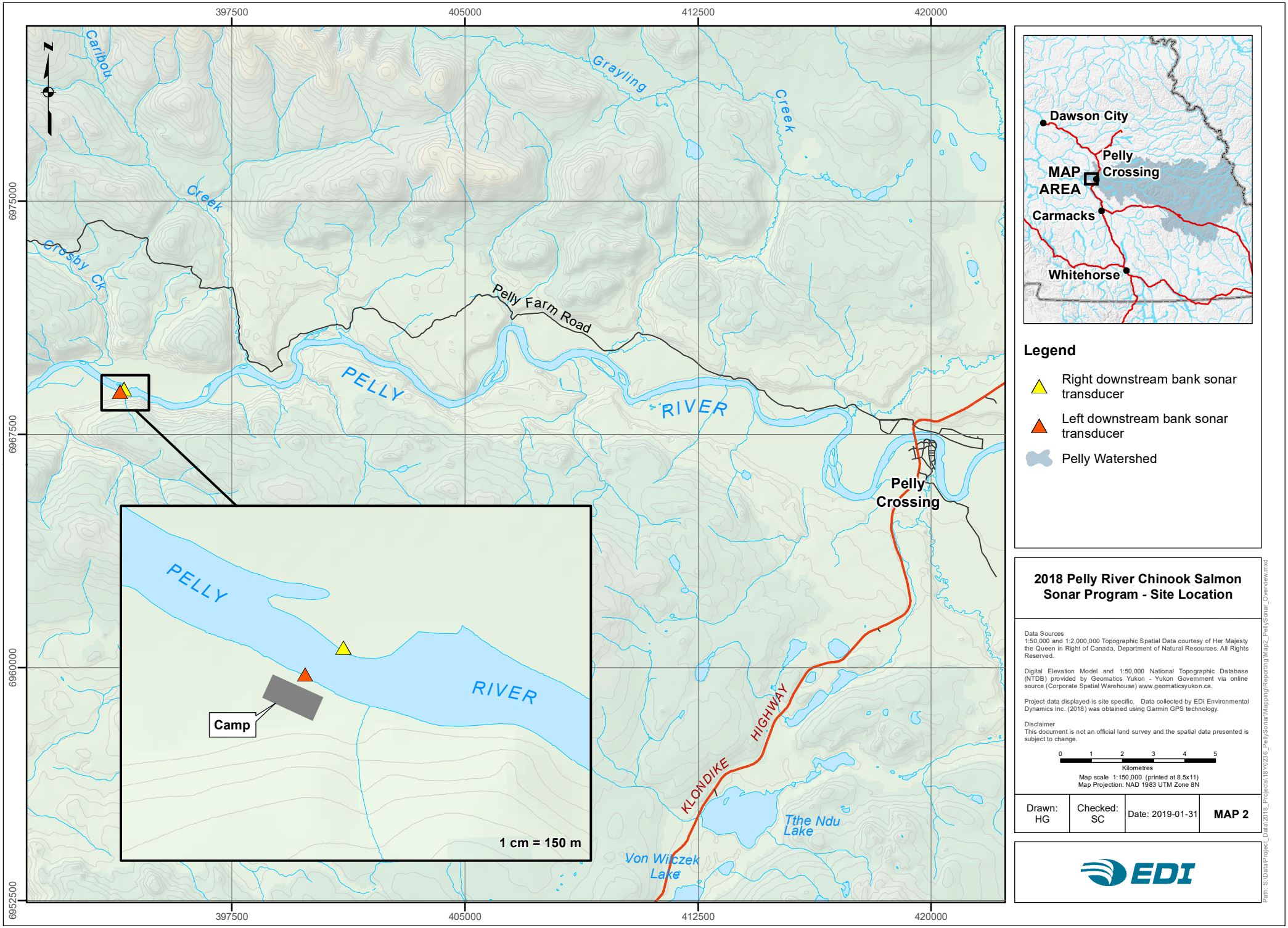
0 20 40 60 80 100
Kilometres

Map scale 1:2,250,000 (printed at 8.5x11)
Map Projection: NAD 1983 Yukon Albers

Drawn:	Checked:	Date:	
HG	SC	2019-01-31	MAP 1

EDI

Path: S:\Data\Project_Data\2018_Projects\18Y0236_PellySonar\Mapping\Reporting\Map1_PellyWatercourse_Overview.mxd



2018 Pelly River Chinook Salmon Sonar Program - Site Location

Data Sources
1:50,000 and 1:2,000,000 Topographic Spatial Data courtesy of Her Majesty the Queen in Right of Canada, Department of Natural Resources. All Rights Reserved.

Digital Elevation Model and 1:50,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2018) was obtained using Garmin GPS technology.

Disclaimer
This document is not an official land survey and the spatial data presented is subject to change.

0 1 2 3 4 5
Kilometres
Map scale 1:150,000 (printed at 8.5x11)
Map Projection: NAD 1983 UTM Zone 8N

Drawn:	Checked:	Date:	
HG	SC	2019-01-31	MAP 2

EDI

Path: S:\Data\Project_Data\2018_Projects\18Y0236_PellySonar\Mapping\Reporting\Map2_PellySonar_Overview.mxd

2 METHODS

2.1 FIELD CREW AND CAMP SETUP

A crew of three people travelled to the Pelly River sonar site on July 7, 2018, to setup the field camp. This crew consisted of two experienced technicians from EDI as well as a local SFN technician.

Following initial setup, two EDI technicians and two local SFN technicians conducted the day to day operations of the field program, with offsite support from EDI biologists in Whitehorse. EDI and SFN staff operated on a rotation-based schedule for the duration of the program which ensured that there was at least one EDI and SFN technician onsite at all times.

2.2 SONAR DEPLOYMENT

On July 9, 2018 an ARIS Explorer 1200 multi-beam sonar system and an ARIS Explorer 1800 multi-beam sonar system were deployed across the river from each other on the left and right banks, respectively (one system on each bank). Each sonar system consisted of a sonar transducer, power/data cable, and command module. The power/data cable carried the sonar data from the submerged transducers to the command module, which was located onshore and allowed for control of the system power (on/off switch) and interfacing with a laptop computer through an Ethernet cable connection. The sonar transducers were affixed to aluminum 'goal post' type mounts, which were purchased, and custom built in Whitehorse for this project. The mounts allowed for easy adjustment of the transducer pitch and depth within the water column.

On each bank of the river, sonar data was transmitted from the sonar command module to a laptop computer, to allow for data capture and review. On the left bank (when looking in a downstream direction), the command module was connected to the laptop computer by wired Ethernet connection. On the right bank, the command module was connected to a wireless Ethernet bridge and data was transmitted across the river wirelessly to a second laptop computer on the left bank. This configuration allowed all equipment to be operated from the left bank. The equipment was powered using two portable 2000-watt gas powered generators on each bank.

This sonar setup allowed for ensonification of approximately 90 m of the river channel (30 m from the left bank, 60 m from the right bank). The width of the wetted portion of the Pelly River at the sonar site was estimated to be approximately 140 m using a range finder at the initial onset of the project, which meant that approximately 50 m of channel was not ensonified. The section of the river that was not ensonified was primarily across the thalweg (i.e., deepest part) of the river.

2.2.1 TARGET TESTING

At the initial onset of sonar operation, target testing was conducted to ensure that targets in all areas of the water column were covered adequately by the sonar beam. Target testing consisted of one crew member watching the sonar screen in real time, while the other crew members drifted through the sonar beam in a boat at various distances from the sonar transducer. A reflective target (lead downrigger weight) was drifted beneath the boat to determine if it could be seen on the sonar. Targets were drifted at various depths from surface to bottom. Surface detection was also confirmed by visual detection of the hull of the boat in some cases. Once complete, any major gaps in sonar coverage were noted and adjustments to the sonar aim were made where feasible.

2.2.2 FISH DEFLECTION FENCE

To ensure fish did not migrate behind the sonar or the ensonified area, a fish deflection fence was set up to force fish away from the shore and out in front of the transducer. Flexible plastic link fencing was erected perpendicular to the river channel to extend the fence out into deeper water (to a depth of approximately 1 m; see Appendix A for site photos). The fencing was supported using steel T-rail type stakes, which were pounded into the river bed to secure the fence. After the fencing was erected, field staff keyed the bottom of the fence into the river bed material, to ensure that no salmon could pass underneath. The approximate total length of fence was 2 to 3 m on the left bank and up to 25 m on the right bank. The fence was deployed approximately 1 m downstream of the sonar transducer on both banks. The transducers and mounts were typically placed a minimum of 3 m back from the end of each fence (towards the shore) to ensure that all fish passing in front of the fence were a sufficient distance away from the face of the transducer to allow them to be readily detected.

2.2.3 SONAR SOFTWARE SETUP AND DATA COLLECTION

The proprietary data collection software for the ARIS sonar system is ARIScope (version 2.4.7013.0) which was used to control the operation of the two sonars and to record all collected sonar data. The relevant settings of this software that were used during this project are shown in Table 1. Both sonars were set to record data continuously (24 hours per day), and all sonar data was recorded to a NAS drive. Data recorded to the NAS drive was stored on two 4 TB drives, which were configured in a mirrored RAID-array, to ensure data redundancy. This array ensured that all recorded sonar data was secured in the event of a hard drive failure.

The sonar systems were powered on after the initial setup was completed, the sonar aim was checked, and fine scale pitch and depth adjustments were made to optimize the sonar positioning. Periodic adjustments to the sonar positioning were made throughout the field program, primarily in response to changing water levels. Sonar data was collected from July 10 to August 25, 2018. A total of 25 hours of data (totaled for both left and right bank sonar units) was not recorded due to instances of temporary generator failures, equipment maintenance and updates.

Table 1. Summary of ARIS Explorer 1200 and 1800 data collection parameter values and settings used during the 2018 Pelly River Chinook salmon sonar program.

Parameters	Left Bank Sonar	Right Bank Sonar
Model	ARIS Explorer 1800	ARIS Explorer 1200
Frequency Low/High (kHz)	High (1.8 MHz)/Low (1.1 MHz)	High (120 kHz)
Beam Width (Horizontal/Vertical)	8º H/14º V	9.5º H/2.5º V
Window Range	30 m	60 m

2.3 ENUMERATION OF CHINOOK SALMON

Sonar data was reviewed using Echotastic version 3.0b1, a software package developed by Carl Pfisterer of the Alaska Department of Fish and Game (ADFG). Echotastic allows for sonar data files to be reviewed and for detected fish targets to be tallied. The enumeration methods used for this project consisted of reviewing an echogram of each collected sonar file, identifying fish targets with upstream and downstream motion and tallying all such targets within each file. An explanation of the enumeration process is detailed in the following sections.

2.3.1 ECHOGRAM INTERPOLATION

An echogram is the visual representation of sonar data; it provides an image based on the intensity of returned echoes and time of reception. Echotastic provides a means to generate colour echograms from recorded ARIS sonar data files. Time can be displayed on the horizontal axis of the image, and the distance from the front of the sonar transducer can be displayed on the vertical axis of the image. When using the echogram configuration described above to enumerate riverine fish, the series of horizontal lines through the echogram indicates ensonification of the river bottom.

2.3.2 DATA PROCESSING PARAMETERS

Echotastic allows the user to specify a number of data processing options, to assist in viewing and interpreting the echogram data. A summary of the processing options used during the 2018 Chinook sonar program and the rationale for each option are presented in Table 2. The field crew found these settings to be the most suitable for review of the collected data.

Table 2. Echotastic data processing options used during the review of sonar data collected during the operation of the 2018 Pelly River Chinook salmon sonar program.

Processing Option	Setting Used	Explanation of Setting	Rationale
Colour Map	Simrad/Amber	Provides a full colour spectrum picture of echogram	Ease of viewing, personal preference
Colour by Angle	On	Colours echogram data based on direction of horizontal travel of fish targets	Allows differentiation of upstream and downstream moving sonar targets
Lower Threshold	-50 dB	Displays all sonar data stronger than -50 dB	Excludes sonar signals of lower intensity than -50 dB from the echogram; removes noise from image
Colour Background	Black	Displays sonar data against a black background	Ease of viewing

2.3.3 DISTINGUISHING MIGRATING SALMON ON ECHOGRAM

Migrating salmon can be identified from Echotastic echograms based on shape and shadowing. Salmon generally appear as characteristic crescents or "wavy" traces on the echogram that are usually oriented parallel to the river current (Figure 1). This shape and orientation can aid in the separation of salmon targets from non-salmon targets. In addition to the shape, the relative size of the target on the echogram and intensity (brightness) of the trace on the echogram were also used to help distinguish between salmon and non-salmon traces; salmon traces are generally brighter and larger than freshwater fish. Larger salmon also block a portion of the sonar beam as they travel through it, causing a shadowing of the area of the echogram directly behind the fish. Shadowing is visible on an echogram as a dark vertical line behind the fish, extending away from the transducer. This shadowing effect is visible behind the fish in the example echograms in Figure 1 and Figure 2.

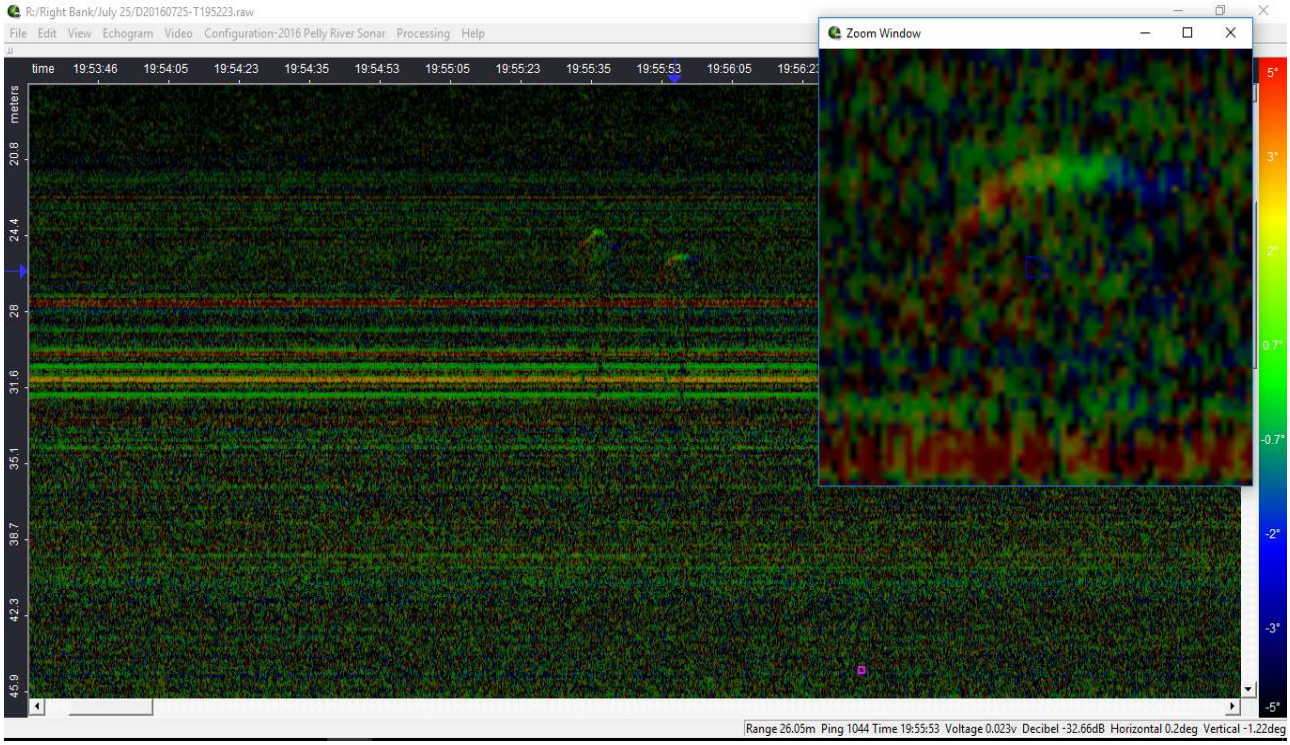


Figure 1. Echotastic echogram showing the crescent shaped sonar target and shadowing typical of a fish target. Image is from the Pelly River right bank sonar unit.

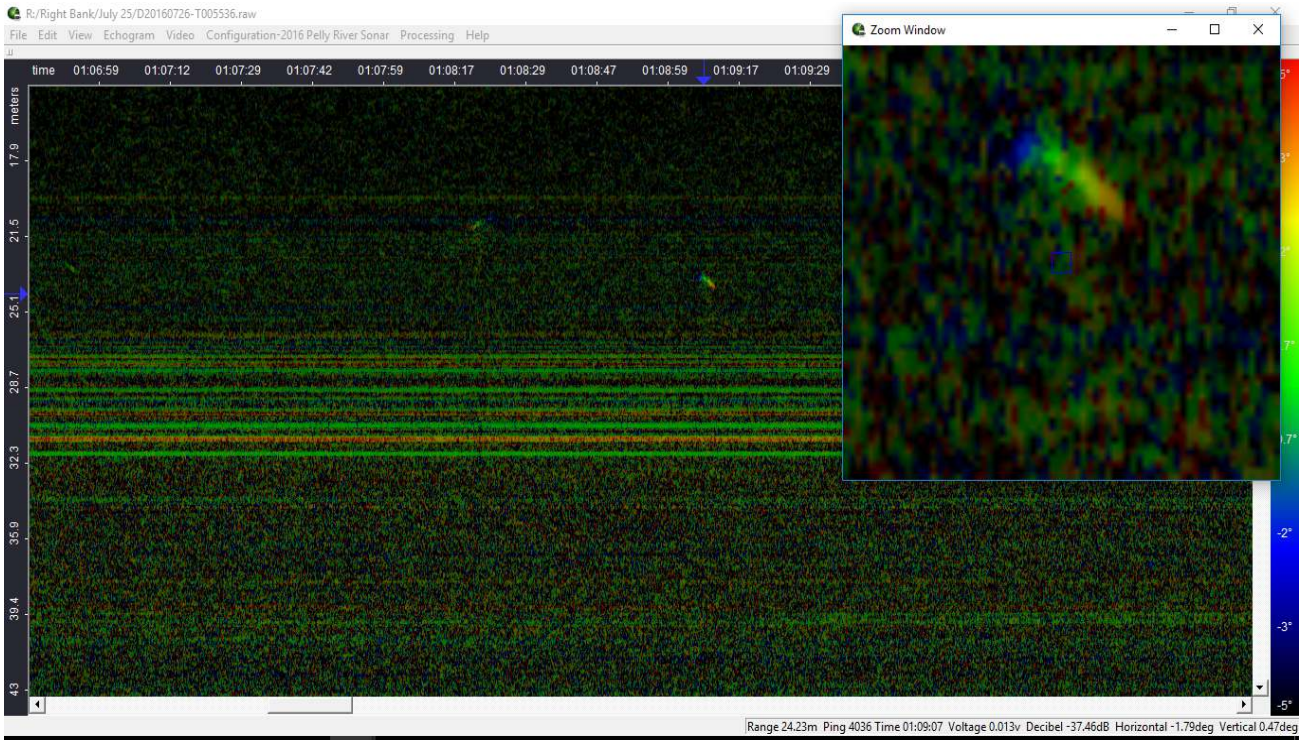


Figure 2. Echotastic echogram window showing two fish travelling in opposite directions. The fish on the left of the screen is traveling upstream and the fish on the right is traveling downstream. Image is from the Pelly River right bank sonar unit.

Instream debris (non-fish targets) can be distinguished from fish targets because debris is always downstream moving with the current. Instream debris and animals, such as a beaver or muskrat, often show a fainter, longer trace on the echogram than fish targets.

The ability to detect and discern fish targets is a skill developed through practice. At the beginning of the 2018 season, sonar technicians completed a comprehensive training module, created by Fisheries and Oceans Canada (DFO) biologist Elizabeth MacDonald in 2016. This training module was comprised of example data files and practice enumeration tests to develop the sonar technicians' ability to distinguish salmon targets, freshwater fish targets, and non-fish targets on the sonar echograms. This module was designed to help standardize the training and review techniques used across Yukon salmon sonar programs.

Staff training was supervised by the EDI project technician and all staff were tested on the training files to ensure that they could effectively differentiate between different sonar targets (salmon, freshwater fish, and instream debris). Additional training was conducted when deemed necessary by the supervising technician. Throughout the training program, staff were encouraged to work as a team and to maintain dialogue and consultation with the project technicians if challenging and/or unclear data files were encountered during the review process. Staff were also instructed to be conservative when enumerating salmon targets; if the identity of a particular trace was still questionable after consultation with other project staff, it was not counted as a migrating salmon.

2.3.4 DETERMINING DIRECTION OF TRAVEL

The direction of travel (upstream or downstream) was determined for each salmon identified on the sonar during review of the collected sonar data. Direction of travel is determined by the change in the horizontal angular position of a fish as it passes through the area of ensonification, relative to the center of the acoustic beam (measured in degrees). The change of angle position (from positive to negative degrees) for a fish moving upstream is the opposite of that for a fish moving downstream and can be used to differentiate between directions of travel.

When the reviewer enables the colour by angle option in Echotastic, the echogram colour scale provides a visual representation of the changes in angular position. Hot colours (reds or yellows) represent movement in one direction while cold colours (blues or blacks) represent movement in the opposite direction. In this manner, fish moving upstream can be easily identified since they possess the opposite colour spectrum orientation to those fish which are moving downstream (Figure 2).

Once onsite technicians were confident that a detected acoustic target was a migrating salmon, the salmon target in question was marked on the Echotastic echogram. The was done by left clicking on the location of the fish on the echogram window and marking the upstream migrating salmon target with a pink square. In the same manner, if the reviewer identified a salmon target that was moving downstream, they would right click on the location of the fish, which marked the target with a blue square. Echotastic records the total number of marks in either direction. Field staff recorded these totals for each file, as well as a net total of upstream salmon migrants (total number of upstream salmon targets minus the total number of downstream

salmon targets). These counts were then entered into a Microsoft Excel spreadsheet as well as a paper backup copy. Saved marks on the Echotastic echogram were then output to a text file for post-season processing and data analysis.

2.3.5 INTERPOLATION OF COUNT DATA

During the operation of the sonar program, equipment malfunctions and maintenance requirements resulted in periods when sonar data was not collected. For in-season reporting, missing data was interpolated by multiplying raw daily counts by the percentage of the day that was missing. If five hours of data was missing, data was interpolated by taking an average of the preceding and following five hours of count data. This method provided a simple means for field staff to generate preliminary adjusted counts in time for in-season updates to be delivered to fisheries managers.

Post-season (i.e. in this report), missing data was interpolated using different methods. The post-season methods of interpolation for periods when portions of a day's data were missing followed the methods used at the Eagle sonar station in Alaska (Crane and Dunbar 2009). Three different interpolation methods were used depending on how much data was being interpolated. All three methods are detailed below (Crane and Dunbar 2009):

> "When a portion of a sample was missing, on either bank, passage was estimated by expansion based on the known portion of the sample. The number of minutes in a complete sample period (m_s) was divided by the number of minutes counted (m_i), and then multiplied by the number of fish counted (x) in that period (i). Passage (y_i) was estimated as:
>
> $$\hat{y}_i = \left(m_s / m_i\right) x_i$$
>
> If data from one or more complete sample periods was missing, passage for that portion of the day (y_m) was estimated by averaging passage from the [equivalent number of] sample periods immediately before (y_b) and after (y_a) the missing sample period(s), and then multiplying by the number of sample periods missing (n) [n is generally 1 if the equivalent number of sample periods is available]:
>
> $$\hat{y}_m = \left(\frac{y_b + y_a}{2} \right) n$$
>
> When multiple days were missing on only one side of the river, passage for the period of missing days was estimated by determining a proportion of fish passing one bank, compared to the amount of fish passing the other bank, and averaging the proportions for the amount of days missing immediately before and after the missing sample period(s)."

In cases where interpolation formulas resulted in non-integer values (i.e. counts with decimals), these values were left as decimals until our final number where they were rounded down (to be conservative) to a full number.

2.3.6 SONAR DATA QUALITY ASSURANCE/QUALITY CONTROL AND RELIABILITY

To ensure a high-quality data set, QA/QC measures were implemented for review of the sonar files during the field component of the program.

Sonar technicians reviewed a subset of each other's count data as a means to QA/QC the data in the field. Approximately 10% of the daily files (i.e. three files per bank, per day) were re-opened without saved fish marks and re-counted by a second technician onsite. Any differences in counts were recorded, but no changes were made to the original counts as the goal was to quantify person to person variability. The average percent error (APE) was calculated using a formal used by DFO (Mather and Milligan 2018, pers. comm. available upon request). Some subjectivity exists when interpreting sonar target data and differences in interpretation between technicians is expected; therefore, it is important the counting and review process is standardized amongst technicians and sonar programs to provide the most accurate and consistent data.

Post season analysis was done to quantify variability (reliability) in counts by each technician. Post season analysis included; sample variance ($Var\ (\hat{Y})$), standard deviation ($SD_{TotalCount}$) and confidence interval (Mather and Milligan 2018, pers. comm.).

Sample variance ($Var\ (\hat{Y})$) was calculated using the formula:

$$Var(\hat{y}) = \frac{\Sigma(X_i - X)^2}{(n-1)}$$

Where X_i is the estimated hourly passage, X is the mean estimated hourly passage for the day and n is the number of files counted in the day.

The standard deviation ($SD_{TotalCount}$) was calculated using the formula:

$$SD_{TotalCount} = \sqrt{Var(\hat{Y}) + APE}$$

Where $Var(\hat{Y})$ is the sum of the daily variance in counts and APE is the average percent error explained in the next section.

Using the standard deviation the confidence interval was calculated by multiplying it by ± 1.96 to determine the 95% confidence interval in our Chinook salmon estimate.

2.4 TEST NETTING

The 2018 test netting program was reduced from previous years to reduce crew size and associated costs of the sonar program, as well as ensuring accurate and continuous collection of sonar data. The test netting program included set netting to confirm sonar count data between Chinook salmon, larger freshwater fish (inconnu and northern pike), and any other salmon species that have the potential to co-migrate with the Chinook. The test netting was done only when sufficient time and crew members were available.

Out of respect for Doòli, SFN's way of respecting and living in harmony with the natural world, all captured fish were handled as gently and minimally as possible, quickly removed from nets, and placed in a water filled tote to recover while sampling. Scale samples were collected from all captured Chinook (five scales per individual) and delivered to DFO for aging analysis. Salmon were also sexed, measured, and released. Genetic samples (axillary process clippings) were also collected and were delivered to DFO for analysis. All other captured fish were identified to species, measured and released. Test netting used nets that were hung at a relatively loose ratio of 3:1.

2.4.1 SET NETTING

Set netting was conducted between July 20 and August 8, 2018, over eight days. Set netting occurred on both banks of the river in the vicinity of the sonar site; however, the most suitable sites were located on the right bank upstream from the sonar. Nets were set for a targeted eight hours per day and checked on a frequent and regular basis. Net mesh sizes included 5.25, 6.75, 7.5, and 8.5 inches (13.3, 17.1, 19.1, and 21.6 cm) stretch diameter specifically to target Chinook and any larger freshwater fish. Nets were 100 feet (30.5 m) long, with mesh depths equivalent to net depths of 12 to 16 feet (3.6 to 4.9 m). Net mesh sizes were chosen to replicate the sampling methods used for the Eagle sonar program (Lozori and Borden 2015). However, a 6.5-inch mesh size is typically used at the Eagle sonar site, but due to stock availability, the closest mesh size (6.75 inch) was purchased.

2.4.2 DRIFT NETTING

Offshore (mid-channel) drift netting was conducted on two days of the field program with the goal of capturing Chinook salmon that were possibly migrating through the non-ensonified section of the river between the two sonar systems. The majority of the drift netting was conducted offshore downstream of the sonar site. Net mesh sizes used were the same as the set netting program and included 5.25, 6.75, 7.5, and 8.5 inches (13.3, 17.1, 19.1, and 21.6 cm). Drift nets were 100 feet long (30.5 m) with mesh depths equivalent to net depths of 12 to 16 feet (3.6 to 4.9 m). Each drift last approximately 6 minutes long.

2.4.3 CHINOOK SALMON AGE ANALYSIS

Scales were collected from Chinook salmon captured during set netting and provided to DFO for age analysis. Methods for scale collection followed protocols provided by DFO and included the collection of five scales from each Chinook salmon, taken from just above the lateral line between the dorsal and anal fins of the fish. Scales were placed in scale card books (also provided by DFO) and allowed to dry each day.

3 RESULTS

3.1 SONAR DATA

3.1.1 RAW WEEKLY SONAR COUNTS

A raw net total of 9,498 upstream moving fish were identified from the collected sonar data over the duration of the sonar program (Table 3, APPENDIX C). This number is slightly higher than the number released at the end of the sonar program (9,491) due to data corrections. The weekly net upstream count is calculated by subtracting the total weekly count of fish moving downstream from the total weekly count of fish moving upstream.

During all program weeks, the number of fish moving upstream substantially exceeded the number of fish moving downstream on both the right and left banks. The majority (71%, net upstream total) were counted on the right bank of the sonar site (Table 3). The peak of the run occurred during the week of July 29–August 4, with a net upstream total of 3,157, approximately 33% of the total run.

Table 3. Raw weekly counts of salmon at the Pelly River sonar site from July 10 to August 25, 2018.

Program Week	Right Bank			Left Bank			Net Upstream Total
	Upstream	Downstream	Net Upstream Total	Upstream	Downstream	Net Upstream Total	
Jul 10-14 [A]	129	4	125	140	0	140	265
Jul 15-21 [B]	815	17	798	353	2	351	1149
Jul 22-28	2,205	6	2,199	876	9	867	3,066
Jul 29-Aug 4	2,347	21	2,326	838	7	831	3,157
Aug 5-11 [C]	931	8	923	398	3	395	1,318
Aug 12-18	295	3	292	183	3	180	472
Aug 19-25	60	2	58	13	0	13	71
Total	**6782**	**61**	**6,721**	**2,801**	**24**	**2,777**	**9,498**

[A] Right bank sonar down missing data for 5 hours July 10, 2 hours July 11 and 4 hours July 12

[B] Left bank sonar down, missing data for 2 hours July 16.

[C] Right bank sonar down, missing data for 2 hours August 5, left bank sonar down, missing data for 2 hours August 5, 1 hour August 7, 6 hours August 11. August 6 and 7 left bank data recounted postseason.

Daily counts suggest the sonar site was in operation after the initial onset of the Chinook migration. On the first day of counting (July 10), a total of 28 Chinook were recorded and the total count for the following days continued to rise. Although the data indicates the peak (July 29–August 4) of the Chinook run had passed, the daily counts show Chinook were still migrating past the sonar site after the program operations ceased. On August 25, the final day of sonar operation, a total of five upstream moving fish targets were counted (APPENDIX B).

3.1.2 SONAR DATA QUALITY ASSURANCE/QUALITY CONTROL AND RELIABILITY

A total of 358 sonar files were re-counted for QA/QC purposes; 173 on the right bank and 185 on the left bank. A total of 52 (30%) files from the right bank and 49 (26%) files from the left bank differed in the count of fish. Typically, the targeted difference in the original versus the QA/QC files was less than a 10% difference, therefore, additional QA/QC was completed on the sonar count data to investigate how this may have affected the overall total estimated Chinook salmon counts.

Of the QA/QC files that had discrepancies, there was a difference of -33 for the right bank and -1 for the left bank. The total number of fish counted in the original files was 1,577 and the total number of fish counted in the QA/QC files was 1,543. This constituted a difference of +34 fish or 2.2% of the total number of fish counted in the QA/QC files. The left bank had an APE of 16.33% and right bank had an APE of 9.57%. This means the mean difference in the original count versus the two QA/QC counts was 16.33% on left bank and 9.57% on right bank.

3.2 TEST NETTING

The amount of netting done during the 2018 project was greatly reduced from the amount of netting done in previous years. This is due to having a smaller crew size as well as focussing on quality, continuous data collection for the duration of the sonar program.

3.2.1 SET NETTING

Set netting occurred on eight different days between July 20 and August 8 (Table 4, APPENDIX C). Field crews rotated through the four mesh net sizes using a different net each day. Nets were set for as long as possible as time allowed following sonar data review and completion of other tasks. A total of 32.55 hours of set netting was completed, resulting in an average of 3.25 hours per set. All the fish captured during the set netting program were Chinook salmon. No other fish species were captured (Table 4, APPENDIX C).

The majority of the net sets did not catch any Chinook and all but one of the individuals were captured in a single net set on July 28. Of the seven fish captured during set netting, three were female and four were males. The average fork length for captured female fish was 86 cm and 91 cm for captured males.

Table 4. Summary of set netting effort and catches at the Pelly River sonar site in 2018.

Date	Set ID	Netting Effort (hours)	Chinook Salmon Captured	Chum Salmon Captured	Total Fish Captured
20-Jul-18	1.1	3.50	0	0	0
21-Jul-18	2.1	3.00	0	0	0
22-Jul-18	3.1	4.42	0	0	0
24-Jul-18	4.1	5.42	0	0	0
27-Jul-18	5.1	5.00	0	0	0
28-Jul-18	6.1	2.25	0	0	0
28-Jul-18	6.2	5.83	6	0	6
6-Aug-18	7.1	0.72	0	0	0
6-Aug-18	7.2	1.03	1	0	1
8-Aug-18	8.1	2.38	0	0	0

3.2.2 DRIFT NETTING

The left bank ARIS sonar unit was a short-range sonar system; this unit was only effective to approximately 30 m. As a result, a large gap (approximately 50 m) between the sonar units was present during ensonification with the potential of missing targets in the mid-channel of the river. This gap was located primarily within the thalweg (deepest section of the river) where it is suspected Chinook salmon were not likely migrating as it is the fastest flowing section within the river and they have been shown to be bank orientated and travel in sections where the flow is reduced. Offshore drift netting was conducted throughout this section of the river in an attempt to determine if Chinook salmon were migrating between the sonar units where they would not be visible and counted by the sonar.

Offshore drift netting occurred on two different days—August 6 and 8, 2018—with a combined total of seven drifts completed (Table 5, APPENDIX A). The 6.27 and 7.5 inch mesh sizes were used, each being used for the duration of the day. A total of 0.65 hours of offshore drift netting was done, capturing one female Chinook salmon with a fork length of 86.9 cm. No other fish species were captured during drift netting.

Table 5. Summary of offshore drift netting effort and catches at the Pelly River sonar site in 2018.

Net ID	Netting Effort (minutes)	Chinook Salmon Captured	Chum Salmon Captured	Total Fish Captured
D1.1	6	1	0	1
D1.2	6	0	0	0
D1.3	6	0	0	0
D2.1	5	0	0	0
D2.2	4	0	0	0
D2.3	6	0	0	0
D2.4	6	0	0	0

In 2018, only one Chinook salmon was captured during the seven drifts completed. In 2016 a total of 93 offshore drifts were completed capturing one Chinook salmon (EDI 2017). In 2017 a total of 209 offshore drifts were completed with no fish captured (EDI 2018). When looking at results from all years combined a total of 309 offshore drifts have be completed in the mid-channel near the sonar camp capturing two Chinook salmon. This provides us with rationale to suggest that very few, if any, Chinook are migrating through the un-ensonified portion of the river.

3.2.3 CHINOOK SALMON AGE ANALYSIS

At the time this report was written, results from the 2018 test netting samples were not available.

4 DISCUSSION

4.1 INTERPOLATION OF RUN DATA

4.1.1 INTERPOLATION OF MISSING COUNT DATA

Interpolation of several hours of missing sonar data was required due to periodic power failures with the generators, computer software updates and movement of the sonar systems due to changing water levels. Interpolation was conducted according to the methods outlined in Section 2.3.5 and interpolated net upstream sonar counts were calculated for each week of program operation (Table 8). Daily interpolated count data is included in Appendix B.

After interpolating missing count data, a total of 9,678 fish were estimated to have passed the sonar site between July 10 and August 25, 2018 (Table 8). The general trends in fish passage rates and relative distribution of counts (right vs. left bank) were unchanged from the raw weekly sonar counts (Table 3). Overall, the sonar system operated very well, with minimal missing data compared to previous years which experienced high water events.

Table 6. Interpolated net upstream weekly counts at the Pelly River sonar site between July 10 and August 25, 2018.

Program Week	Left Bank	Right Bank	Both Banks Combined Interpolated Net Upstream Total
Jul 10-14	140	131	271
Jul 15-21	353	798	1,151
Jul 22-28	867	2,199	3,066
Jul 29-Aug 4	831	2,326	3,157
Aug 5-11	420.5	1,099.5	1,520
Aug 12-18	179	292	471
Aug 19-25	12	30	42
Totals	**2,802.5**	**6,875.5**	**9,678**

A total of 13 hours of right bank sonar data were interpolated, resulting in 21 estimated fish counts. A total of 12 hours of left bank data was interpolated, resulting in only 27 estimated fish counts. Sonar and weir reposition/aiming, computer software updates, generator failures and schedule sonar maintenance are what made up the 25 hours of interpolated data. In addition to interpolation of data, counts for 24 hours on August 6, 7 and 11 hours on August 11, on the left bank only, were recounted post-season. This was due to unexpected sonar setting changes result in difficulty reviewing the files for the original counters. The recounted left bank daily totally for August 6 increased from 19 to 101, August 7 increased from 7 to 69 and August 11 increased from 19 to 52 (including 6 hours of interpolated data for August 11).

In addition, the final five days of sonar data for each site were recounted by an experienced technician after the field program had finished. The final five days were recounted because the daily numbers had decreased to two fish on August 20 and increased back up to a daily total of 18 on August 24. It was suspected that this

end of the season increase could have been early fall chum migrating up the Pelly River. After review, it was deemed that these fish were Chinook salmon. However, the total net upstream (both banks combined) migration of Chinook decreased from 45 to 35 for the last 5 days of operation.

4.1.2 CHUM SALMON RUN OVERLAP

It is understood, through anecdotal information from SFN members, that the Pelly River is not known to be a spawning destination for fall chum; however, chum are known to travel and spawn in the mainstem of the Yukon River near the confluence with the Pelly River. To accurately estimate the escapement of Chinook within the lower Pelly River, an estimate of the total chum that passed the sonar site must be subtracted from the total count of Chinook. Due to the potential for chum to be present in the Pelly River and co-migrate with the Chinook in early to late August, onshore drift netting was conducted as part of the test netting program in 2017 to target chum with no catches. Throughout each project no chum salmon have been captured in any drift netting or set netting (EDI 2017, 2018).

In 2018, the estimated run timing for chum salmon past the Pelly River sonar site was estimated to be between August 27 and 31. It is suspected that chum salmon were not present during the 2018 sonar operation, however, to further support this notion, the run timing of chum salmon in 2018 was reviewed. Travel rates of chum within the Yukon River were used to estimate the approximate arrival date of chum at the sonar site. The distance from the Eagle sonar site to the Pelly River sonar site is approximately 456 km. The travel rate for chum salmon has been estimated at 25 miles per day (40.2 km/day; ADFG 2019). The fall chum count began at the Eagle sonar site on August 20, 2018 with a daily count of 66 chum (ADFG 2019). Based on this information, the first arrival of chum at the Pelly River sonar site was estimated to be approximately August 29 to September 2, after the completion of the Chinook run.

For the purposes of estimating the final Chinook salmon counts to the end of the migration after the sonar program was no longer operating, it has been assumed that no chum were present during the operation of the 2018 Pelly River sonar program, given the lack of chum salmon captures during test netting and the estimated arrival of chum at the sonar site (post operation). It is assumed that all net upstream sonar targets counted and estimated were enumerated as Chinook salmon.

4.1.3 FINAL CHINOOK SALMON PASSAGE ESTIMATE

The 2018 program ran approximately the same amount of time as the 2017 program (46 and 43 days, respectively). However, the 2018 program started later (July 10 in 2018 versus July 3 in 2017) and ran later into August (August 25 in 2018 versus August 15 in 2017). In 2018, Chinook salmon were observed on the first day of sonar counting (July 10) and still observed to be migrating past the sonar site on August 25 when the sonar shut down. To gather an estimate of the total escapement of Chinook salmon in the lower Pelly River, a pre- and post-season estimate was calculated as part of the goals of the program. In subsequent years, the start and end date for the Pelly River sonar program may continue to be refined as the Chinook migration at the sonar site is better understood.

Expansion of Chinook counts for the period prior to the beginning of this project (i.e. late June/early July) was required as the total number of Chinook migrating past the sonar site was 30 on the first day of operation. A total of five Chinook salmon were counted in the final day of sonar operations (August 25, 2018). As conducted for the 2016 and 2017 post-season estimate, the final passage date of Chinook for the Pelly River sonar site was chosen by comparing to the Chinook counts recorded at the Eagle sonar site since the migration patterns at these two sites have followed similar patterns throughout the 2016, 2017 and 2018 seasons. The peak in daily counts at the Pelly River sonar site generally occurred five days after the peak daily count at the Eagle sonar site. The Chinook count ended at the Eagle sonar site on August 20, 2018 with a daily count of 66 Chinook (ADFG 2019). Using the second order polynomial equation below (MacDonald pers. comm. 2017; same methods as for the 2016 Pelly River sonar program), the final daily count from Eagle sonar was extrapolated to determine the date of the final Chinook passage at the Pelly sonar site. After extrapolation it is estimated that the final Chinook passage at Eagle sonar was August 26, 2018. The distance from the Eagle sonar site to the Pelly River sonar site is approximately 456 km, resulting in approximately 7.5 days travel days. The final passage of Chinook at the Pelly River sonar site is estimated to be no later than September 2, 2018.

The preliminary period of August 29 to September 2 was used to extrapolate Chinook salmon passage rates past the end date of the 2018 sonar program (after August 25). Extrapolated Chinook counts were calculated for the period of August 25 to 29 using the following second order polynomial equation (MacDonald pers. comm. 2017; same methods as for the 2016 Pelly River sonar program):

$$y_i = \frac{L}{d^2} \times (x_i - d)^2$$

Where y_i is the ith daily salmon passage estimate at the sonar site, L is the count on the last day of the period of extrapolation, d is the total number of days that are being extrapolated, and x_i is the number of the day that is being estimated (i.e. day number within the period of extrapolation).

A total of 67 Chinook salmon are estimated to have passed the sonar site before the sonar operations began, the total extrapolated daily Chinook salmon passage estimates began on July 3, 2018 with a single Chinook passage (Table 7). On July 9, 2018, the day before sonar operation began, a total of 22 Chinook salmon are estimated to have migrated past the sonar site (Table 7). A total of six Chinook salmon are estimated to have passed the site after sonar operations ceased (Table 8). When added to the interpolated total estimate of 9,678 (Table 6.), this post-season expansion data results in a final Chinook salmon passage estimate of 9,751. Using the formulas explained in section 2.3.5 and 2.3.6 the confidence interval was calculated for each bank (APPENDIX B). Left bank counted ±27 fish and right bank counted ±42 fish with 95% confidence. The total confidence interval is ±69 Chinook salmon over the entire program. Based on the test netting data collected during the 2016, 2017 and 2018 programs and the local knowledge of salmon species present in the Pelly River, this estimate is fully apportioned as Chinook salmon.

Table 7. Extrapolated daily Chinook salmon counts at the 2018 Pelly River sonar site between July 1 and July 9, 2018.

Date	Both Banks Combined Extrapolated Net Upstream Total
July 1	0
July 2	0
July 3	1
July 4	3
July 5	5
July 6	8
July 7	12
July 8	16
July 9	22
Total	**67**

Table 8. Extrapolated daily Chinook salmon counts at the 2018 Pelly River sonar site between August 26 and August 29, 2018.

Date	Both Banks Combined Extrapolated Net Upstream Total
August 26	3
August 27	2
August 28	1
August 29	0
Total	**6**

4.2 PELLY RIVER CHINOOK SALMON MIGRATION DYNAMICS

The following sections include data on the migration dynamics observed, including run timing and run strength, bank orientation, and water levels. As this was the third year of operation for this program, the data presented in the following sections cannot yet be used to determine long-term trends; however, it is presented here as baseline information with the intention that these components will be further developed in future years.

4.2.1 RUN TIMING AND RUN STRENGTH

Sonar data collected during the 2018 Pelly River sonar program (third season of sonar operation) provides additional insight on the run timing and strength of the lower Pelly River Chinook salmon migration and will provide important information on these aspects of the Chinook run in future years.

Upstream Chinook salmon were recorded at the Pelly River sonar site on the first day of sonar recording (July 10). A total of 30 upstream migrating Chinook salmon were counted on the first day with the daily total increasing each subsequent day. This indicates that the 2018 project did not capture the very start of the Pelly River Chinook salmon run. The daily counts began to spike around July 15/16 and this increasing trend continued throughout the sonar operation (Figure 3 to Figure 5; APPENDIX B). The peak of the 2018 Chinook salmon run was not as well defined as it had been in previous years, which was also observed at the Eagle sonar site. Daily counts reached a high of 479 on July 24 and dropped back down to 424 on July 26. On July 28 the daily total was back up to 498, before dropping down to 466 on July 29. The highest daily total was observed on July 30 with a total of 520 Chinook salmon counted. Following the peak of the run the daily totals had a few spikes, but overall had a consistent decrease. However, at the end of the project a small pulse was recorded in the final days of sonar operation which was also observed at the Eagle sonar site (ADFG 2019). On August 20 daily counts had decreased to two but increased back up to a daily total of ten Chinook salmon on August 24. On the final day of sonar operation (August 25) five Chinook salmon were recorded, approximately 1% of what was observed on the day the run peaked, indicating the project captured the majority of the run. The Pelly sonar was successful in capturing a comprehensive data set for the 2018 Chinook salmon run, pre- and post-season expansions accounting for less than 1% of the total run estimate.

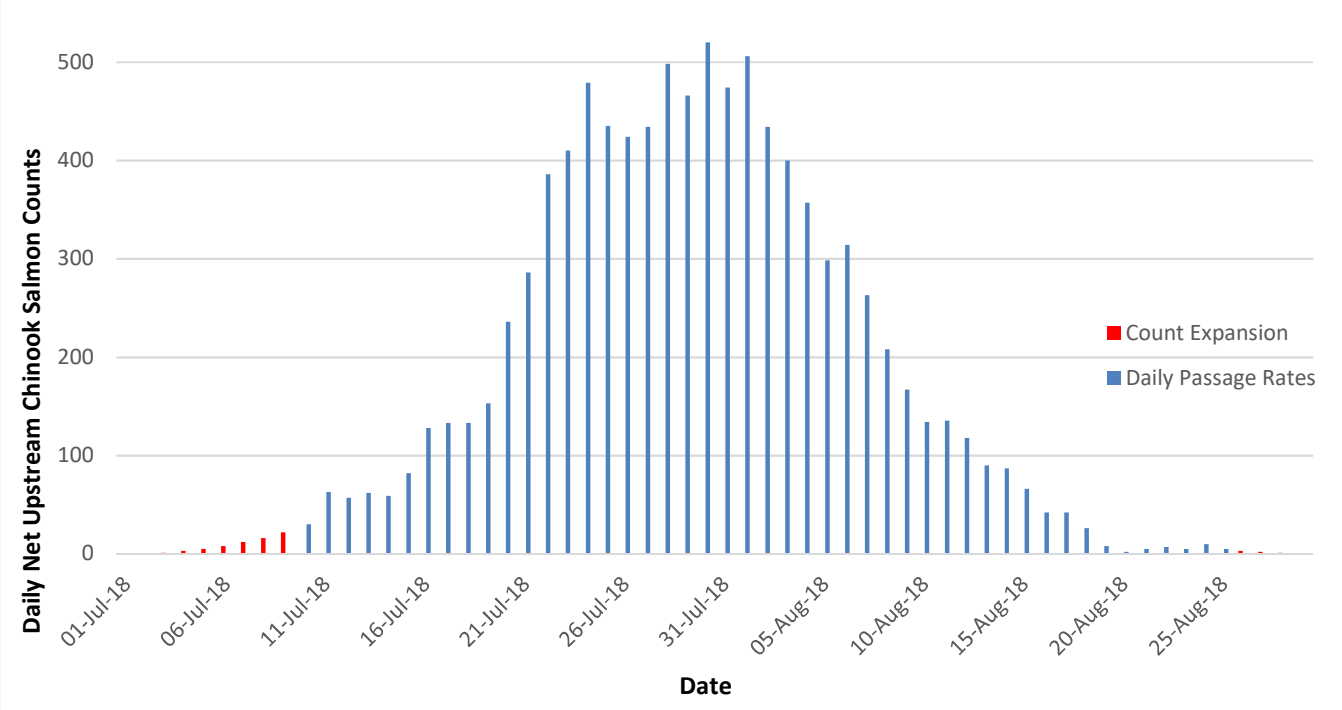


Figure 3. Daily net upstream Chinook salmon counts at the Pelly River Chinook sonar site in 2018, including the pre- and post-season extrapolated data.

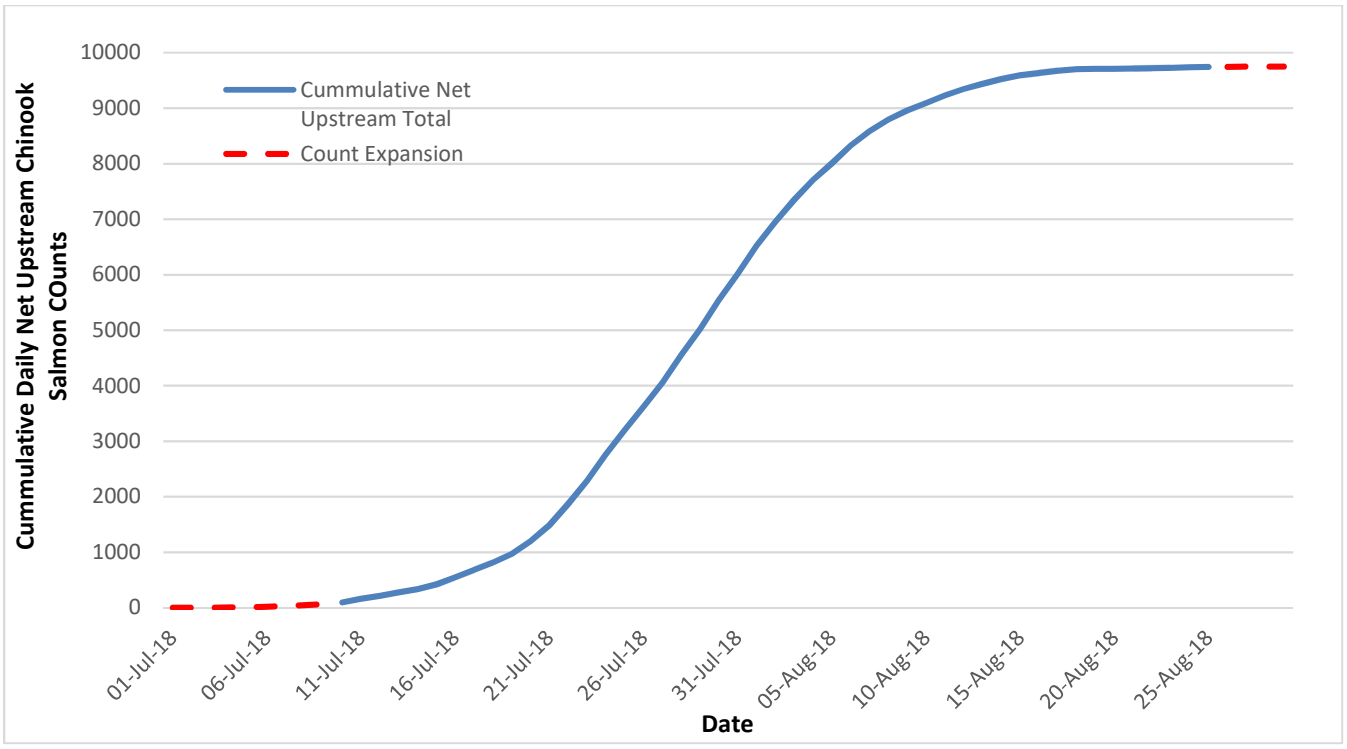


Figure 4. Daily cumulative net upstream Chinook salmon counts at the Pelly River sonar site in 2018, including pre and post-season extrapolated data.

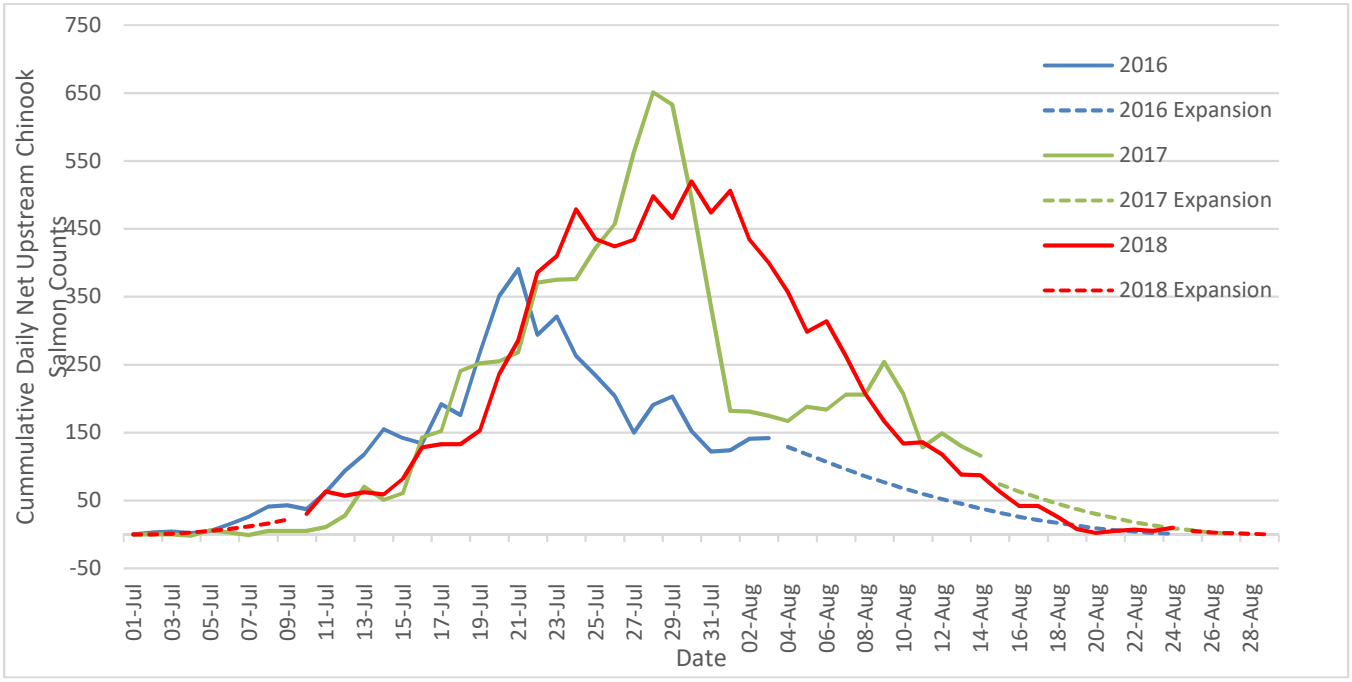


Figure 5. Yearly comparison of daily cumulative net upstream Chinook salmon counts at the Pelly River sonar site in 2016, 2017 and 2018, including pre- and post- season extrapolated data.

4.2.2 CHINOOK SALMON BANK ORIENTATION

The review of collected sonar data using Echotastic produces a text file record, which includes a measurement of the distance of each fish target from the sonar transducer. This data can be used to detect patterns in fish movements; for example, whether salmon are bank oriented at a particular location within the river. The target range data was graphed separately for each bank of the river to investigate potential patterns in the movement of Chinook as they pass through the zones of ensonification on each side of the river (Figure 6 and Figure 7). There are several factors that may affect the spatial migration patterns of Chinook salmon including river discharge, water clarity, and water temperature. Review of the target range data is intended as a preliminary assessment of the spatial distribution of fish targets with the understanding that additional years of data collection are required to determine if identified trends are consistent over a multi-year period.

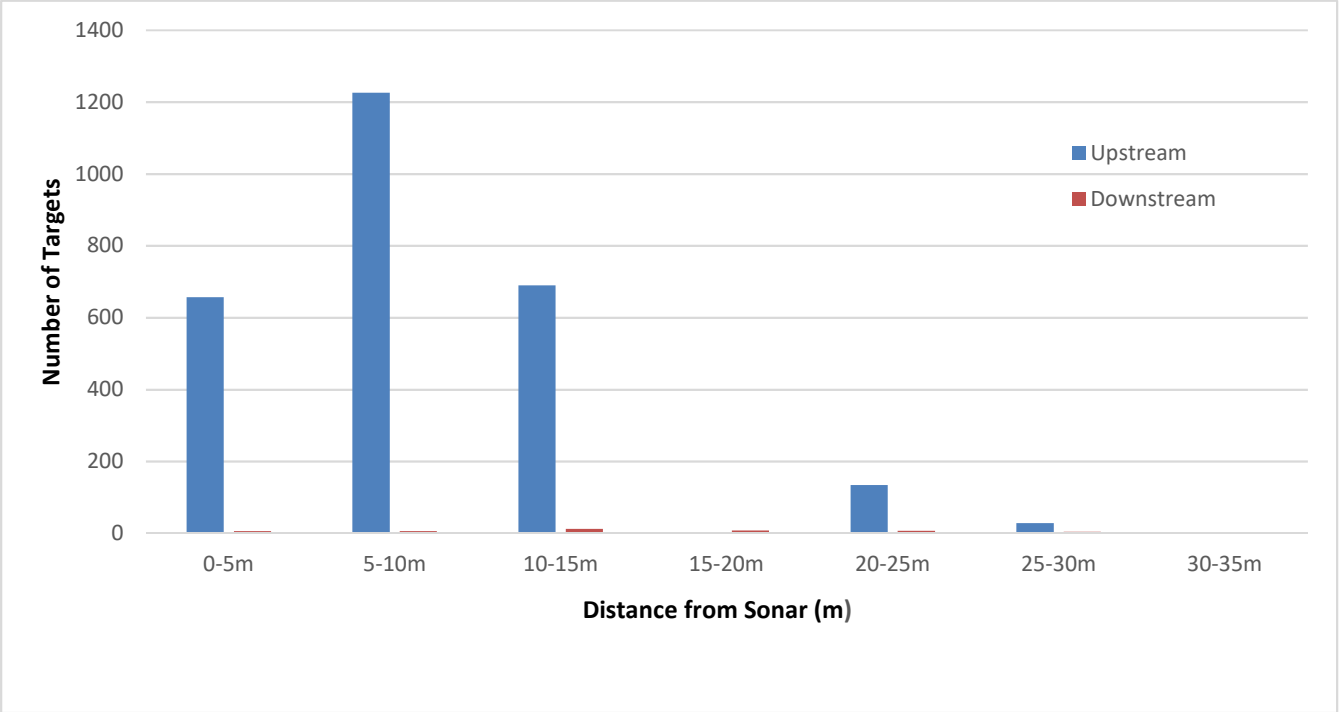


Figure 6. Ranges of upstream and downstream moving fish targets detected on the left bank of the Pelly River sonar site in 2018.

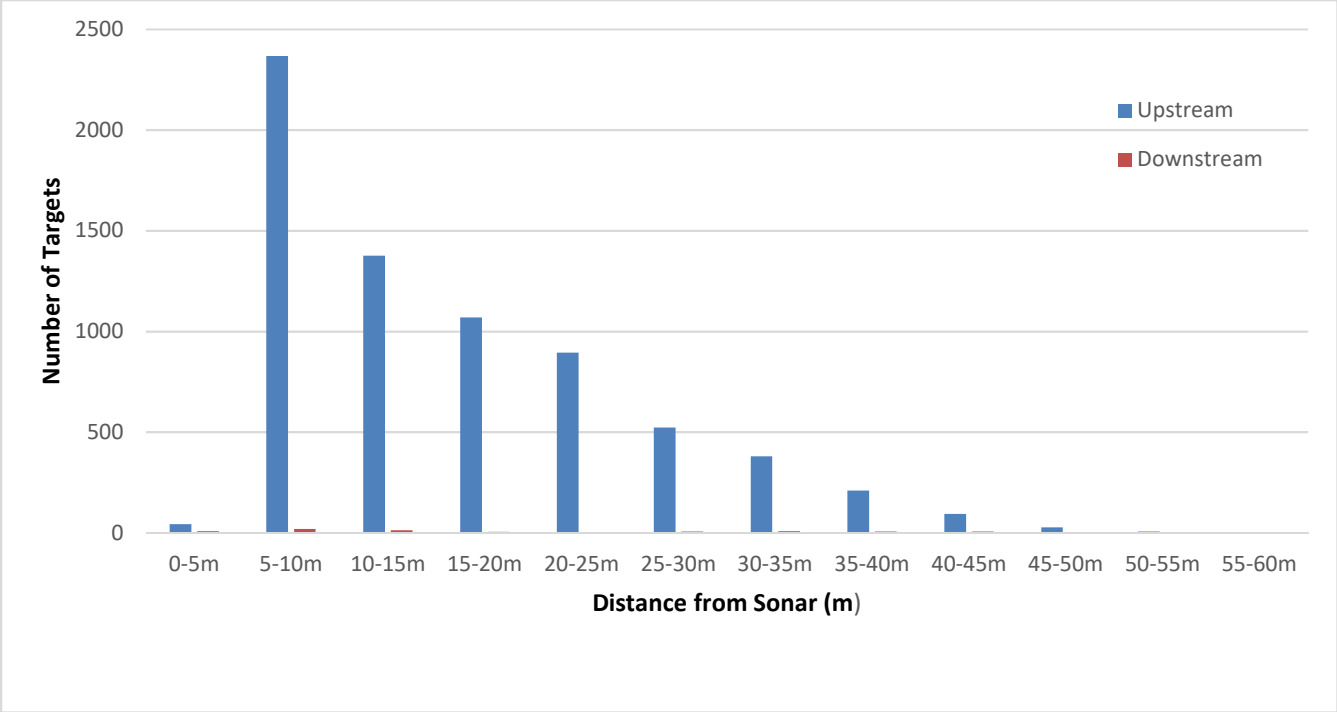


Figure 7. Ranges of upstream and downstream moving fish targets detected on the right bank of the Pelly River sonar site in 2018.

The target range data suggests that upstream migrating fish targets were strongly bank oriented in the vicinity of the Pelly River sonar site during operation in 2018, which is consistent with previous years data. A total of 9,608 upstream moving targets were analyzed[3]; 28% were observed on the left bank and 72% on the right bank (Table 9, Table 10, Figure 6 and Figure 7). The majority of upstream moving sonar targets were detected within 5 to 10 m of the sonar transducers for both banks. None of the upstream moving targets on the left bank were detected beyond 25-30 m and approximately 6percent were detected beyond 15 m from the sonar transducer on the left bank (note the limit of ensonified area on the left bank is 35 m). Given the low number of offshore, upstream moving targets on the left bank, and that only two Chinook salmon have been captured during drift netting within the non-ensonified area between 2016 and 2018, the Pelly River sonar project can be successfully run with one long range and one short range sonar unit.

On the right bank 10% of the total upstream moving targets were beyond 30 m. This number is up from 4% in 2017 and may be connected to lower water levels and higher water temperatures in 2018. Downstream moving targets also appeared to be bank oriented with the majority (91% and 61%, left and right banks, respectively) of the targets observed within 25 m of the sonar transducers (Table 9, Table 10, Figure 6 and Figure 7).

[3] Note that 9,608 is the total raw, net moving target count of upstream targets after subtracting downstream targets. This total is higher than what was reported as there is some error in saving of the text files following review of each sonar file.

Table 9. Ranges of upstream and downstream moving fish targets detected on the left bank of the Pelly River sonar site in 2018.

Target Range	Upstream Targets		Downstream Targets	
	Number of Targets	Proportion of Total Targets (%)	Number of Targets	Proportion of Total Targets (%)
0-5 m	657	24.02	6	13.95
5-10 m	1226	44.83	6	13.95
10-15 m	690	25.23	12	27.91
15-20 m	0	0.00	8	18.60
20-25 m	134	4.90	7	16.28
25-30 m	28	1.02	4	9.30
30-35 m	0	0	0	0.00
Total	**2735**	**100**	**43**	**100**

Table 10. Ranges of upstream and downstream moving fish targets detected on the right bank of the Pelly River sonar site in 2018.

Target Range	Upstream Targets		Downstream Targets	
	Number of Targets	Proportion of Total Targets (%)	Number of Targets	Proportion of Total Targets (%)
0-5 m	43	0.61	8	10.39
5-10 m	2368	33.86	19	24.68
10-15 m	1376	19.68	13	16.88
15-20 m	1070	15.30	5	6.49
20-25 m	894	12.78	2	2.60
25-30 m	523	7.48	7	9.09
30-35 m	380	5.43	8	10.39
35-40 m	210	3.00	7	9.09
40-45 m	94	1.34	6	7.79
45-50 m	28	0.40	0	0.00
50-55 m	7	0.10	2	2.60
55-60 m	0	0.00	0	0.00
Total	**6993**	**100**	**77**	**100**

Differences in the slope of the shoreline between the left and right banks at the Pelly River sonar site were observed by the field crew (see photos in APPENDIX A) and were documented during the 2015 Pelly River sonar reconnaissance survey (EDI 2015). Both banks near shore were characterized by a shallow, even slope; however, the left bank was noted as being steeper than the right. The thalweg of the river at the sonar site was oriented closer to the left bank (EDI 2015), indicating flows are likely higher towards the left bank. This may

have influenced the Chinook in their migration patterns as they were oriented more towards the right bank where velocities were lower.

4.2.3 PELLY RIVER WATER LEVELS

Water levels can have an important effect on salmon run timing; higher water levels and corresponding increased river discharge can slow migration rates, and vice versa. Daily water level data is recorded at a Water Survey of Canada gauging station on the Pelly River near the community of Pelly Crossing, approximately 24 km upstream from the Pelly River sonar site (Station Number 09BC001; Government of Canada 2017). This station operates on a continuous basis and there are no major watercourses that enter the Pelly River between this station and the sonar site. The proximity of this station to the sonar site provides a good indication of the water level at the sonar site during summer months. The available water level data was reviewed to investigate the water levels during the operation of the sonar, as compared to the mean, minimum, and maximum levels over the same period (including data from 2011 to 2018; Figure 8).

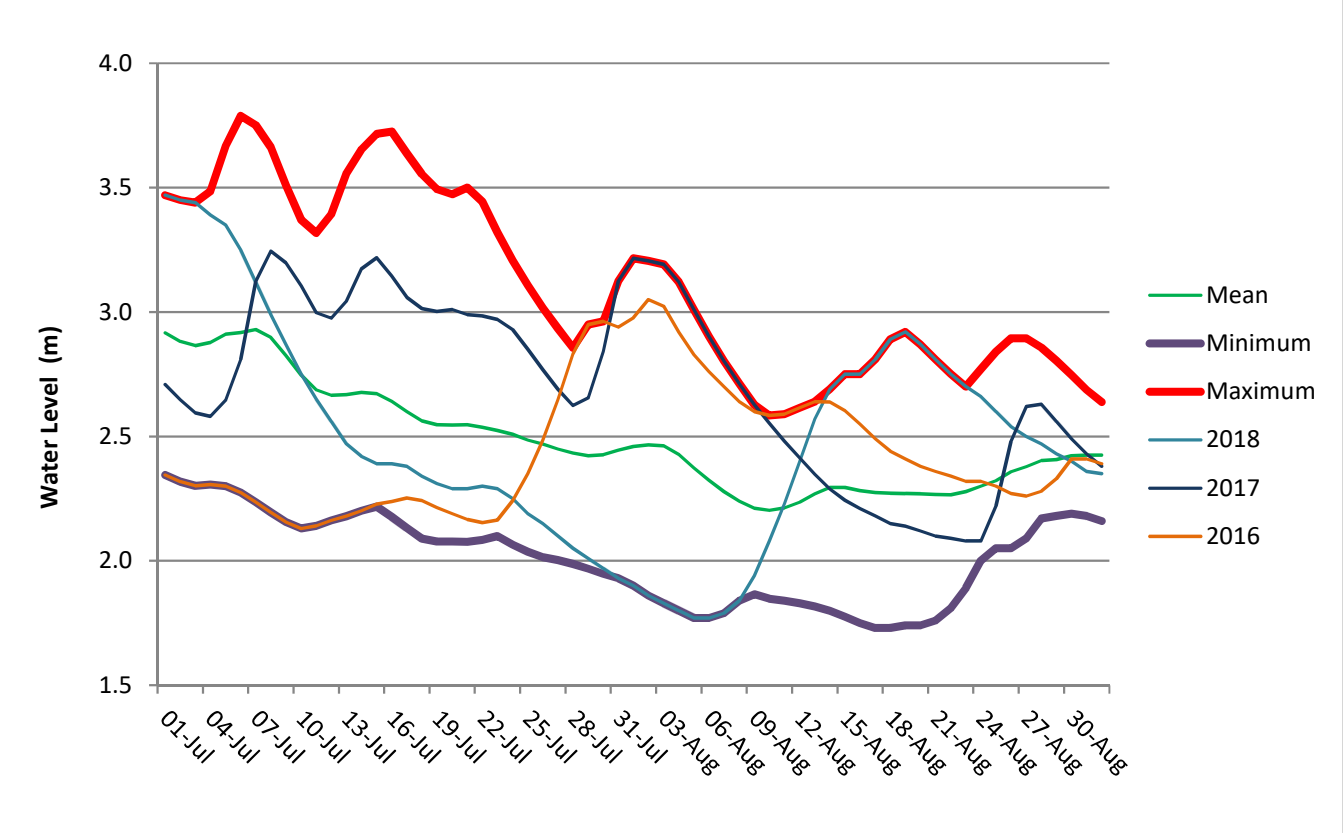


Figure 8. July 1 to September 1, 2018 Pelly River water levels as compared to the mean, minimum, and maximum daily raw water levels from 2011 to 2018. Water levels measured at Water Survey of Canada gauging station 09BC001 near the community of Pelly Crossing. Earliest year available for water levels at this station was 2011.

As shown in Figure 8, water levels at the start of the 2018 sonar program were equal to the maximum recorded water levels for that time period. On approximately July 3, 2018 water levels began to steadily decrease until it reached the minimum water levels recorded for this time period from July 31 to August 8, 2018 (Figure 8). Water levels began to steadily increase again, reaching maximum recorded water levels, before falling back down to average levels at the end of the field program.

Similar to high water events seen in previous years, water levels did allow the back channel behind the right bank island to become connected to the mainstem of the Pelly River. However, the back channel was not connected throughout the entire duration of the sonar program. On July 19, 2018 water levels were observed to have low flow behind the right bank island (Photo 9, APPENDIX A). Shortly after the back channel became cut off and there was no connectivity to the mainstem Pelly River on the upstream end of the right bank island. As water levels began to rise in early August, the back channel became connect to the mainstem again. On August 13, 2018, before water levels got too high, crews were able to erect a temporary fence to block upstream passage behind the sonar by migrating Chinook salmon (Photo 10, APPENDIX A).

4.3 TEST NETTING EFFECTIVENESS

The two primary goals of test netting in 2018 were to:

1. Conduct test netting to confirm species in the sonar count data between Chinook salmon and all other fish species (including chum salmon [*Oncorhynchus keta*] and larger freshwater fish species); and
2. Collect age, sex and length (ASL) data from Chinook salmon that are captured in the test fishery.

The test netting program did achieve both of these goals; however, since the test netting portion of the project was reduced, the amount of data collected was less than previous years. Onshore drift netting was no longer conducted at the Pelly River sonar site as no chum salmon have been captured in either drift or set netting in the previous two years. Onshore drift netting was also removed from the program to focus time and resources on other areas of the project. The number of chum salmon that co-migrated with Chinook salmon during the operational period of this program is believed to be zero, as speculated from the run timing of chum salmon at Eagle sonar site. This assumption is further supported by the fact that no chum salmon were captured in any portion netting program over the three years the program has been running.

Observations in the sonar count files (of inconnu and northern pike) showed there was a presence of larger freshwater species in the vicinity of the Pelly River sonar site in 2016 and 2017. Compared to previous years, there were no freshwater fish (particularly inconnu) captured during the set netting program in 2018. This is likely a result of the reduced test netting effort in 2018 compared to the 2016 and 2017 projects. Field crews noted that there were several upstream targets exhibiting slow movements across the sonar beams and behaviours not typical of migrating salmon; it was presumed these were freshwater fish, and therefore not counted. These observations highlight the importance of the test netting program in confirming what is being recorded in the sonar files and developing a stronger understanding of the local conditions at the sonar site.

4.4 DEVELOPMENT OF LOCAL CAPACITY

An important goal of the 2018 Pelly River Chinook sonar program was to continue developing local capacity within the SFN and community of Pelly Crossing to conduct fisheries research programs. This program provided approximately seven weeks of fisheries related work for two local technicians, including the opportunity to gain skills in the operation of sonar systems and conduct set and drift netting. Two local field technicians were trained and participated in this program, both of which were returning SFN employees from the 2017 program. There remains a strong interest within the community of Pelly Crossing to pursue future sonar programs for Chinook salmon stock assessment purposes and to continue building skills and experience amongst SFN community members. SFN and EDI continue to collaborate to expand the roles and build the responsibilities of SFN employees. The 2019 Chinook sonar program is again proposing the use of two full time local technicians for the field component of the program, as well as looking to increase the office-based task and preparation duties for SFN members. Currently, the long-term goal of the Chinook sonar program is to develop it into a permanent stock assessment initiative, entirely operated by SFN and local field technicians with professional assistance and support provided as needed.

5 RECOMMENDATIONS

Overall, the 2018 Pelly River Chinook Salmon Sonar Program was successful in meeting the goals and objectives as outlined in the 2018 Pelly River Chinook Salmon Sonar Program Proposal submitted to the Yukon River Panel Restoration and Enhancement Fund. Two local technicians were present onsite for nearly the full duration of the sonar program (seven weeks) and minimal amounts of test netting was achieved and successful at capturing Chinook salmon. This sonar program provided a count that is local to Pelly Crossing, is accurate, and available in-season.

Recommendations for future Pelly River Chinook salmon sonar programs include:

- Continued collaboration between SFN and EDI to increase local capacity in other roles and responsibilities (in addition to the field program, i.e., SFN technician involvement in field preparation and post field reporting, etc.).
- All test nets should be repaired or replaced prior to or at the very onset of the 2019 program.
- Continue improving upon the data QA/QC protocols by ensuring field personnel are regularly re-counting 10% of the daily sonar files throughout the entire duration of the sonar operation and that crew members are communicating to maintain counting consistency.
- Increased community involvement through the encouragement of site visits by locals, including youth and Elders, to the sonar camp.
- The local fishery should be monitored with information communicated to the EDI biologist and Pelly River sonar personnel. This will provide valuable data to assist in documenting the beginning and end of the Chinook migration in the lower Pelly River and will be used to refine the extrapolated data for more accurate total escapement estimates. Communication between SFN members and the sonar camp personnel will also assist in fostering community engagement.

6 REFERENCES

6.1 LITERATURE CITED

Alaska Department of Fish and Game (ADFG). 2018. Escapement Monitoring, In-season and Historical Data. Available at: http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareayukon.salmon_escapement [Accessed January 2019].

Crane, A.B. and Dunbar, R.D. 2009. Sonar Estimation of Chinook and Fall Chum Salmon Passage in the Yukon River near Eagle, Alaska, 2008. Prepared by the Alaska Department of Fish and Game, Division of Sport Fish and Commercial Fisheries. Fishery Data Series No. 09-30.

EDI 2015. Pelly River Sonar Reconnaissance Survey. Prepared by EDI Environmental Dynamics Inc. for Selkirk First Nation.

EDI 2017. 2017 Pelly River Chinook Salmon Sonar Program. Prepared by EDI Environmental Dynamics Inc. for Selkirk First Nation.

EDI 2018. 2018 Pelly River Chinook Salmon Sonar Program. Prepared by EDI Environmental Dynamics Inc. for Selkirk First Nation.

Government of Canada. 2017. Water Survey of Canada, Real-Time Hydrometric Data Graph for Pelly River at Pelly Crossing (09BC001). Yukon Territory. Available at: https://wateroffice.ec.gc.ca [Accessed January 2019].

Joint Technical Committee of the Yukon River US/Canada Panel (JTC). 2016. Yukon River Salmon 2015 Season Summary and 2016 Season Outlook. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A16-01, Anchorage.

Lozori, J.D. and Borden, L.K. 2015. Sonar Estimation of Chinook and Fall Chum Salmon Passage in the Yukon River near Eagle, Alaska, 2014. Prepared for Alaska Department of Fish and Game. Fisheries Data Series No. 15-44.

6.2 PERSONAL COMMUNICATIONS

Alfred, E. 2017. Selkirk First Nation, Fish and Wildlife Officer, personal communication January 2017.

MacDonald, E. 2017. Fisheries and Oceans Canada, Aquatic Science Biologist, personal communication via email January 2017.

Mather, V and Milligan, M. 2018. Fisheries and Oceans Canada, Aquatic Science Biologists, personal communication January 2018.

APPENDIX A. PHOTOGRAPHS

This page is intentionally blank.

Photo 1. View of Pelly River Chinook sonar camp from the river

Photo 2. View of inside the sonar tent and field office

Photo 3. View of the right bank Aris sonar in the Pelly River, facing upstream

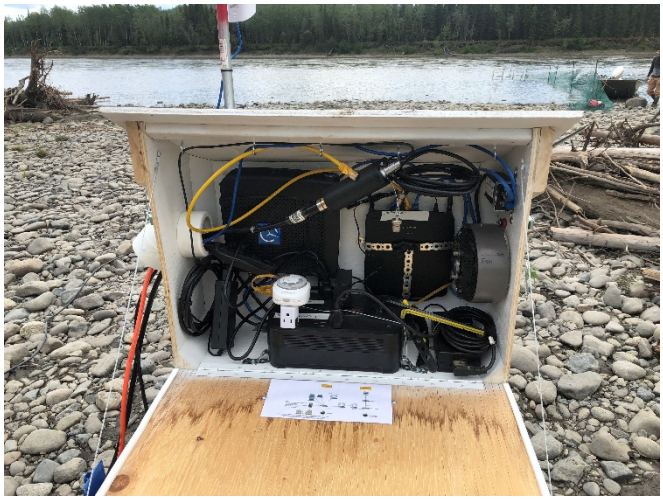


Photo 4. View of the right bank sonar, network and internet electrical setup

Photo 5. View of the left bank Aris sonar in the Pelly River

Photo 6. View of the fuel storage "shed" near camp

Photo 7. View of a set net located at PR 2 near sonar camp, facing upstream

Photo 8. View of a male Chinook salmon captured during test netting

Photo 9. Upstream end of side channel with low flow connecting it to the main channel

Photo 10. Side channel with temporary fence installed to stop salmon migration behind right bank sonar

APPENDIX B. RAW AND INTERPOLATED PELLY RIVER DAILY SONAR COUNTS

This page is intentionally blank.

Table B1. Daily interpolated and expanded sonar counts from the 2018 Pelly River Chinook salmon sonar program.

Date	Left Bank				Right Bank				Both Banks Combined Net Total Upstream
	Raw Upstream	Raw Downstream	Upstream Interpolated	Net Total Upstream	Raw Upstream	Raw Downstream	Upstream Interpolated	Net Total Upstream	
02-Jul	-	-	-	-	-	-	-	-	0
03-Jul	-	-	-	-	-	-	-	-	1
04-Jul	-	-	-	-	-	-	-	-	3
05-Jul	-	-	-	-	-	-	-	-	5
06-Jul	-	-	-	-	-	-	-	-	8
07-Jul	-	-	-	-	-	-	-	-	12
08-Jul	-	-	-	-	-	-	-	-	16
09-Jul	-	-	-	-	-	-	-	-	22
10-Jul	16	0	0	16	13	1	2	14	30
11-Jul	37	0	0	37	25	0	1	26	63
12-Jul	37	0	0	37	18	1	3	20	57
13-Jul	36	0	0	36	26	0	0	26	62
14-Jul	14	0	0	14	47	2	0	45	59
15-Jul	43	0	0	43	40	1	0	39	82
16-Jul	31	1	3	33	99	4	0	95	128
17-Jul	35	0	0	35	108	10	0	98	133
18-Jul	20	1	0	19	115	1	0	114	133
19-Jul	48	0	0	48	106	1	0	105	153
20-Jul	81	0	0	81	155	0	0	155	236
21-Jul	94	0	0	94	192	0	0	192	286
22-Jul	109	0	0	109	278	1	0	277	386
23-Jul	128	0	0	128	282	0	0	282	410
24-Jul	145	0	0	145	335	1	0	334	479
25-Jul	134	0	0	134	301	0	0	301	435
26-Jul	144	2	0	142	282	0	0	282	424

Date	Left Bank				Right Bank				Both Banks Combined Net Total Upstream
	Raw Upstream	Raw Downstream	Upstream Interpolated	Net Total Upstream	Raw Upstream	Raw Downstream	Upstream Interpolated	Net Total Upstream	
27-Jul	102	5	0	97	339	2	0	337	434
28-Jul	114	2	0	112	388	2	0	386	498
29-Jul	131	2	0	129	337	0	0	337	466
30-Jul	150	0	0	150	371	1	0	370	520
31-Jul	120	2	0	118	357	1	0	356	474
01-Aug	135	3	0	132	374	0	0	374	506
02-Aug	110	0	0	110	333	9	0	324	434
03-Aug	112	0	0	112	293	5	0	288	400
04-Aug	80	0	0	80	282	5	0	277	357
05-Aug	80	0	9	89	199	5	15.5	209.5	298.5
06-Aug	101	0	0	101	213	0	0	213	314
07-Aug	69	1	1	69	196	2	0	194	263
08-Aug	39	0	0	39	170	1	0	169	208
09-Aug	34	0	0	34	133	0	0	133	167
10-Aug	36	0	0	36	100	2	0	98	134
11-Aug	39	1	14.5	52.5	83	0	0	83	135.5
12-Aug	90	2	0	88	31	1	0	30	118
13-Aug	25	1	0	24	66	0	0	66	90
14-Aug	32	0	0	32	55	0	0	55	87
15-Aug	23	0	0	23	44	1	0	43	66
16-Aug	4	0	0	4	38	0	0	38	42
17-Aug	5	0	0	5	38	1	0	37	42
18-Aug	3	0	0	3	23	0	0	23	26
19-Aug	1	0	0	1	7	0	0	7	8
20-Aug	0	0	0	0	2	0	0	2	2
21-Aug	0	0	0	0	5	0	0	5	5
22-Aug	4	0	0	4	3	0	0	3	7

Date	Left Bank				Right Bank				Both Banks Combined Net Total Upstream
	Raw Upstream	Raw Downstream	Upstream Interpolated	Net Total Upstream	Raw Upstream	Raw Downstream	Upstream Interpolated	Net Total Upstream	
23-Aug	0	0	0	0	5	0	0	5	5
24-Aug	5	0	0	5	5	0	0	5	10
25-Aug	2	0	0	2	5	2	0	3	5
26-Aug	-	-	-	-	-	-	-	-	3
27-Aug	-	-	-	-	-	-	-	-	2
28-Aug	-	-	-	-	-	-	-	-	1
29-Aug	-	-	-	-	-	-	-	-	0
Total	**2798**	**23**	**27.5**	**2802.5**	**6917**	**63**	**21.5**	**6875.5**	**9751**

Table B2. Results from average percent error, variance, standard deviation and confidence intervals.

	APE	Variance	SD	CI
Left Bank	16.33	180.69	14.03	27.51
Right Bank	9.57	451.21	21.46	42.07

This page is intentionally blank

APPENDIX C. TEST NETTING CAPTURES

This page is intentionally blank.

Table C1. Net locations from the 2018 Pelly River Chinook Salmon Sonar Program.

Name	Location	Description
PR1	08V 393285 6969180	1.5 - 2 KM upstream of camp on left bank, big eddy
PR 2	08V 391319 6969341	Upstream of camp on right bank, near fallen down beaver chewed tree
PR3	08V 390952 6968863	Upstream of camp on left bank, eddy above sonar
PR4	08V 390702 6968894	Downstream of camp, right bank, calm water below gravel bar
Drift Netting	08V 390782 6968826	Mid-channel in front of camp (all offshore drift netting completed here)

Table C2. Set netting effort and fish captures from the 2018 Pelly River Chinook Salmon Sonar Program.

Date	Set Number	Net Location	Net in	Net Out	Effort (hours)	Mesh Size	Fish Species	Length (cm)	Sex
20-Jul-2018	1.1	PR1	13:00	16:30	3.5	7.5	NFC		
21-Jul-2018	2.1	PR2	14:30	17:30	3	6.75	NFC		
22-Jul-2018	3.1	PR2	13:20	17:45	4.42	8.5	NFC		
24-Jul-2018	4.1	PR1	12:20	17:45	5.42	5.25	NFC		
27-Jul-2018	5.1	PR3	14:00	18:00	4	7.5	NFC		
28-Jul-2018	6.1	PR4	10:15	12:30	2.25	6.75	NFC		
28-Jul-2018	6.2	PR2	12:45	18:35	5.83	6.75	CH	91.5	M
28-Jul-2018	6.2	PR2	12:45	18:35	5.83		CH	89.0	F
28-Jul-2018	6.2	PR2	12:45	18:35	5.83		CH	92.0	M
28-Jul-2018	6.2	PR2	12:45	18:35	5.83		CH	93.0	F
28-Jul-2018	6.2	PR2	12:45	18:35	5.83		CH	89.0	M
28-Jul-2018	6.2	PR2	12:45	18:35	5.83		CH	91.0	M
6-Aug-2018	7.1	PR2	16:57	17:40	0.72	6.75	NFC		
6-Aug-2018	7.2	PR2	17:50	18:52	1.03	6.75	CH	71.1	F
8-Aug-2018	8.1	PR2	14:42	17:05	2.38	7.5	NFC		

Table C3. Offshore drift netting effort and fish captures from the 2018 Pelly River Chinook Salmon Sonar Program.

Date	Drift Number	Net Location	Net in	Net Out	Effort (minutes)	Mesh Size	Fish Species	Length (cm)	Sex
6-Aug-2018	D1.1	Drift Netting	17:10	17:16	6	6.75	CH	86.9	F
6-Aug-2018	D1.2	Drift Netting	17:31	17:37	6	6.75	NFC		
6-Aug-2018	D1.3	Drift Netting	17:48	17:54	6	6.75	NFC		
8-Aug-2018	D2.1	Drift Netting	13:47	13:52	5	7.5	NFC		
8-Aug-2018	D2.2	Drift Netting	13:55	13:59	4	7.5	NFC		
8-Aug-2018	D2.3	Drift Netting	14:02	14:08	6	7.5	NFC		
8-Aug-2018	D2.4	Drift Netting	14:12	14:18	6	7.5	NFC		